Co-designing and evaluating the feasibility of an online physical activity, nutrition, and psychosocial intervention for post-treatment cancer survivors

By

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Abstract

Regular physical activity and a nutritious diet following anti-cancer treatment can improve cancer survivors' Quality of Life (QoL), but many are not meeting healthy lifestyle recommendations. Qualitative research suggests cancer survivors desire holistic programs that target physical health, mental health and adjustment following treatment. Online-platforms offer an accessible delivery modality for such multicomponent interventions. This thesis aimed to evaluate evidence for effectiveness of multicomponent interventions and co-design an online physical activity, nutrition, and psychosocial support intervention for cancer survivors.

The first study comprised a systematic review and meta-analysis of healthy living interventions effect on post-treatment cancer survivors' QoL, and the moderating effect of including a mental health component. Ninety-two articles were included, and 53 effect sizes were extracted. The pooled effect size demonstrated a small positive effect of healthy living interventions in comparison to control ($d = 0.30$). Subgroup analyses revealed no differences between interventions which did versus did not include mental health, however, this finding was based on a small number of interventions that included mental health.

The second study co-designed Healthy Living after Cancer *Online* (HLaC *Online*). A basic outline of the program was presented in focus groups and interviews to cancer survivors, oncology healthcare professionals, and cancer support representatives. Thematic analysis of the transcripts identified five themes relating to website design, promoting and maintaining long term engagement, relatability and relevance, navigating professional support, and family and peer support. Recommended changes, such as simple activities and guidance videos, were integrated into HLaC *Online*.

A mixed-methods study, including pre/post questionnaires and an interview, was then used to evaluate the feasibility and usability of HLaC *Online*. Eleven cancer survivors participated in the 12-week program. Five participants did not interact with HLaC *Online*. The remaining participants on average accessed 3.33 modules. Perceived usability varied. Qualitative feedback indicated that topics were relevant and helpful, but motivation challenges emerged relating to cancer-related symptoms and the program’s perceived time burden. One suggestion was to provide human guidance for website orientation and accountability.

The final study evaluated whether adding brief telephone support improved the feasibility of HLaC *Online*. Fifty-two cancer survivors were randomised (n=47 commenced allocated intervention) to receive HLaC *Online* as self-directed (n=25) or with two telephone coaching calls (HLaC *Online*+coaching n=22). Participants completed questionnaires at baseline, post-intervention, and one-month follow-up. HLaC *Online*+coaching participants rated usability and satisfaction higher. A higher proportion of HLaC *Online* participants did not engage with the intervention. Preliminary efficacy signals found small to moderate improvements for symptom distress, fibre intake behaviours, and sitting time in both conditions. HLaC *Online* yielded small improvements in QoL, while HLaC *Online*+coaching demonstrated moderate improvements in fear of cancer recurrence.

Overall, findings indicated that HLaC *Online* is feasible and holds promise for supporting cancer survivors achieving a healthy lifestyle. However, lack of intrinsic motivation can be a barrier to intervention engagement. Adding two telephone coaching calls can reduce non-engagement. Developing a standardised assessment to identify participants at risk of non-engagement could be used to appropriately stratify telephone coaching calls in future.

Declaration

I certify that this thesis:

1. does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university

2. and the research within will not be submitted for any other future degree or diploma without the permission of Flinders University; and

3. to the best of my knowledge and belief, does not contain any material previously published or written by another person except where due reference is made in the text.

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Overview & Aims of the Research

There are current over 1.2 million people living with or beyond cancer in Australia (Australian Institute of Health and Welfare [AIHW], 2021), with the cancer survivor population expected to rise. Given this, identifying strategies and interventions to maintain or improve the health and wellbeing of this population, and reduce health system burden is critical. A healthy lifestyle, including physical activity, nutrition, and weight management, has been shown to mitigate some of the unique adverse physical and psychological consequences associated with post-treatment cancer survivorship (Aune et al., 2022; Duijts et al., 2011). However, only 35 to 41% of Australian cancer survivors are currently meeting healthy lifestyle guidelines (Eakin et al., 2007; Elder-Robinson et al., 2020). While a plethora of interventions to improve adoption of healthy living recommendations have been investigated, typically in face-to-face settings (Broderick et al., 2013; Capozzi et al., 2015; Koutoukidis et al., 2019; Kristensen et al., 2020; O'Neill et al., 2018), these face accessibility barriers. Therefore, developing accessible interventions to address this issue are required. One such effective Australian intervention to support cancer survivors in making healthy lifestyle changes was the telephone-delivered Healthy Living after Cancer (Eakin et al., 2020). Briefly, this 6-month intervention involved post-treatment cancer survivors being offered 12 telephone calls with a cancer nurse targeting goal setting, physical activity, healthy eating, and weight loss. Healthy Living after Cancer was implemented through Cancer Council, an Australian non-government cancer support organisation. While Healthy Living after Cancer utilised an accessible delivery modality and yielded significant clinical benefits to participants, including improvements in physical activity, diet quality, symptom distress, and physical quality of life (Eakin et al., 2020), the program was not sustainable following the research trial. The telephone delivery modality utilised for this intervention was found to be resource intensive, costly, and did not suit all users' preferences (Morris & Kirkbride, 2019).

Digital health interventions, such as online platforms and mobile applications, offer an alternative accessible delivery modality that promotes the self-management of health and behaviour change (Kuijpers et al., 2013). Once developed, digital health interventions require minimal financing and human input, therefore adapting the telephone-delivered Healthy Living after Cancer into an online version has the potential to reach cancer survivors who may not have access to traditional face-to-face support, whilst also enhancing the program's sustainability through reducing the financial and resource cost of the delivery (Donker et al., 2015; Paterson et al., 2022; Schulz et al., 2014). The adaptation of Healthy Living after Cancer to an online delivery modality therefore formed the key aim of this thesis. To achieve this aim however, two critical limitations of prior research or gaps in knowledge need to be addressed. First, there is currently mixed evidence for the efficacy of digital health interventions improving health behaviours in cancer survivors; this may be the result of lack of co-design in their development (Williams et al., 2022), resulting in poor uptake and engagement with the intervention (Forbes et al., 2015; van de Wiel et al., 2021). This thesis therefore aimed to address this limitation by utilising a co-design approach to ensure the program meets the specific needs and preferences of cancer survivors.

Co-design refers to the involvement of end-user stakeholders at each stage of the program development, and is considered the gold standard (Skivington et al., 2021). The Stanford University's Design Thinking Process was utilised for this doctoral program of research (Woods et al., 2017). This co-design process includes five iterative phases: (1) empathise (i.e., to understand the end-users everyday life);

(2) define (i.e., identify what needs to be addressed in the intervention); (3) ideate (i.e., generate ideas of what could be included in the program); (4) prototype (i.e., develop a basic visualisation of the program); and (5) test (i.e., provide the intervention with a small group of end-users; Woods et al., 2017). The empathise and define phases of the co-design process were previously conducted in 2020, when Grant and colleagues invited post-treatment cancer survivors, oncology healthcare professionals and representatives from cancer support organisations to define what healthy living means to post-treatment cancer survivors and what a new version of Healthy Living after Cancer could look like. Overall, the stakeholders defined healthy living as a good overall quality of Life, including physical health, mental health, and adjustment to the new normal after cancer treatment. They recommended that a new healthy living intervention should expand beyond physical activity and healthy eating and address mental health, fatigue management, and peer support. Furthermore, they recommended that healthy living intervention should offer a flexible format and long-term accessibility (Grant et al., 2021). These findings lead to a second critical gap in knowledge in this field, regarding whether there is evidence to support the addition of psychosocial / mental health components to a healthy living intervention.

Thesis Aims

The overarching aims of this thesis therefore were to address these two gaps by (1) evaluating the evidence supporting the addition of a mental health component to digital healthy living interventions, to ensure its addition is warranted and safe; and (2) co-designing and evaluating the feasibility of Healthy Living after Cancer *Online* (HLaC *Online*), an online physical activity, nutrition, and psychosocial intervention for

Australian post-treatment cancer survivors. This thesis reviews the current literature of healthy living interventions, to understand the potential benefits of including a mental health component on post-treatment cancer survivors' QoL, as recommended by the stakeholder group; and presents the ideate, prototype, and test co-design phases of the intervention's development. A basic visualisation of the program was developed and presented to the stakeholder group. Their feedback informed the website development of HLaC *Online*, which was tested with a new group of end-users. The end-users program use and feedback then informed the next iteration of the intervention, which included brief telephone human support.

Summary of chapters

Chapter 1 presents a literature review summarising the prevalence of cancer survivors in Australia, the commonly reported sequalae of survivorship, current evidence for addressing health behaviours in this population, and the potential of digital health delivery modalities.

Current interventions targeting health behaviours in post-treatment cancer survivors are further explored in a meta-analysis presented in **Chapter 2**. In this chapter, sub-group analyses are utilised to understand which intervention characteristics are associated with greater changes in QoL, including interventions which did verses did not include a mental health component, mode of delivery (Individual, group, telephone, digital, and print), and intervention duration (≤12 weeks and ≥13 weeks).

Chapter 3 presents the *ideate* and *prototype* phases of the Stanford Design's Thinking Process (Woods et al., 2017). A black and white visualisation of the proposed HLaC *Online* program (i.e., a wireframe) was developed based on the content from the telephone-delivered Healthy Living after Cancer and the *empathise* and *define* phases (Grant et al., 2021).The post-treatment cancer survivors, oncology healthcare professionals, and representatives from cancer support organisations who had previously participated in the first round of stakeholder engagement (Grant et al., 2021) were invited to review and provide qualitative feedback on the wireframe.

The qualitative feedback was integrated into the website development of HLaC *Online*, as detailed in **Chapter 4.** The first iteration of the 12-week intervention includes nine self-paced modules targeting goal setting, finding the new normal after cancer treatment, physical activity, healthy eating, mental health, fatigue management, maintaining a healthy weight, peer support, and staying on track. This chapter also presents the *test* phase of the Stanford Design's Thinking Process (Woods et al., 2017), whereby the initial feasibility HLaC *Online* was evaluated with a small group of Australian post-treatment cancer survivors. This evaluation involved a mixed methods design, including pre-post questionnaires and a semi-structured telephone interview to assess program usage, usability, satisfaction, and preliminary efficacy.

The uptake, usage and qualitative feedback provided in **Chapter 4** was integrated into the final iteration of the HLaC *Online* program. In particular, **Chapter 5** evaluated the feasibility and preliminary efficacy of adding brief human support to HLaC *Online* in comparison to a self-guided version of the program in a randomised trial.

The key findings from this thesis are summarised in **Chapter 6**, with associated clinical implications, overall limitations, and recommendations for future research.

Published papers

Leske, M., Koczwara, B., Blunt, J., Morris, J., Eakin, E., Short, C.E., Daly, A., Degner, J. & Beatty, L., Morris, J., & Beatty, L. (2022). Co-designing Healthy Living after Cancer Online: an online nutrition, physical activity, and psychosocial intervention for post-treatment cancer survivors. *Journal of Cancer Survivorship*. https://doi.org/10.1007/s11764-022-01284-y

Leske, M., Galanis, C., Koczwara, B., & Beatty, L. (2024). A meta-analysis of healthy lifestyle interventions addressing quality of life of cancer survivors in the post treatment phase. *Journal of Cancer Survivorship*. https://doi.org/10.1007/s11764-023-01514-x

Conference proceedings

Leske, M., Koczwara, B., Blunt, J., Morris, J., Eakin, E., Short, C.E., Daly, A., Degner, J. & Beatty, L., Morris, J., & Beatty, L. (2021, November 16 – 18). *Co-designing Healthy Living after Cancer Online: an online nutrition, physical activity, and psychosocial intervention for post-treatment cancer survivors* [Conference Presentation]. Clinical Oncology Society of Australia Annual Scientific Meeting, held virtually, Australia.

Leske, M., Koczwara, B., Blunt, J., Morris, J., Eakin, E., Short, C.E., Daly, A., Degner, J. & Beatty, L., Morris, J., & Beatty, L. (2022, August 29 – September 1). *Co-designing Healthy Living after Cancer Online: an online* *nutrition, physical activity, and psychosocial intervention for post-treatment cancer survivors* [Conference Presentation]. International Psycho-Oncology Society World Congress, held virtually, Toronto, Canada.

Leske, M., Koczwara, B., Morris, J., & Beatty, L. (2022, November 2 – 4). *Evaluating the feasibility of a co- designed, online healthy living intervention for post-treatment cancer survivors: Healthy Living after Cancer Online* [Poster Presentation]. Clinical Oncology Society of Australia’s Annual Scientific Meeting, Brisbane, Australia.

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Leske, M., Koczwara, B., Morris, J., & Beatty, L. (2023, March 9 – 10). *A meta-analysis of health behaviour interventions addressing quality of life among post-treatment cancer survivors* [Poster Presentation]. Cancer Survivorship Conference, Adelaide, Australia.

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Leske, M., Koczwara, B., Eakin, E., Short, C.E., Daly, A., Degner, J. & Beatty, L. (2023, September 1 – 3). *Feasibility and preliminary efficacy of brief coaching calls in Healthy Living after Cancer Online: a randomised control pilot trial* [Conference Presentation]. International Psycho-Oncology Society World Congress, Milan, Italy.

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Chapter 1.

Literature review

Overview

The following chapter aims to define and provide an overview of cancer survivorship in Australia. Initially, this chapter explores commonly occurring concerns that arise following active cancer treatment, including treatment-related side-effects and psychosocial changes. The following sections of this chapter then introduce cancer survivorship lifestyle recommendations, evidence supporting the various components of healthy lifestyles, and potential interventions that have been trialled to date. An evaluation of delivery modalities that promote accessibility of these interventions, such as the telephone or online-platforms, examining their efficacy and scope for implementation is provided at the conclusion of this chapter.

Cancer in Australia

Cancer is a major cause of illness in Australia, with more than 1 million individuals currently living with a personal history of a cancer diagnosis (Australian Institute of Health and Welfare [AIHW], 2023). This number is expected to increase due to the rise in cancer diagnoses and cancer survival rates; indeed, the AIHW estimates that the incidence of cancer will increase from 165,000 in 2023 to 200,000 in 2033. While these increases are primarily a reflection of the growing and aging population in Australia, an additional 11,000 of the cancer diagnoses in 2023 are estimated to be attributed to an increase in cancer incidence rates. Additionally, advancements in early detection and diagnosis, treatment options, and supportive care are collectively fostering improved survival rates among those with a cancer diagnosis (AIHW, 2023) . Although survival rates vary across cancer type, the estimated 5-year survival rate across all cancer diagnoses has increased from 52.2% in 1993 to 70.1% in 2018 (AIHW, 2023). Overall, more people are diagnosed and living longer with and beyond cancer. Consequently, more people are also at risk of cancer survivorship concerns, including the short- and long-term effects of the illness and its associated treatments, psychological distress, and changes to their social relationships (Skandarajah et al., 2021).

Cancer Survivorship

Cancer survivorship is a term used to describe the physical and psycho-social experience of a cancer diagnosis. The National Cancer Institute (2024) states that “an individual is considered a cancer survivor from the time of diagnosis, through the balance of his or her life.” For the purpose of this thesis, the focus will be on the “post-treatment” phase of survivorship. That is individuals who have been diagnosed with cancer treated with the intention of cure, who have completed active anti-cancer treatment, such as chemotherapy, radiotherapy, surgery, and/or immunotherapy (Miller et al., 2015). The transition from undertaking active treatment to the post-treatment phase of survivorship can be a significant milestone for cancer survivors. This transition can be associated with positive changes, such as post-traumatic growth, a renewed appreciation for life, family, and friends, and provide an opportunity to reprioritise values and life goals (Jakobsen et al., 2018; Jefford et al., 2008). However, for many cancer survivors, it can also be a time of uncertainty and adjustment.

Physical sequalae

Those who have completed treatment can face ongoing physical challenges that are the consequence of the cancer itself or it’s associated treatments. Depending on the cancer type and the treatment received, cancer survivors can have an increased risk of developing (a) secondary cancers, and (b) a diverse range of physical side effects which can persist throughout a person’s lifetime (Lisy et al., 2019; Mazariego et al., 2020; Skandarajah et al., 2021). One large cross-sectional study involving 20,811 Australian cancer survivors demonstrated higher levels of self-reported poor health for long term cancer survivors (i.e., >10 years) in comparison to healthy controls (Tran et al., 2020). While not an exhaustive list, common side effects have been detailed in **Table 1.1**. Furthermore, comorbidities, that is co-occurring chronic conditions such as cardiovascular disease, muscular-skeletal problems, obesity, and diabetes, are more prevalent amongst cancer survivors in comparison to those without a history of cancer (Ng et al., 2018). Thus, the end of treatment may not always signify the end of physical complications and returning to pre-treatment functioning can present challenges.

Table 1.1

Commonly reported long-term physical side effects of cancer treatments (Kroschinsky et al., 2017; Miller et al., 2019)

Treatment	**Possible long-term side effects**
Surgery	Scarring, lymphoedema (i.e., tissue swelling caused by a blockage in the lymphatic system), pain, gastro-intestinal problems, and sexual dysfunction
Chemotherapy	Fatigue, change sense in taste, impaired cognitive function, impaired fertility, cardiotoxicity (i.e., damage to the heart), urinary and gastro-intestinal problems, and neuropathy (i.e., a nerve condition characterised by pain, numbness, weakness, or tingling, usually in the hands or feet)
Radiotherapy	Pain, fatigue, skin irritation or sensitivity, sexual dysfunction, cardiotoxicity, impaired cognitive function, urinary and gastro-intestinal problems, and second primary cancers
Hormonal therapy	Joint pain, blood clots, menopausal symptoms, sexual dysfunction, weight gain, osteoporosis, cardiotoxicity, and second primary cancers
Immunotherapy	Gastro-intestinal problems, hypertension, immunodeficiency, cardiotoxicity, blood clots, and neurotoxicity (i.e., disruptions to the nervous system).

Psychosocial Sequalae

The experience of physical side-effects described above, paired with the reductions in support offered by healthcare professionals and their social networks can contribute to psychological distress in cancer survivors (Hewitt et al., 2005). An Australian population-based study involving 22,505 cancer survivors reported that 21% had severe physical functioning limitations and these limitations were associated with a higher prevalence of psychological distress (Joshy et al., 2020). Further, both qualitative and quantitative studies of post-treatment cancer survivors' experiences have consistently identified feelings of loss of control over their health, anxiety and fear around the cancer recurring, or their mortality (Buro et al., 2023; Hauken et al., 2013; Jakobsen et al., 2018; Luigjes-Huizer et al., 2022). This distress can be compounded by the reduction of appointments with the oncology team, as cancer survivors report no longer knowing who to seek information from about their health, while simultaneously perceiving the physical side-effects as indicators that cancer has recurred (Deimling et al., 2006). Moreover, cancer survivors may notice changes in their social interactions: they may become less socially engaged due to the lasting effects of cancer treatment; or experience a withdrawal of support from family and friends who may assume that the survivor is fully recovered following the completion of treatment (Buro et al., 2023; Hewitt et al., 2005).

Population studies have indicated that cancer survivors are at higher risk of clinically significant distress than the general population (Ng et al., 2023). However, the estimates of the prevalence of mental health disorders, such as depression, and anxiety, vary widely in the published literature and can depend on how they are assessed (Krebber et al., 2014). A systematic review indicated that, using structured diagnostic interviews, the prevalence of major depressive *disorder* was 9% in survivors within their first-year post-treatment and 8% after the first-year post-treatment (Krebber et al., 2014). More recently, the prevalence of self-reported major depressive *disorder* in long-term (≥ 5 years post-diagnosis) was between 9.7% (Petrova et al., 2021) and 17% (Götze et al., 2020). In comparison, the prevalence of self-reported depressive *symptoms* cancer survivors can range between 5 and 49% (Brandenbarg et al., 2019). A systematic review, including both diagnostic interviews and self-report outcomes, estimated the prevalence of anxiety *disorders* to be 17.9% (Mitchell et al., 2013). In long-term cancer survivors, the prevalence of self-reported anxiety *disorders* is 9% (Götze et al., 2020), while the prevalence of anxiety *symptoms* can range between 3 and 43% in cancer survivors (Brandenbarg et al., 2019). These data indicate the persistent nature of these conditions if left untreated. Comparatively, in Australia, the 12-month prevalence of self-reported major depressive *disorder* and anxiety *disorders* in adults is 4.9% and 17.2% (Australian Bureau of Statistics [ABS] 2023). Thus, the prevalence of these disorders, particularly depression, are higher in cancer. It is important to note that these prevalence estimates do not include Adjustment Disorder, that is a maladaptive emotional or behavioural response to a psychological stressor (American Psychological Association, 2022). While there is no Australian data on the prevalence of Adjustment Disorder, in a similar cancer survivor population in the Netherlands estimated the prevalence was 13.1% (Van Beek et al., 2022). In addition to recognised diagnostic disorders, one unique type of anxiety experienced by cancer survivors is Fear of Cancer Recurrence (FCR), that is, the fear that cancer could return or progress in the same place or another part of the body (Vickberg, 2003). In a systematic review investigating the prevalence of FCR in cancer survivors and patients (Luigjes-Huizer et al., 2022), 20% of cancer survivors scored above a twenty-two on the Fear of Cancer Recurrence Inventory, indicating clinically significant levels (Fardell et al., 2018).

Overall, the experience of both the physical and psychosocial side effects of cancer can have a substantial impact on survivors' Quality of Life (QoL). QoL for cancer survivors is a subjective multi-dimensional concept that encompasses and measures various aspects of a person's physical, emotional, social, and spiritual well-being, and functional status (Cella et al., 1993; Niezgoda & Pater, 1993). It refers to how a person perceives their life in the context of their health and personal values, and how well they can function and participate in activities that are important to them (Ferrell et al., 1995). In a large Australian cohort study, cancer survivors were more likely to report lower physical functioning, self-reported health, and quality of life in comparison to individuals without a cancer history (Joshy et al., 2020). These data coincide with qualitative reports from cancer survivors regarding the physical repercussions of cancer-treatment and the impact of multiple dimensions of QoL (Neris et al., 2020). The experience of physical side-effects can reduce ability to participate in daily activities, such as domestic tasks and employment. Cancer survivors can also experience changes to their sexual functioning, due to erectile dysfunction (Michael et al., 2016) or vaginal dryness (Zeng et al., 2011). Furthermore, gastrointestinal symptoms and urinary incontinence can generate feelings of loss of control (Michael et al., 2016). Cancer survivors' self-image and identity can also be affected by these changes in their physical and sexual functioning, which can be further impacted by visible changes to a person's appearance (e.g., amputation, scarring, and changes in skin texture; Lundberg & Phoosuwan, 2022; Neris et al., 2020; Vogel et al., 2017). In addition, cancer survivors describe social adjustments that need to be made to accommodate the physical demands, such as reducing the frequency of leisure activities, only participating in events where toilets are easily accessible (Michael et al., 2016), or wearing different clothing to hide scars (Anbari et al., 2019). The financial burden of cancer treatment, due to medical costs and absence from employment, is also widely recognised adverse effect that has been associated with reduced QoL (Smith et al., 2022; Ver Hoeve et al., 2021). Therefore, it is important to investigate interventions which promote recovery after cancer treatment and improve QoL.

Improving post-treatment survivorship via lifestyle behaviours

It is well documented that engaging in a healthy lifestyle, including regular physical activity and adequate nutrition, can promote recovery and improve QoL after cancer on multiple fronts (Mohammadi et al., 2013). First, adopting these behaviours can reduce the risk of all cause and cancer-related mortality (Schwedhelm et al., 2016; Spei et al., 2019), cancer recurrence (Miyamoto et al., 2022; van Zutphen et al., 2023; Wesselink et al., 2023; Zagalaz-Anula et al., 2022) and comorbidities, such as diabetes, cardiovascular disease , osteoporosis, and obesity (Kang et al., 2018; Rock et al., 2012). Further, healthy lifestyle behaviours have been shown to mitigate the challenging impacts of cancer and its associated treatments by alleviating side effects and enhancing emotional well-being and fostering a sense of control over one’s health (Burke et al., 2017; Juvet et al., 2017; Lahart et al., 2018).

Adopting these healthy lifestyle behaviours not only improves QoL in cancer survivors but can also play a pivotal role in reducing pressure on the healthcare system. In comparison to the general population, cancer survivors are more likely to have consults general practitioners, specialists, nurses, pharmacists, opticians, and dentists (Ng et al., 2020). They are also more likely to be admitted to hospital as an inpatient, and have visited emergency, an outpatient clinic, or a day clinic (Ng et al., 2020). Furthermore, the presence of comorbidity is associated with a greater likelihood of accessing healthcare services in the cancer population (Ng et al., 2020). Therefore, promoting the engagement in a healthy lifestyle following treatment could be proactive approach to reducing healthcare utilisation by cancer survivors through mitigating the risk of side-effects and other chronic health conditions (Schmitz et al., 2019). Evidence supporting the adoption of various lifestyle behaviours are broadly summarised below, however it is beyond the scope of this chapter to provide a comprehensive / detailed analysis of specific nutrients or subtypes of physical activity.

Physical Activity

Physical activity refers to any bodily movement produced by skeletal muscles that requires energy expenditure and includes movement for leisure, transportation, or work (World Health Organisation [WHO], 2022). Activity types can include: (1) *aerobic*, involving activities that increase your heart rate, such as running, swimming, and cycling; (2) *resistance*, involving activities which strengthen muscles, such as lifting weights, push ups or sit ups, and digging in the garden; and (3) *flexibility and balance*, involving activities that improve range of motion and resist falls, such as stretching, yoga, Pilates, or tai chi (WHO, 2022).

Currently, physical activity is the most widely investigated modifiable lifestyle behaviour for improving outcomes following cancer treatment, via either (a) increasing leisure-time activity (Casla et al., 2014) and/or exercise (a subcategory of physical activity involving planned, structured, and repetitive movements aimed at improving physical fitness; Brown et al., 2021; Caspersen et al., 1985) or (b) reducing sedentary time (waking behaviour characterised by minimal energy expenditure such as sitting or lying down; Blair et al., 2021; Koutoukidis et al., 2019; Tremblay et al., 2017). Cross-sectional and cohort studies have consistently found that cancer survivors who meet the exercise recommendations for the general population (i.e., 150 minutes of moderate to vigorous physical activity (MVPA) per week) report less severe treatment related side effects, such as fatigue (Schmidt et al., 2015), lymphoedema (Brown et al., 2013), and depression (Brunet et al., 2018; Ribeiro et al., 2020), than those who do not meet those recommendations. These findings are further supported by several meta-analyses of randomised control trials of interventions, which have demonstrated small-to-medium positive effects of physical activity on QoL (Aune et al., 2022; Duijts et al., 2011; Sun et al., 2023; Zeng et al., 2014), physical functioning (Juvet et al., 2017; Maike et al., 2018; Swartz et al., 2017), cancer-related fatigue (Brown et al., 2011; Juvet et al., 2017; van Vulpen et al., 2016) and psychological distress (Brown et al., 2012; Lahart et al., 2018; Sun et al., 2023) after completing treatment. Progressive resistance training in particular has been demonstrated as safe and unlikely to produce negative effects for cancer survivors experiencing lymphoedema, however, these studies have primarily focused on breast cancer survivors and there is limited evidence available for other cancer types, such as head and neck, bladder, gynaecological, and prostate cancers (Singh et al., 2016; Wanchai & Armer, 2019).

In contrast, sedentary behaviour has been associated with an increased risk of cardiovascular disease (Hawkes et al., 2011), weight gain (Wijndaele et al., 2009), greater fatigue, and lower physical functioning (Phillips et al., 2015; van Roekel et al., 2016). Reducing sedentary behaviour through light physical activity leads to demonstrated clinically significant benefits in general health, physical functioning, and social functioning in older (≥60 years) cancer survivors (Blair et al., 2021). More intense intervention, through increasing resistance training, has demonstrated improvements in fatigue and physical functioning in breast cancer survivors (Hagstrom et al., 2016).

In sum, the available evidence suggests that reducing sedentary behaviour and engaging in at least 150 minutes of MVPA and resistance training can improve QoL following cancer treatment by reducing the risk of comorbid cardiovascular disease and obesity and treatment related side effects, such as fatigue and psychological distress. There is also some emerging evidence that engaging in resistance training may reduce lymphoedema, however, additional research is required in other types of cancer beyond breast cancer.

Nutrition

Although the role of nutrition in cancer survivorship has not been as thoroughly explored as physical activity, there is growing evidence to support the relationship between dietary intake and the experience of cancer- and treatment-related side effects (Baguley et al., 2019; Barchitta et al., 2020; Hedelin et al., 2019). One systematic review and meta-analysis demonstrated preliminary evidence that dietary interventions which focus on either (a) improving fruit and vegetable intake or (b) prescribing an anti-inflammatory diet, high in fruits, vegetables, nuts, seeds, and fish resulted in a moderate effect on reducing cancer-related fatigue (Baguley et al., 2019). However, this finding was based on a small number of studies. The same systematic review and meta-analysis by did not show an effect of *all* dietary interventions, including increasing protein intake, increasing energy intake (e.g., additional 2500 kilojoules), decreasing energy intake (e.g., a 2090-4180 kilojoule deficit) or the Nordic Nutritional Guidelines (Becker et al., 2004) on cancer-related fatigue.

Outside of fatigue, select studies have explored the effect eating certain diets and food groups has on specific cancer symptoms - such as gastrointestinal toxicities (Hedelin et al., 2019), dyspnoea (i.e., shortness of breath), and insomnia (Barchitta et al., 2020) - stress, and QoL. In a cohort study (Hedelin et al., 2019), gynaecological cancer survivors were asked how often in the last 6 months they consume different foods, including citrus fruits, beans and lentils, cabbage and broccoli, onion and garlic, vegetables, foods with gluten, chocolate, dairy products, spicy food, and food high in fats. Hedelin et al. (2019) found that frequent intake of citrus fruit intake and vegetables decreased defecation-urgency and faecal leakage. In a cross-sectional survey with breast cancer survivors, Barchitta et al. (2020) found that consuming less than one serving of meat per day reduced dyspnoea and drinking less than two servings of carbonated drinks per day reduced dyspnoea and insomnia. Interestingly, consuming three or more fish servings per week was associated with lower emotional functioning and increased side effects and breast symptoms. Similarly, eating three commercial sweets and pastries per week was associated with worse scores on body image and arm symptoms. More recent research found that the anti-inflammatory diet improved perceived stress scores (Long Parma et al., 2022), however, did not find improvements in QoL. In contrast, more recent cross-sectional surveys have found a small, but significant relationship between scores on the Healthy Eating Index, which measures the extent to which an individual follows the Dietary Guidelines for Americans (Barchitta et al., 2020), and social functioning (Pisegna et al., 2021). However, other cross-sectional surveys have shown that the relationship between diet quality and QoL is no longer significant when adjusted for BMI (Orchard et al., 2018).

Overall, the weight of existing literature supports that increasing fruit and vegetable consumption and an anti-inflammatory diet can improve cancer related fatigue and gastrointestinal symptoms. Furthermore, there is some evidence suggesting that reducing the intact of meat, sugar, and carbonated drinks may improve dyspnoea and insomnia. However, there is limited evidence for the impact of diet on QoL and psychological symptoms beyond perceived stress have not been investigated.

Lifestyle recommendations for cancer survivors: The goal vs the reality

In line with these findings, recommendations for adopting a healthy lifestyle after cancer treatment have been outlined by national cancer support organisations in Australia (Cancer Council Australia, 2018; Cancer Australia, 2019; Clinical Oncology Society of Australia, 2020) and internationally (Rock et al., 2022). Specifically, for physical activity, it is recommended that cancer survivors engage in 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity aerobic exercise and two to three resistance exercise sessions per week. For nutrition, it is recommended that cancer survivors consume a diet consisting primarily of vegetables, fruit, legumes, grains, and cereals and limiting red meat, processed food and drinks high in fat, starches, and/or sugars (e.g., processed meats and sugary drinks; Cancer Council Australia, 2019).

However, despite cancer survivors viewing their cancer diagnosis as a ‘teachable moment’ to change their lifestyle (Corbett et al., 2018), many still do not meet the lifestyle guidelines. Reasons for this are multifactorial: First, it is likely that cancer survivors were not engaging in a healthy lifestyle before their diagnosis and therefore, were potentially lacking a good foundation to build upon (Stone et al., 2019). Indeed, in the Australian adult population, 25.8% did not meet the guidelines of 150 minutes of MVPA per week and 73.4% did not meet the guidelines of two sessions of resistance exercise per week, respectively (ABS, 2022). Furthermore, 77% and 90% are not consuming enough fruit or vegetables, respectively (AIHW, 2018). Second, declines in physical activity and weight gain are common throughout survivorship (Eakin et al., 2007; Elder-Robinson et al., 2020). Recent estimates suggest that only 35 to 41% of Australian cancer survivors are currently meeting physical activity recommendations (Gunn et al., 2020; Leach et al., 2023), with physical inactivity more prevalent in rural Australians than their urban counterparts. Furthermore, global trends also indicate that physical activity in the cancer survivor population decreased by 52 minutes during the COVID-19 pandemic (Tabaczynski et al., 2022). Gunn et al. (2020) also investigated eating behaviours and revealed that only 13% of cancer survivors were meeting the recommended vegetable intake and 48% were meeting the recommended fruit intake. Similar estimates have been observed globally: in a systematic review and meta-analysis, Tollosa et al. (2019), reported that adherence to dietary recommendations for red and processed meat, fat, fruit and vegetable, and fibre intake were 47%, 42%, 34%, and 31%, respectively. Clearly then, interventions to improve the adoption of healthy living recommendations are needed.

The evidence for healthy living interventions – in research and in practice

Promisingly, face-to-face interventions have demonstrated efficacy in promoting these health behaviours among cancer survivors (Leach et al., 2019), particularly with respect to physical activity. In an early systematic review and meta-analysis of randomised control trials, Speck, et al. (2010a) reported a small effect of physical activity interventions delivered following cancer treatment on self-reported physical activity levels. A subsequent systematic review and meta-analysis of trials involving only breast cancer survivors by Bluethmann et al. (2015) supported this finding, reporting a medium effect of physical activity interventions with medium to high supervision. With regard to diet interventions, a systematic review by Gan et al. (2022) including six dietary interventions for cancer survivor reported significant improvements in fruit and vegetable intake in five studies. Of these, participants of two interventions maintained these changes at follow up. However, in this review, limited data was available for other dietary behaviours and only one study involving a nurse-led dietary intervention measured intake of wholegrains and did not find a significant effect (Del Valle et al., 2018).

Diet interventions are often combined with exercise interventions. This muti-component approach to interventions has been recommended, as only 28% of cancer survivors are meeting recommendations of multiple health behaviours (Blanchard et al., 2008; Tollosa et al., 2019) . In a systematic review and meta-analysis of these multi-component interventions that address both healthy eating and physical activity, exercise-specialist-led and dietitian-led interventions showed large effects in physical activity and fat-intake, respectively (Amireault et al., 2016). Smaller, but significant treatment effects were observed for behaviours outside the primary expertise of the delivery provider and in nurse- or multi-disciplinary-led interventions. Therefore, while it may result in more modest improvements, both physical activity and diet can be addressed simultaneously within the same intervention.

As touched upon earlier, face-to-face healthy living interventions have demonstrated promising effects on QoL, however, some inconsistencies have been noted in the literature. Specifically, interventions targeting physical activity in all cancer types (Ferrer et al., 2011) and breast cancer survivors (Aune et al., 2022; Duijts et al., 2011; Zeng et al., 2014) have demonstrated small to moderate positive effects on QoL. Similarly, education on physical activity and nutrition delivered to lung cancer survivors' have demonstrated moderate positive effects of QoL (Heredia-Ciuró et al., 2022). In contrast, meta-analyses found that interventions targeting only nutrition or were delivered to gynaecological cancer survivors had no significant effects on QoL in comparison to a usual care control.

Although face-to-face lifestyle interventions have demonstrated efficacy in improving health behaviours and some promising effects on QoL among post-treatment cancer survivors, an evidence-practice gap has emerged, with these programs not routinely implemented in clinical care (Corbett et al., 2018; Lisy et al., 2019). This gap has emerged due to implementation barriers experienced across three levels of cancer survivorship care: (1) Organisational level barriers such as the cost and lack of reimbursement for delivering interventions, no established pathways for managing referrals and follow ups and absence of specialised staff to deliver the intervention (Kennedy et al., 2021); (2) Provider level barriers including limited time, competing priorities, lack of awareness of existing programs, and not self-identifying as the right person to provide advice (Koutoukidis et al., 2018); and (3) Consumer level barriers, such as lack of guidance and support, not understanding the benefits of participating in health programs, low engagement in interventions due to competing priorities and/or high levels of fatigue (Clifford et al., 2018; Corbett et al., 2018). Cancer survivors who live in rural and remote areas of Australia experience additional accessibility barriers, imposed by the time and financial costs of travel (Roberts et al., 2017). Finally, the social distancing restrictions associated with the

COVID-19 pandemic reduced practitioners’ ability to address health concerns and behaviours in face-to-face appointments (Edge et al., 2021). These barriers highlight the importance of developing cost-effective and accessible delivery modalities to increase the reach and availability of health interventions.

Increasing the reach: Evidence supporting the accessible delivery modalities

Telephone

One of the first accessible delivery modalities to be trialled for health interventions was telephone, in which participants engage with a coach or healthcare professional over a series of phone calls to receive health behaviour guidance (Pierce et al., 2002). Telephone delivery has demonstrated strong evidence for improving physical activity, diet, and psychosocial outcomes in the cancer survivor population. Goode et al. (2015) conducted a systematic review including twenty-two telephone delivered healthy living interventions in cancer survivors, of which ten addressed physical activity only, two addressed diet only, and five addressed both physical activity and diet. All the interventions addressing physical activity only found significant improvements at post intervention. As indicated by Cohen’s *d*, two demonstrated a large effect ($d \geq 0.80$), one a moderate effect ($d = 0.50$), and three a small effect ($d = 0.20$). Similarly, all interventions which addressed diet found a significant improvement at post treatment. Cohen’s *d* could only be calculated for one intervention (Pierce et al., 2007), which demonstrated a large effect for vegetable intake and a small effect for fruit intake. Of the five interventions that addressed both physical activity and diet, all found significant improvements in diet at post-intervention, with one also finding improvements in physical activity. Two studies targeted and measured weight loss specifically and found significant improvements at post-intervention (Djuric et al., 2002; Morey et al., 2009).

Healthy Living after Cancer (HLaC)

In the Australian context, the largest and most rigorously developed and evaluated telephone-delivered intervention to date was the 6-month *Healthy Living after Cancer* program (HLaC; Eakin et al., 2015). HLaC offered cancer survivors twelve telephone calls with a cancer nurse to support health behaviour change and addressed goal setting, physical activity, healthy eating, weight loss, and behavioural change maintenance strategies. HLaC was delivered in several states by Cancer Council, an Australian non-government, not-for-profit cancer support organisation, using their existing telephone support infrastructure.

The design of HLaC was grounded in Social Cognitive Theory (SCT), which outlines a core set of determinants that influence how health knowledge is translated into health behaviour change and practice (Bandura, 2004). These core determinants include *knowledge* of the benefits and risks of health behaviours, *perceived self-efficacy* that one can complete health behaviours, *outcome expectations* about the benefits and costs of health behaviours, the health behaviour *goals* that the person has set and the plan for achieving them, and the *perceived facilitators and barriers* for health behaviour change. SCT specifies that perceived self-efficacy is a focal determinant of health behaviour change due to its influence on the other determinants of health behaviour change. Specifically, higher perceived self-efficacy can encourage higher goal setting, view outcomes of health behaviour as more favourable, and promote self-management skills and effort to overcome barriers to the health behaviour. These determinants have a bidirectional relationship, whereby achieving goals, experiencing favourable outcomes, and overcoming barriers can improve one’s self-efficacy. HLaC focuses on improving self-efficacy by providing health behaviour education, promoting positive outcome expectancies, structured goal setting, problem solving to overcome barriers, self-monitoring, and social support. In addition, HLaC was guided by evidence-based behaviour change techniques used in motivational interview and health coaching, including stimulus control, positive self-talk, and self-reward (Emmons & Rollnick, 2001; Michie et al., 2009).

In a pre-post implementation trial, HLaC demonstrated an increase in MVPA by 147.64 minutes per week, a rise in vegetable intake by one serve per day, and improvements in healthy fat and fibre intake behaviours (Eakin et al., 2020). Furthermore, reductions in sitting time by 1.19 hours were observed. Notably, there were also improvements in psychosocial outcomes, including enhancements in physical and mental QoL and reductions in fear of cancer recurrence and distress (Eakin et al., 2020). While HLaC yielded significant clinical benefits to participants, sustainability barriers were encountered (Morris & Kirkbride, 2019). Specifically, the intervention was resource intensive, with Cancer Councils unable to continue providing the program after the trial ceased. Furthermore, feedback from participants suggested that the telephone delivery did not suit all users’ preferences (Morris & Kirkbride, 2019). Some participants experienced challenges specific to the telephone delivery, including difficulties scheduling calls, feeling rushed, and a decrease in motivation when calls shifted from weekly to monthly delivery per the intervention protocol (Morris & Kirkbride, 2019). These findings are not isolated; two studies implementing a telephone-delivered lifestyle intervention in the general population found that 46% of participants withdrew before the end of the intervention period, citing lack of time (Goode et al., 2013; McGill et al., 2018), losing contact with the coach, or dissatisfaction with the scripted telephone calls (McGill et al., 2018). Therefore, other delivery modalities that are cost-effective and offer more flexibility to the participant are needed to be explored to improve sustainability of the program.

Digital health

Digital health has emerged as another promising accessible delivery modality for cancer survivor healthy living programs. The introduction of digital health modalities - including online platforms, mobile phones and applications, and wearable technology - is largely influenced by widespread adoption of the internet and smartphone technology (Schiavo, 2008). The latest estimates suggest that between 86% and 93% of Australian households have access to the internet (Australian Bureau of Statistics, 2018; Australian Communications and Media Authority, 2023). Although there is still a substantial gap in digital inclusion (i.e., our ability to access, pay for, and use digital technologies; Thomas et al., 2023) among our vulnerable populations, including First Nation and older adult Australians, this gap is slowly closing (Thomas et al., 2023).

While several digital health delivery modalities have been trialled in the cancer survivor population, including SMS messaging (Job et al., 2021; Singleton et al., 2023), email (Hatchett et al., 2013; Paxton et al., 2017), mobile applications (Chung et al., 2020; McCarroll et al., 2015), and wearable activity trackers (Gell et al., 2020; Lynch et al., 2019), there is a particular interest in healthy living interventions delivered via online platforms (Williams et al., 2020). Online platforms can promote self-management of health and self-directed behaviour change, as these can be offered with or without the guidance of a healthcare professional (Kuijpers et al., 2016). These modalities enable participants to self-tailor the information they would like to access and can integrate dynamic elements that users can engage with at any time to support the establishment, and achievement, of health-related goals. Unlike mobile applications and wearable activity trackers, online platforms do not require additional downloads or technology, and can be accessed from a computer, tablet, or mobile device. Furthermore, an online platform may meet the preferences of cancer survivors for the intervention delivery (Martin et al., 2016; Leske et al., 2023). More specifically, United States data indicates that a higher proportion of cancer survivors prefer online (28%) to telephone (17%) delivery for lifestyle advice (Martin et, al., 2016). Similarly, cancer survivors residing in Australia prefer online (64.9%) to telephone (23.8%) for the delivery of a healthy lifestyle intervention (Leske et al., 2023). Contrary to popular belief, this preference was not influenced by sociodemographic factors, specifically, age, gender, educational achievement, and socio-economic status (Leske et al., 2023).

Evidence base

One systematic review and meta-analysis has synthesised digital health interventions, including eight web-based physical activity and nutrition interventions (Roberts et al., 2017). However, to date, twenty-one web-based healthy living interventions have been trialled in the post-treatment cancer survivor population (Berg et al., 2014; Demark-Wahnefried et al., 2023; Evans et al., 2021a; Finlay et al., 2020; Forbes et al., 2015; Frensham et al., 2018; Golsteijn et al., 2018; Holtdirk et al., 2021; Kanera et al., 2016; Kenfield et al., 2019; Kuijpers et al., 2016; Lee et al., 2014; Lynch et al., 2017; O'Carroll Bantum et al., 2014; Paxton et al., 2017; Rabin et al., 2011; Rees-Punia et al., 2022; Short et al., 2017; Trinh et al., 2018; Valle & Tate, 2017; van de Wiel et al., 2021; Williams et al., 2022). Notably, all the interventions addressed physical activity, while only nine targeted diet (Berg et al., 2014; Demark-

Wahnefried et al., 2023; Frensham et al., 2018; Holtdirk et al., 2021; Kanera et al., 2016; Kenfield et al., 2019; Lynch et al., 2017; O'Carroll Bantum et al., 2014; Williams et al., 2022).

Physical activity outcomes. In terms of physical activity outcomes, seven interventions demonstrated significant increases in self-reported MVPA (Demark-Wahnefried et al., 2023; Evans et al., 2021a; Golsteijn et al., 2018; Kuijpers et al., 2016; Lee et al., 2014; O'Carroll Bantum et al., 2014; Trinh et al., 2018; Williams et al., 2022). Interestingly, while Williams et al. (2022) found that their *SurvivorSHINE* intervention significantly improved subjective self-reported MVPA, these increases were not observed in objective accelerometer data. While not significant, trends for improved physical activity emerged for an additional two interventions (Kanera et al., 2016; Rees-Punia et al., 2022). While Rabin et al. (2011) did not find an increase in minutes spent engaging in MVPA, the online version of *Step into Motion* had a higher proportion of participants (37.5%) meeting physical activity recommendations following the intervention period in comparison to a usual care control condition (10%). Short et al. (2017) investigated three different delivery schedules for an online version of *Move More for Life* (i.e., single module, three modules released over three weeks, or three modules released over three months), with all three demonstrating improvements in aerobic and resistance activity and no significant differences between groups. Three interventions did not measure physical activity as an outcome.

Nutrition outcomes. Of the nine web-based interventions that also addressed nutrition, five demonstrated small improvements in diet quality (Demark-Wahnefried et al., 2023; Holtdirk et al., 2021; Kenfield et al., 2019; Lee et al., 2014; O'Carroll Bantum et al., 2014). The *Kanker Nazorg Wijer* (Cancer Aftercare Guide) led to improved fruit and fish consumption in participants who accessed the diet module (Kanera et al., 2016). In contrast, *SurvivorSHINE* did not find any differences in diet outcomes (Williams et al., 2022). Interestingly, while targeting physical activity and nutrition within the *intervention*, three of the studies did not measure physical activity or diet quality as an *outcome* (Berg et al., 2014; Frensham et al., 2018; Lynch et al., 2017).

Psychosocial outcomes. Of note, while not explicitly targeted within the intervention, ten of twenty-one studies measured psychosocial outcomes, with mixed improvements in QoL, fatigue, insomnia, and distress (Forbes et al., 2015; Golsteijn et al., 2018; Holtdirk et al., 2021; Kuijpers et al., 2016; Lee et al., 2014; Trinh et al., 2018; van de Wiel et al., 2021). Specifically, QoL was measured in nine of the studies: Holtdirk et al., (2021) demonstrated improvements in overall QoL, as well as physical and psychological subscale. Two studies only found significant improvements on subscales relevant to emotional functioning (Forbes et al., 2015; Trinh et al., 2018), however, these changes were not clincially significant. Kuijpers et al. (2016) measured QoL, with significant improvements found in role functioning, mental health, and social functioning subscales. In contrast, Lee et al. (2014) only demonstrated significant differences on the physical functioning subscales and van de Wiel et al. (2021) only found significant improvements on the bodily pain scale. One study did not find significant effects on any QoL scales (Golsteijn et al., 2018).

With respect to other psychosocial outcomes, eight studies measured fatigue (Forbes et al., 2015; Golsteijn et al., 2018; Holtdirk et al., 2021; Lee et al., 2014; O'Connor et al., 2018; Rabin et al., 2011; Trinh et al., 2018; van de Wiel et al., 2021) of which only two found significant improvements (Golsteijn et al., 2018; Holtdirk et al., 2021). Insomnia was measured in two studies, both of which found a small positive effect of the online healthy lifestyle intervention (Holtdirk et al., 2021; O'Connor et al., 2018). Mood or distress was measured in five studies (Holtdirk et al., 2021; Lee et al., 2014; O'Connor et al., 2018; Rabin et al., 2011; van de Wiel et al., 2021). Rabin et al. (2011) was the only study to find a significant effect and revealed a 25.86 point decrease in the Profile of Mood States following the online version of *Step into Motion*.

In sum, digital delivery of healthy living programs holds promise, with evidence to suggest it improves MVPA, resistance activity, diet quality, fruit and fish consumption, and insomnia. However, this must be balanced against the mixed evidence for the effect of such interventions on QoL and a lack of evidence to date for other dietary outcomes, fatigue, mood, and distress. Exploring the factors that may explain the variance in these outcomes is therefore important.

The impact of engagement on digital health outcomes

The mixed evidence produced by these online healthy living interventions on health behaviours and psychosocial outcomes may be partially the result of varied levels user uptake and engagement with the program (O'Connor et al., 2016; Seiler et al., 2017). Trinh et al. (2018) reported a high adherence rate, with 72% logging in three times per week. Short et al. (2017) had a low post-intervention retention rate of 32%, however all participants accessed at least one module. Similarly, Rees-Punia et al. (2022) also reported 82.9% of their participants logged in at least once. In contrast, lower usage rates were reported by Forbes et al. (2015), and van de Wiel et al. (2021). More specifically, Forbes et al. (2015) found that 67% viewed the modules at least once; while van de Wiel et al. (2021) reported that 53.2% of their participants, irrespective of whether in the self-directed or healthcare professional supported conditions, never logged in.

Findings from systematic reviews suggest that engagement with digital health interventions depend on factors relating to the individual (e.g., demographics, and cognitive factors), their environment (e.g., internet access), and the characteristics of an intervention (e.g., participants expectancies of whether the program will help them, and perceived treatment credibility; Beatty & Binnion, 2016; Ritterband et al., 2009). Therefore, these factors need to be considered in the design of an online intervention to promote user usage and engagement.

Optimising interventions via codesign

One approach to intervention development that may address these factors and enhance user engagement is co-design (Burkett, 2012). Co-design involves end-users at each stage of intervention development, resulting in an intervention that is both sensitive to consumer's specific needs and preferences. Furthermore, co-design follows best-practice principles for consumer-led development and evaluation of interventions (National Health and Medical Research Council, 2018; National Institute for Health and Care Excellence, 2016; Skivington et al., 2021). Meaningful engagement with stakeholders (i.e., those involved in the development, or delivery, or those who are targeted or affected by the intervention) is one of the core elements of the United Kingdom's Medical Research Council's (MRC) framework for developing and evaluating complex interventions (Skivington et al., 2021). The MRC framework encourages the consideration of stakeholder engagement and the other five core elements – considering context, developing and testing program theory, identifying key uncertainties, intervention refinement, and economic considerations –

at each of the four phases of intervention research: development and identification of the intervention, feasibility testing, evaluation, and implementation. Engagement with stakeholders is arguably the most important core element of the MRC framework, as their feedback can help to inform the other core elements. Specifically, stakeholders from the organisation intending to deliver the intervention and the target population can provide insight into how the intervention might interact with the *context* it is delivered in based on their previous experiences and expertise (e.g., how could the intervention fit and be effective within the current physical, organisational, political, social, cultural, and economic settings). Similarly, these stakeholders can provide suggestions on how interventions can be *refined*, based on what they have previously implemented or participated in that has shown to be effective. The framework recommends that stakeholders also contribute to the *program theory* to promote shared understanding of how the intervention mechanisms and how these are expected to lead to positive outcomes. Stakeholders can help to determine which of the *key uncertainties,* that is the unanswered questions at each phase, are the most important to answer, guiding appropriate research questions. Finally, stakeholders with economic expertise or who are organisation decision makers can contribute to the *economic considerations* of the intervention by identifying which costs and benefits need to be assessed for the intervention feasibility. Overall, engaging with various types of stakeholders can not only inform intervention content, but provide guidance on how it should be evaluated to ensure ongoing implementation following its development.

Co-design frameworks

There are several co-design frameworks available to guide the collaboration with stakeholders to ensure that the resultant intervention is practical and relevant for all end-users. Five of the commonly used frameworks for the design of digital health interventions include Experienced Based Co-design, the Double Diamond Design Process, the Person-Based approach, The Centre of eHealth and Well-being Research Roadmap, and the Stanford University's Design Thinking Process. A summary each of these frameworks is provided below.

Experienced Based Co-design

Primarily used to improve healthcare service delivery, Experienced Based Co-design is empathy driven and aims to create practical solutions to healthcare based on consumers actual experiences. Using qualitative methods, such as interviews and storytelling, Experienced Based Co-design captures human experiences during their interactions with services and identifies key emotional or practical challenges – known as touchpoints (Bate & Robert, 2006). Workshops with various stakeholders, including consumers and service providers, are then held co-create solutions to address these touchpoints. While this co-design framework is described as iterative, it does not define distinct phases. In digital health intervention development, Experienced Based Co-design has been used in conjunction with the MRC Framework to design a mobile application addressing lifestyle changes in Australians with obesity (Song et al., 2021). The resulting four phased approach used by Song et al. (2021) included: (1) Understanding user's needs, involving discussion with a multidisciplinary panel of medical and health information system experts; (2) Identification of applicable underlying theory through literature review; (3) Integrating theory into the prototype design and development; and (4) Evaluating and refining prototype of mobile application using focus group discussions with people with obesity.

Person Based approach

The Person Based approach was designed to complement theory- and evidence-based approaches to intervention development by using in-depth qualitative methods to inform *how* best to implement evidence-based behaviour change techniques to the intended population using the intervention (Yardley et al., 2015). Qualitative methods are used to engage stakeholders in three stages of intervention development and evaluation. These stages are: (1) intervention planning; (2) intervention design; and (3) intervention development and the evaluation of intervention acceptability and feasibility. During the intervention planning stage, interviews and focus groups can be used elicit user views on the planned intervention and the possible behaviour change techniques. Themes arising from the planning stage are used in the intervention design stage to inform the intervention objectives (i.e., what the intervention aims to achieve) and shape the key features of the intervention intended to achieve those objectives. Finally, during the intervention development and the evaluation of intervention acceptability and feasibility, a prototype of the intervention is developed and provided to their target population. Their feedback is gathered on the interventions ease of use, persuasiveness, and overall interest in the intervention. Think-aloud protocols, whereby participants verbalise their thoughts and decision-making process as they use the intervention, are recommended by Yardley et al. (2015) to understand how the intervention might be used and people’s immediate reactions. Changes are then made to the intervention based on the users’ feedback and further interviews are conducted to ensure the changes are suitable.

Double Diamond Design Process

The Double Diamond Design Process offers a structured, four phased approach to the development of an intervention (Design Council UK, 2019). The four phases are divided into two ‘diamonds’ that represent first exploring a wide range of ideas, possibilities, and/or solutions (i.e., divergent thinking) and then narrowing down those options into viable solutions (i.e., convergent thinking). The first diamond includes the Discover and Define phases. The Discover phase involves exploring and understanding the ‘problem’ by engaging with target end-users and healthcare professionals and/or literature review. Following, the Define phase aims to synthesise the information to clearly define the problem that the intervention will address. The second diamond includes the Develop and Deliver phases. The Develop phase involves generating potential solutions and developing a prototype of the intervention and iterating based on feedback from end-users. The last phase, Deliver, involves pilot testing the intervention and adjusting the intervention based on user feedback before the final intervention is implemented in its intending setting.

The Centre of eHealth and Well-being Research Roadmap

The Centre of eHealth and Well-being Research Roadmap is a guideline specifically for the development, implementation, and evaluation of digital health interventions (van Gemert-Pijnen et al., 2011). This roadmap includes five intertwined phases, including: (1) Contextual enquiry, where the design team gathers the perspective of users on how technology can be used within their day-to-day life; (2) Value specification, which translates the values, needs, and wishes of users into intervention requirements; (3) Design, in which a prototype of the intervention is developed based on the requirements in collaboration with end-users; (4)

Operationalisation, where the intervention is launched within the intended organisation; and (5) Summative evaluation, involving a comprehensive assessment of the intervention's effectiveness.

The Stanford University's Design Thinking Process

The Stanford University's Design Thinking Process is a human centred, iterative approach to intervention development (Roberts et al., 2016; Woods et al., 2017). This process consists of five phases of end-user engagement. The first phase, Empathise, involves gaining an understand users' needs and what is meaningful and important to them. Next, the Define phase, involves synthesising what was learned from the previous phase into an actionable statement of what problem needs to be addressed in the intervention. Then, the Ideate phase concentrates on the idea generation of source material for the intervention. That is, potential intervention content and behaviour change techniques used. Following, the Prototype phase involves developing a basic black and white visualisation of the program, known as a wireframe. The wireframe is presented to end-users for their feedback and insights into the content and layout of the intervention. Their feedback is integrated into a more refined prototype. The final phase, Test, is when the refined prototype is provided to end-users to evaluate its feasibility and effectiveness. The prototype continues to be refined by end-user feedback.

Unpacking the similarities and differences in co-design frameworks

Each of the frameworks described above involve an iterative approach to inform the development of interventions, whereby end-user feedback is continuously gathered and integrated into the intervention design. Overall, the six common steps can include: (1) a review of background evidence; (2) gathering end-user perspectives of their needs; (3) idea generation of possible solutions to address these needs; (4) designing a prototype, including potential intervention content, framing, and behaviour change techniques; (5) acceptability and feasibility testing of the intervention; (6) implementing the intervention into its intended service. Where these frameworks differ is in their emphasis on user experience and their structure. Specifically, Experienced Based Co-design and the Person Based approach focus primarily on the experience of end-users' day-to-day life and technology and adapt digital health interventions accordingly. By encouraging end-users to draw on understanding from their own experience, these approaches derive solutions that are sensitive to the 'real world' context in which the target population will be using the digital health intervention in, therefore, ensuring that the interventions are engaging and feasible (Yardley et al., 2015). However, these approaches can include several time consuming iterations before prototyping, which can impact retaining the interest of stakeholders if they are expecting tangible outcomes (Raynor et al., 2020). In comparison, the Double Diamond Design Process, the Centre of eHealth and Well-being Research Roadmap, the Stanford University's Design Thinking Process offer a more structured co-design approach with a systematic exploration of users' needs, rapid prototyping, and testing of ideas (Roberts et al., 2016). While these more structured approaches can differ in their creative exploration of the users lived experience, these frameworks provide clearly defined steps for co-design, reducing the risk of unnecessary iterations and allows for easier tracking of project progress (Kochanowska et al., 2022). This structure is especially beneficial when working with funding organisations that require regular updates on the project outcomes. Overall, these approaches are well-suited to co-designing a digital health intervention.

Selecting an appropriate framework depends on the complexity of the project and the wider context of the project (i.e., organisational and funding requirements).

This thesis will follow the Stanford University's Design Thinking Process as described by Woods et al. (2017). As that this project will focus on co-designing the adaption of an established evidence-based intervention, a structured approach is appropriate. The Stanford University's Design Thinking Process, while a structured approach, still emphasises empathy through the first phase of co-design, where the aim is to understand the user's everyday life. Furthermore, it is more flexible than the Double Diamond Design Process and the Centre of eHealth and Well-being Research Roadmap, as phases can be revisited, and rapid adjustments can be made and tested with prototypes to ensure that the intervention meets users' needs.

Digital health interventions using co-design

Of the digital health interventions described earlier in the chapter, only one involved end-users (i.e., cancer survivors) during the intervention development of *SurvivorSHINE* (Williams et al., 2022). However, this involvement was limited. While Williams et al. (2022) utilised co-design to gather feedback on the specific *design* features of the website to enhance website uptake and usage, cancer survivors were not involved in the *content* development of the website. Furthermore, the authors did not gather perspectives from other end-users, such as health care professionals or organisational representatives, who may be able to provide additional recommendations on content delivery and program sustainability (Grant et al., 2021; Hoekstra et al., 2021; Whelan et al., 2017).

Summary, evidence gaps, and future directions

As has been demonstrated in this chapter, a cancer diagnosis and its associated treatments can have a profound impact on an individual's physical, functional, emotional, and social well-being (Fong et al., 2012; Rock et al., 2012). This impact is particularly salient at the post-treatment phase of survivorship as individuals may continue to experience the side effects of treatment, high levels of distress, and changes to their support networks and social relationships (Buro et al., 2023; Hauken et al., 2013; Jakobsen et al., 2018; Luigjes-Huizer et al., 2022). Traditional face-to-face healthy living interventions have demonstrated meta-analytic evidence of efficacy in improving health behaviours (Bluethmann et al., 2015; Gan et al., 2022) and may improve QoL after completing treatment (Aune et al., 2022; Duijts et al., 2011). However, an evidence-practice gap has emerged whereby these interventions are not routinely offered at the completion of treatment. Although the Australian Healthy Living after Cancer (HLaC) program attempted to address this issue via embedding an accessible and efficacious telephone-delivered lifestyle intervention for post-treatment cancer survivors within Cancer Council infrastructure, the intervention was not sustainable due to the costs and resources required to continue the intervention and the lack of flexibility offered to the participants (Eakin et al., 2020; Morris & Kirkbride, 2019). Therefore, delivery modalities that offer comparable accessibility as the telephone at a lower cost and with more flexibility for participants need to be explored, to enhance the long-term sustainability of the intervention. Online-platforms are one such delivery modality that can facilitate the accessibility of healthy living interventions which require minimal funding following their development and can be accessible at any time (Kuijpers et al., 2016). Furthermore, this modality offers the ability to develop complex interventions that address multiple areas of health behaviour change, including physical activity, healthy eating, mental health, and other psychosocial challenges associated with the completion of treatment (Kuijpers et al., 2016). Thus, translating the current HLaC intervention into an online format has the potential to overcome geographical barriers, enhance sustainability by requiring minimal financing and resources following its development, and improve participant experience by meeting the needs and preferences of cancer survivors.

Psychosocial aspects of healthy living

As summarised earlier, cancer survivorship includes a substantive and enduring psychosocial impact (Lisy et al., 2019). Yet while psychosocial variables are often measured as *outcomes* of healthy living programs, few have explored these as targets for intervention *within* the programs (Holtdirk et al., 2021; Kanera et al., 2016). This is warranted, given that focus groups and interviews with cancer survivors and healthcare professionals identified that “healthy living” is more than just physical activity, nutrition, and weight management, but also encompasses mental health and adjustment to the ‘new normal’ after cancer treatment (Grant et al., 2021). Indeed, Australian cancer survivors want holistic programs that reflect this definition by also incorporating mental health, adjustment to the new normal, fatigue management and peer support (Grant et al., 2021). This expansion of healthy living programs to include mental health is therefore a critical avenue for future research, given that one systematic review suggests the most prevalent unmet needs in cancer survivors are in the psychological domain, including help with fear of cancer recurrence, coping with uncertainty, and reducing stress (Lisy et al., 2019). Taking a multifactorial approach has also been recommended by other cancer survivors internationally. A recent survey investigating the correlates of cancer survivors identified that the key barriers to physical activity is lack of energy and this needs to be addressed in interventions (Aumaitre et al., 2024). Furthermore, a recent network meta-analysis demonstrated that psychosocial interventions, including mindfulness, psycho-education, and psychotherapy, produced a greater effect on QoL than physical activity and healthy eating interventions (Yeganeh et al., 2024). However, there is limited information about what the combined effect might be for addressing all three components (i.e., psychosocial, physical, and nutrition) within the same intervention.

To address these gaps, co-designing and evaluating a multicomponent online program, which addresses psychosocial as well as physical aspects of healthy living after cancer, is warranted and thus the focus of this dissertation. The co-design process will involve amalgamating the available literature on ‘what works’ with the perspectives from relevant stakeholders (end-users, website developers, and experts in digital health), to ensure that any resulting intervention not only addresses needs and preferences but is grounded by evidence-based behaviour change strategies. Therefore, the first step of this co-design process is to update the evidence for healthy living interventions impact on QoL after cancer treatment and determine the empirical support available for alternative deliveries to face-to-face and for multicomponent interventions, specifically those which also address mental health. This review is presented in the next chapter.

Chapter 2.

A meta-analysis of healthy lifestyle interventions addressing quality of life of cancer survivors in the post-treatment phase.[1]

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[1] Findings from this chapter have been published and can be found in **Appendix A**

Leske, M., Galanis, C., Koczwara, B., & Beatty, L. (2024). A meta-analysis of healthy lifestyle interventions addressing quality of life of cancer survivors in the post treatment phase. *Journal of Cancer Survivorship*. https://doi.org/10.1007/s11764-023-01514-x

Author contributions

Morgan Leske contributed 60%, 75%, and 70%, Lisa Beatty contributed 30%, 0%, 15%, Bogda Koczwara contributed 10%, 0%, 10% and Christina Galanis contributed 0%, 25%, and 5% to the research design, data collection and analysis, and writing and editing, respectively.

Abstract

Introduction: Prior meta-analyses have demonstrated the positive effect of participating in a healthy lifestyle intervention on the Quality of Life (QoL) of cancer survivors in the post-treatment phase. The current meta-analysis aims to update and extend of these findings by investigating the moderating effect of key intervention characteristics, namely the inclusion of a mental health component, mode of intervention delivery, and intervention duration.

Method: Included papers were randomized control trials of health behaviour interventions for adult cancer survivors who completed active treatment, with a usual care or waitlist control, and measured QoL. Meta-analyses were conducted to quantify the effects of interventions vs controls on total QoL, physical well-being, emotional well-being, and social wellbeing. Subgroup analyses compared interventions with vs without a mental health component, different modes of delivery (i.e., individual or group face-to-face sessions, digital health, telehealth, or print), and duration (≤12 vs ≥13weeks).

Results: After screening, 88 papers evaluating 110 interventions were included. 66 effect sizes comparing the effect of healthy lifestyle interventions to the control were extracted and 22 papers were narratively synthesised. The pooled effect size demonstrated a small, significant effect of healthy lifestyle interventions in comparison to control for all QoL outcomes (total $g = 0.32$, $p >.001$; physical $g = 0.19$, $p = 0.05$; emotional $g = 0.20$, $p >.001$; social $g = 0.18$, $p = 0.01$). There was no significant difference between interventions with vs without a mental health component. Face-to-face delivered interventions were associated with greater total QoL, and physical well-being compared to other modalities. Interventions delivered

≤12 weeks were associated with greater physical well-being than those delivered ≥13 weeks.

Conclusion: Participating in a healthy lifestyle intervention following cancer treatment improves QoL. Few trials addressed mental health or evaluated online or telephone modalities; future research should develop and evaluate interventions that utilise these features. Brief healthy lifestyle interventions can be recommended for cancer survivors, particularly those interested in improving physical well-being.

Introduction

As noted in **Chapter 1**, healthy lifestyle interventions addressing physical activity, nutrition, and/or weight management have been posited as one strategy to improve QoL and support cancer survivors following the completion of treatment. Such interventions have demonstrated efficacy in (a) improving health behaviours (physical activity and nutrition) (physical activity and nutrition; Amireault et al., 2016); (b) reducing treatment related side effects, cancer recurrence and mortality (Castro-Espin & Agudo, 2022), and (b) improving emotional well-being (Duijts et al., 2011). While several meta-analyses have also evaluated the efficacy of healthy lifestyle interventions in enhancing QoL in cancer survivors, their results have been inconsistent. Small to moderate positive effects on QoL have been demonstrated across meta-analyses involving physical activity interventions involving all cancer types (Ferrer et al., 2011) and breast cancer survivors (Aune et al., 2022; Duijts et al., 2011; Zeng et al., 2014). Similarly, healthy lifestyle education programs have demonstrated a moderate positive effect on lung cancer survivors QoL (Heredia-Ciuró et al., 2022). In contrast, meta-analyses which have investigated healthy lifestyle interventions for gynaecological cancers (Smits et al., 2015) or have only involved nutritional therapy (Baguley et al., 2019) have not demonstrated significant differences to usual care control groups. Two meta-analyses investigating telehealth interventions (Larson et al., 2020; Li et al., 2021), such as those delivered via telephone, videoconferencing, or online platforms, have produced contrasting findings. Larson and colleagues conducted a meta-analysis involving eleven studies and initially obtained a large positive effect; however, the magnitude of the effect was decreased to non-significance when two large studies contributing to heterogeneity were removed. In comparison, the second, and larger, meta-analysis by Li and colleagues involving twenty-eight studies found a small positive effect for telehealth interventions on cancer survivors' QoL.

Although these meta-analyses support the implementation of healthy lifestyle interventions following cancer treatment, they have been limited by focussing on single tumour types (e.g., breast, lung, gynaecological), single delivery modalities (e.g., telehealth only), or single physical health behaviours, such as increasing physical activity, or dietary changes. As explored in **Chapter 1**, qualitative studies with cancer survivors found that they view health as holistic, including both physical and mental health (Grant et al., 2021). Thus, interventions targeting healthy living after cancer treatment should go beyond physical activity and nutrition and address mental health as well. To date, meta-analyses have not examined whether interventions that include a mental health component increase the impact of healthy lifestyle interventions on cancer survivors' QoL. The current meta-analysis addressed the first aim of this thesis by: (a) updating the previous evidence for the efficacy of healthy lifestyle interventions on QoL, and (b) investigating whether interventions which include a mental health component in their intervention protocol are associated with greater effects on QoL in comparison to interventions which only address physical activity or nutrition. A secondary aim of this meta-analysis was to investigate whether other aspects of the intervention, such as mode of delivery (individual, group, telephone, online, or print) or duration (shorter vs longer) affect the association between the interventions and QoL.

Method

This meta-analysis followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Moher et al., 2009) and was prospectively registered on PROSPERO (CRD42021273722).

Study Selection

To identify relevant studies, a review of electronic databases relevant to psychology and health, including PsycINFO, Scopus, Medline, and CINAHL was conducted. In addition, the first 200 references identified in Google scholar, were included in the review. The search strategy was based on the PICO approach, as follows: *population*: terms related to (1) cancer, and (2) survivor; *intervention*: terms related to (1) healthy lifestyle, (2) physical activity, (3) nutrition and (4) weight control; *outcome*: terms related to quality of life (see **Appendix B** for details). The final database search was conducted on the 9th of June 2022.

Papers were included in the analysis if they meet the following criteria: (1) involved adult cancer survivors (i.e., ≥18 years and have completed active treatment); (2) offered an intervention targeting health behaviour change (i.e., physical activity, or diet, or weight management); (3) Reported an outcome measure for total Quality of Life, and/or Physical, Emotional, or Social Well-being on a reliable and valid measure of Quality of Life (i.e., European Organization for the Research and Treatment of Cancer Quality of Life Questionnaire (EORTC QLQ-C30; Niezgoda & Pater, 1993), Functional Assessment of Cancer Therapy - General (FACT-G; Cella et al., 1993), or 12- or 36-Item Short Form Health Survey (SF-12; Ware et al., 1996; SF-36; Ware & Sherbourne, 1992); (4) involved a randomised control trial using a waitlist or usual care control (i.e., access to publicly available materials); (5) written in English and published in a peer-reviewed journal. Papers were excluded if they involved a population other than adult cancer survivors, did not offer a healthy living intervention addressing physical activity, diet and/or weight management, did not measure quality of life, or utilised any of the following designs: pre-post, qualitative, cross-sectional design, protocol paper, systematic review, or meta-analysis. Papers were also excluded if they were grey literature (e.g., dissertations or conference papers).

The PhD candidate and a research assistant (CG) conducted preliminary screening of titles and abstracts. Abstracts meeting inclusion criteria were subject to full-text evaluation. Disagreement between the two reviewers were resolved through discussion. If consensus was not achieved a third investigator (LB) was consulted.

Data extraction

Data extracted from papers that met inclusion criteria included study characteristics (e.g., author, year of publication, country intervention was delivered), participant characteristics (e.g., gender, age, cancer type, and time since diagnosis), intervention characteristics (i.e., duration, mode of delivery, and behaviours targeted) and outcome measures. To calculate effect sizes between the intervention and control groups, the post-treatment sample size and means and standard deviations for total QoL were extracted. As several QoL measures do not quantify a total score, the subscales relevant for Physical, Emotional, and Social Well-being in both the intervention and control groups were also extracted. These subscales were selected as they were present in all valid QoL scales. For inter-rater reliability, the PhD candidate and research assistant undertook data extraction on a subset of papers (n = 58).

Quality Assessment

The risk of bias of each study was evaluated using the Cochrane Risk of Bias tool 2.0 (RoB 2; Sterne et al., 2019). This tool evaluates the risk of bias in five domains: (1) the randomisation process, (2) deviations from intended interventions, (3) missing outcome data, (4) measurement of outcome, and (5) selection of the reported result. As the current meta-analysis was summarising self-reported Quality of Life, domain 4: measurement of outcome, was not considered in the evaluation of risk. Using this tool, the papers were evaluated and judged on the domains as being either low risk of bias, some concerns or high risk of bias. For overall bias, papers were considered to have low risk of bias if they were rated as low risk of bias on each of the domains and high risk of bias if they were rated as having high risk of bias on at least one of the domains or as having some concerns on at least two of the domains.

Data analysis

The Comprehensive Meta-Analysis computer package (Borenstein et al., 2014) was used for all analyses. Standardised mean differences between the intervention and control groups with 95% confidence intervals were calculated for the total QoL and each of the QoL subscales. Hedge's *g* was utilised to achieve the standardisation of effect sizes, as it corrects for bias in small samples, a common feature of the included studies. Effect sizes were pooled using a random effects model to derive the overall effect size of healthy living interventions on QoL for cancer survivors. Following this, three pre-specified subgroup analyses were conducted to investigate whether the efficacy of healthy living interventions on QoL was influenced by selected intervention components. The first subgroup analysis interventions were categorised based on the inclusion of a mental health component. The second sub-group analysis separated interventions based on their dominant mode of delivery, such as individual face-to-face, groups, telehealth, digital health, or print. As there were interventions where one delivery was not dominant, a multiple category was included. The final pre-specified sub-group analysis investigated interventions which had a shorter duration (i.e., 12 weeks or less) or a longer duration (i.e., 13 weeks or more). Narrative synthesis was used to summarise findings in studies which could not be included in the meta-analysis. The narrative synthesis focused on the efficacy of the healthy lifestyle intervention in comparison to the usual care control, and the potential impact the intervention characteristics of the inclusion of a mental health component, the mode of intervention delivery, and intervention duration.

Heterogeneity and Publication Bias

The heterogeneity of the data was assessed using Q and I^2 statistics. A significant Q test result indicates the presence of heterogeneity, while the I^2 statistic represents the proportion of total variation between studies that results from heterogeneity rather than random sampling error (Higgins et al., 2003). The I^2 scale ranges from 0% (no heterogeneity) to 100% (high heterogeneity). According to Cochrane's guide to interpretation of the I^2 statistic, 0 - 40% represents heterogeneity that might not be important, 30 – 60% may represent moderate heterogeneity, 50 – 90% may represent substantial heterogeneity, and 75 – 100% may represent considerable heterogeneity. To interpret the I^2 statistic, the number of studies included, magnitude and direction of the effect, and the Q statistic were taken into consideration. In accordance with Cuijpers (2016) recommendations, sources of heterogeneity were explored by conducting sub-group analyses. This approach involves dividing the studies into two or more subgroups and calculating the Q and I^2 statistics for each subgroup.

Due to the high levels of heterogeneity found, three additional subgroups were created for post hoc analyses, to explore potential sources of heterogeneity. The first sub-group analysis involved categorising interventions based on whether the addressed one health behaviour or multiple health behaviours. Interventions which utilised less frequent delivery modalities (i.e., print) were excluded from the subgroup analysis. The second subgroup analysis divided interventions based on the scale used to measure QoL. To ensure relatively equal groups for this subgroup analysis, the groups related to the measurement system, rather than individual measures. For example, those who included the FACT-Breast, FACT-Colorectal, and FACT-General were grouped under FACT and the SF12 and SF-36 were grouped under SF. Measures which were only used by one study were excluded from this analysis. The final subgroup analysis investigated as a source of heterogeneity was the type of outcome, whereby interventions were divided into those which measured QoL as their primary outcome or secondary outcome. This subgroup analysis was selected as it may represent which studies were adequately powered to find an effect of the health interventions on cancer survivors QoL. Publication bias was evaluated by Egger's regression intercept which examines the correlation between effect sizes and standard errors of effect sizes. If there is a significant association between study effect size and study precision, this indicates the possibility of publication bias. Each QoL outcome was considered separately.

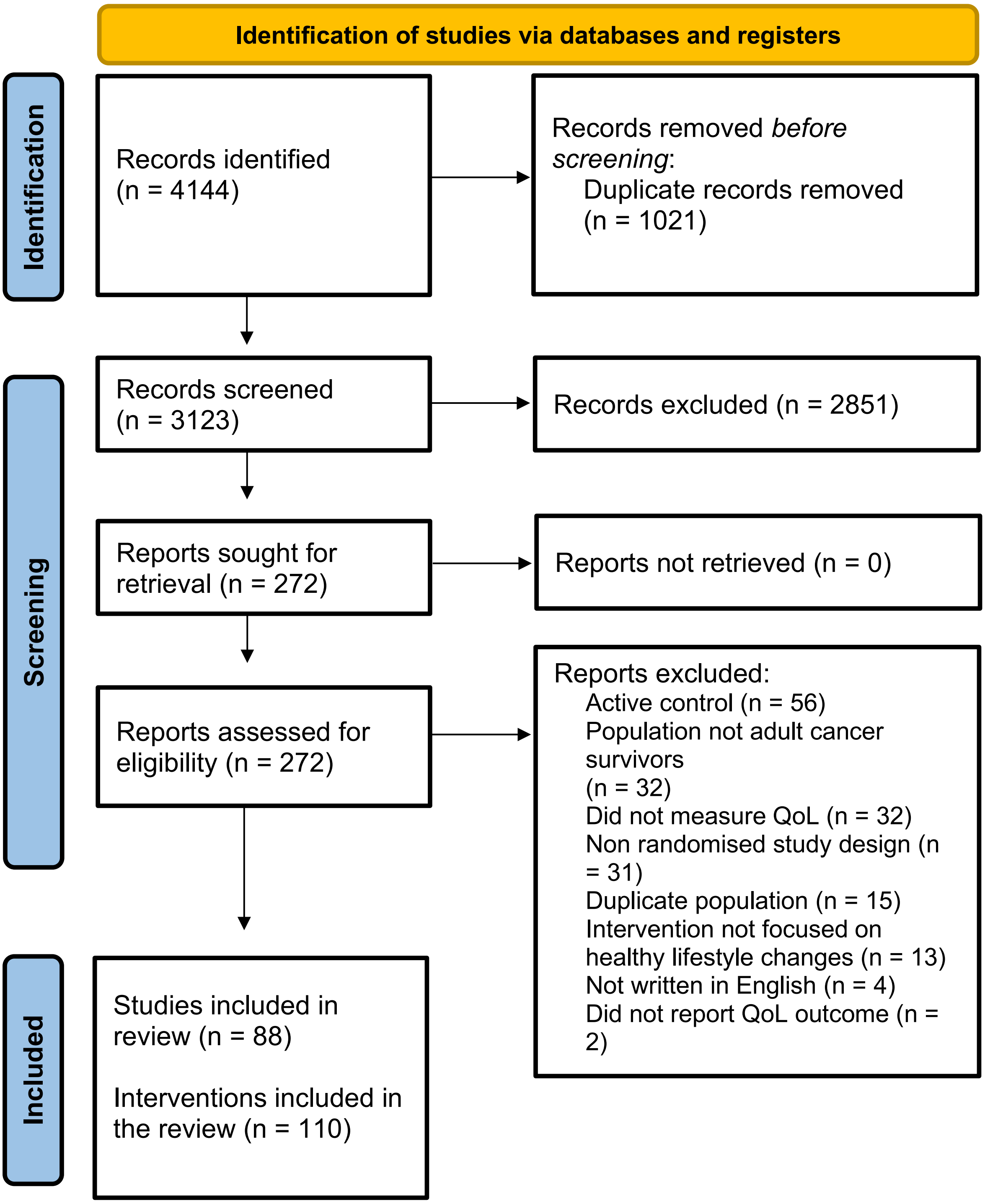
Results

Study Selection

Figure 2.1 presents the PRISMA flow diagram of the study selection process. An electronic database search yielded a total of 4,144 citations, 1021 of which were duplicates and subsequently removed. 3123 title and abstracts were screened, with 2851 excluded. The remaining 272 full text papers were obtained and reviewed, of which 181 were excluded. Papers were most commonly excluded due to the use of an active control (e.g., workbook or frequent telephone calls). Following screening 88 papers involving 110 interventions met inclusion criteria for the systematic review and 66 papers met criteria for meta-analysis. The predominant reason for excluding papers from the meta-analysis was the reporting of change over time instead of post treatment means and standard deviations. The agreement rate between reviewers was 91.5% for title and abstract screening, 77.4% for full text screening and 66% for data extraction. Exacting different total scores for QoL when multiple scales were reported (e.g., SF-36 and FACT-G) accounted for 73% of the differences in the data extraction. In all instances of disagreement, consensus was reached through discussion.

Figure 2.1

PRISMA flow diagram of included studies.



Study Characteristics

Table 2.1 summarises the 88 included studies. The total number of participants included in this review was 9556, with sample sizes ranging from 14 – 641 and a median of 71. There was an over-representation of females in included studies with 51 interventions offered only to breast cancer survivors. The average age of included participants was 57.93 (*SD* = 11.32) years. Countries represented included USA (*n* = 27), Canada (*n* = 11), Australia (*n* = 9), Spain (*n* = 6), Netherlands (*n* = 6), UK (*n* = 5), Ireland (*n* = 3), Germany (*n* = 3), Iran (*n* = 3), France (*n* = 2), South Korea (*n* = 3), with Brazil, Denmark, England, Hong Kong, Italy, Republic of Kosovo, Taiwan, and Puerto Rico all contributing 1 study. In terms of study design, 30.7% studies measured QoL as their primary outcome. The most common measure of QoL were variations of the FACT questionnaires (FACT-General *n* = 19, FACT-Breast *n* = 9, FACT-Colorectal *n* = 3, FACT-Endometrial *n* = 1, and FACT-Esophageal *n* = 1), followed by the EORTC QLQC30 (*n* = 25), and the variations of the SF questionnaire (SF-36 *n* = 18, SF-12 *n* = 2, and SF-16 *n* = 1). Other measures included in single studies were the PROMIS- QoL, CARES-SF, EuroQoL-5D, Quality of Life index for cancer patients, the Sickness Impact Profile 8, and the WHOQOL-BREF.

Table 2.1

Characteristics of included studies

Study	Population	Intervention and control	Post-treatment *N*	Mode of delivery	Duration (weeks)	Intervention components			QoL measure	QoL Life primary outcome?	QoL findings
						Physical Activity	Nutrition	Mental Health			
Adams et al. (2018)	Cancer type: Testicular M^{age}: 43.7 M$^{Months\ since\ diagnosis}$: 96 Gender: 100% male	I: High Intensity Interval Training (HITT) C: Usual care	I:29 C:13	Individual	12	✓			SF-36	No	**Total:** N/A **Physical:** NS **Emotional:** NS **Social:** I>C
Alibhai et al. (2014)	Cancer type: Acute myeloid leukemia M^{age}: 56.1 M$^{Months\ since\ diagnosis}$: 23.4 Gender: 55.3% female	I: Intervention C: Waitlist	I:19 C:17	Group	12	✓			EORTC QLQ-C30	No	Compared mean change. **Total:** NS **Physical:** NS **Emotional:** NS **Social:** NS
Bail et al. (2018)	Cancer type: Breast M^{age}: 60.5 M$^{Months\ since\ diagnosis}$: 64.8 Gender: 100% female	I: Gardening C: Waitlist	I:19 C:17	Individual and print	52	✓	✓		SF-36	No	**Total:** N/A **Physical:** NS **Emotional:** NS **Social:** NS
Baruth et al. (2015)	Cancer type: Breast M^{age}: 56.5 M$^{Months\ since\ diagnosis}$: 5.17 Gender: 100% female	I: Home based walking C: Waitlist	I:18 C:12	Telephone and Pedometer	12	✓			SF-36	Yes	**Total:** N/A **Physical:** I>C **Emotional:** I>C **Social:** NS
Basen-Engquist et al. (2006)	Cancer type: Breast M^{age}: 55.1 M$^{Months\ since\ diagnosis}$: 38.3 Gender: 100% female	I: Lifestyle program C: Usual care	I:28 C:23	Group	24	✓			Unknown	No	**Total:** N/A **Physical:** NS **Emotional:** NS **Social:** NS

Table 2.1. ***continued***

Study	Population	Intervention and control	Post-treatment *N*	Mode of delivery	Duration (weeks)	Intervention components	QoL measure	QoL Life primary outcome?	QoL findings	Study	Population
Blair et al. (2021)	Cancer type: breast, prostate, bladder, cervical, colon, endometrium, kidney, lymphoma, melanoma M^{age}: 69.6 $M^{Months\ since\ diagnosis}$: 52.8 Gender: 66% female	I^1: Activpal I^2: Activpal + health coaching C: Waitlist	I^1: 18 I^2: 17 C: 18	I^1: Mobile application I^2: Mobile Application and telephone	13	✓ ✓			SF-36	No	Compared mean change. **Total:** N/A **Physical:** NS **Emotional:** NS **Social:** NS
Bourke et al. (2011)	Cancer type: Colon M^{age}: 56.1 $M^{Months\ since\ diagnosis}$: N/R Gender: 33.3% female	I: Intervention C: Usual care	I:8 C:9	Group and print	12	✓	✓		FACT-C	No	**Total:** I>C (NS when comparing change over time) **Physical:** N/R **Emotional:** N/R **Social:** N/R
Braakhuis et al. (2017)	Cancer type: Breast M^{age}: 55.5 $M^{Months\ since\ diagnosis}$: N/R Gender: 100% female	I^1:Mediterranean diet I^2: low fat diet C: Usual care	I^1: 15 I^2: 12 C: 13	Group and print	26		✓ ✓	✓ ✓	FACT-G	No	**Total:** NS **Physical:** NS **Emotional:** NS **Social:** NS
Broderick et al. (2013)	Cancer type: Breast, Colon, Lymphoma, and Oesophageal. M^{age}: 51.0 $M^{Months\ since\ diagnosis}$: 9.1 Gender: 86% female	I: Prescribed Exercise After Chemotherapy (PEACH) C: Usual Care	I:21 C:19	Group	8	✓			FACT-G	No	Compared mean change. **Total:** NS **Physical:** I>C **Emotional:** NS **Social:** NS
Brown et al. (2018)	Cancer type: Colon M^{age}: N/R $M^{Months\ since\ diagnosis}$: N/R Gender: 62% female	I^1: COURAGE Low dose I^2: COURAGE High dose C: Usual care	I^1: 14 I^2: 12 C: 13	Individual, telephone, and email	26	✓ ✓			FACT-C	Yes	**Total:** I>C **Physical:** I>C **Emotional:** I>C **Social:** NS

Table 2.1. ***continued***

Study	Population	Intervention and control	Post-treatment *N*	Mode of delivery	Duration (weeks)	Intervention components	QoL measure	QoL Life primary outcome?	QoL findings	Study	Population
Brown et al. (2021)	Cancer type: Breast M^{age}: 59.4 M$^{Months\ since\ diagnosis}$: 92 Gender: 100% female	I^1: Exercise I^2: Diet I^3: Exercise + diet C: Waitlist	I^1: 62 I^2: 56 I^3: 66 C: 60	Group	52	✓ ✓	✓ ✓		SF-36	No	**Total:** N/A **Physical:** I^3>C **Emotional:** NS **Social:** NS
Brown et al. (2022)	Cancer type: Breast, Gynecologic, Hematologic, Genitourinary M^{age}: 58.0 M$^{Months\ since\ diagnosis}$: 40.0 Gender: 86% female	I: Lifestyle Intervention C: Waitlist	I:21 C:19	Group	15	✓	✓		EORTC QLQ-C30	Yes	**Total:** NS **Physical:** I>C **Emotional:** NS **Social:** NS
Burnham and Wilcox (2002)	Cancer type: Breast and Colon M^{age}: 53.6 M$^{Months\ since\ diagnosis}$: 9.7 Gender: 83.3% female	I: Intervention C: Waitlist	I:12 C:6	Individual	10	✓			Quality of Life index for cancer patients	No	**Total:** I>C **Physical:** N/A **Emotional:** N/A **Social:** N/A
Casla et al. (2015)	Cancer type: Breast M^{age}: 49.1 M$^{Months\ since\ diagnosis}$: 10.4 Gender: 100% female	I: Intervention C: Waitlist	I:12 C:6	Individual	12	✓			SF-36	No	**Total:** N/A **Physical:** I>C **Emotional:** I>C **Social:** I>C
Chang et al. (2020)	Cancer type: Esophageal M^{age}: 56.0 M$^{Months\ since\ diagnosis}$: N/R Gender: 9.1% female	I: Intervention C: Waitlist	I:41 C:43	Individual, smartwatch and print	12	✓	✓	✓	EORTC QLQ-C30	Yes	Compared mean change. **Total:** N/A **Physical:** I>C **Emotional:** NS **Social:** I>C

Table 2.1. ***continued***

Study	Population	Intervention and control	Post-treatment *N*	Mode of delivery	Duration (weeks)	Intervention components	QoL measure	QoL Life primary outcome ?	QoL findings	Study	Population
Courneya et al. (2003)	Cancer type: Breast M^{age}: 59.0 $M^{\text{Months since diagnosis}}$: N/R Gender: 100% female	I: Intervention C: Waitlist	I:24 C:28	Individual	15	✓			FACT-G	Yes	**Total:** NS (I>C when comparing mean change) **Physical:** NS (I>C when comparing mean change) **Emotional:** NS **Social:** NS
Cramer et al. (2015)	Cancer type: Breast M^{age}: 49.2 $M^{\text{Months since diagnosis}}$: 30.3 Gender: 100% female	I: Yoga and meditation C: Usual care	I:19 C:21	Group	12	✓		✓	FACT-B	Yes	**Total:** I>C **Physical:** NS **Emotional:** I>C **Social:** I>C
Cuesta-Vargas et al. (2014)	Cancer type: Breast M^{age}: 47.9 $M^{\text{Months since diagnosis}}$: N/R Gender: 100% female	I: Multimodal physiotherapy programme C: Usual care	I:20 C:22	Group	8	✓			EuroQoL-5D	No	**Total:** NS **Physical:** N/A **Emotional:** N/A **Social:** N/A
Culos-Reed et al. (2006)	Cancer type: Breast M^{age}: 50 $M^{\text{Months since diagnosis}}$: 56 Gender: 95% female	I: Yoga C: Waitlist	I:18 C:18	Group	7	✓			EORTC QLQ-C30	Yes	**Total:** I>C **Physical:** N/R **Emotional:** I>C **Social:** N/R
Culos-Reed et al. (2010)	Cancer type: Prostate M^{age}: 67.6 $M^{\text{Months since diagnosis}}$: N/R Gender: 100% male	I: Intervention C: Waitlist	I:40 C:25	Individual	6	✓			EORTC QLQ-C30	No	**Total:** NS **Physical:** N/R **Emotional:** N/R **Social:** N/R
Daley et al. (2007)	Cancer type: Breast M^{age}: 51.3 $M^{\text{Months since diagnosis}}$: NR Gender: 100% female	I: Exercise Therapy C: Usual Care	I: 33 C: 33	Group	8	✓			FACT-G	Yes	**Total:** I>C **Physical:** NS **Emotional:** NS **Social:** I>C

Table 2.1. ***continued***

Study	Population	Intervention and control	Post-treatment *N*	Mode of delivery	Duration (weeks)	Intervention components	QoL measure	QoL Life primary outcome?	QoL findings	Study	Population
De Luca et al. (2016)	Cancer type: Breast M^{age}: 45.6 $M^{\text{Months since diagnosis}}$: 12.5 Gender: 100% female	I: Exercise Therapy C: Usual care	I: 10 C: 10	Individual	24	✓			FACT-G	No	**Total:** I>C **Physical:** N/R **Emotional:** N/R **Social:** N/R
Demark-Wahnefried et al. (2018)	Cancer type: Breast M^{age}: 70.1 $M^{\text{Months since diagnosis}}$: 80.4 Gender: 100% female	I: Harvest for Health C: Waitlist	I: 22 C: 20	Group, email, and telephone	52	✓	✓		SF-36	No	**Total:** N/A **Physical:** NS **Emotional:** I>C **Social:** NS
Dieli-Conwright et al. (2018)	Cancer type: Breast M^{age}: 53.5 $M^{\text{Months since diagnosis}}$: 6.2 Gender: 100% female	I: Intervention C: Usual care	I: 46 C: 45	Individual	16	✓			FACT-G	No	**Total:** I>C **Physical:** I>C **Emotional:** I>C **Social:** I>C
Fillion et al. (2008)	Cancer type: Breast M^{age}: 52.5 $M^{\text{Months since diagnosis}}$: NR Gender: 100% female	I: Lifestyle intervention C: Usual care	I: 44 C: 43	Group	4	✓		✓	SF-12	No	**Total:** N/R **Physical:** N/R **Emotional:** N/R **Social:** N/R **Other:** Physical Composite: NS Mental composite: NS
Galiano-Castillo et al. (2016)	Cancer type: Breast M^{age}: 48.3 $M^{\text{Months since diagnosis}}$: NR Gender: 100% female	I: e-CUIDATE system C: Usual care	I: 39 C: 37	Online platform	8	✓			EORTC QLQ-C30	Yes	**Total:** I>C **Physical:** I>C **Emotional:** NS **Social:** NS

Table 2.1. ***continued***

Study	Population	Intervention and control	Post-treatment *N*	Mode of delivery	Duration (weeks)	Intervention components	QoL measure	QoL Life primary outcome?	QoL findings	Study	Population
Garcia-Soidan et al. (2020)	Cancer type: Breast M^{age}: 63.0 $M^{Months\ since\ diagnosis}$: N/R Gender: 100% female	I^1: Strength I^2: Aquatic I^3: Aerobic C: Usual care	I^1: 74 I^2: 65 I^3: 79 C: 63	Group	104	✓ ✓ ✓			SF-12	Yes	**Total:** N/A **Physical:** NS **Emotional:** $I^1>C$, $I^2>C$, $C>I^3$ $I^1>I^2$, $I^1>I^3$, $I^2>I^3$ **Social:** $I^1>C$, $I^2>C$, $I^3>C$ $I^1>I^2$, $I^3>I^2$
Ghavami and Akyolcu (2017)	Cancer type: Breast M^{age}: 49.0 $M^{Months\ since\ diagnosis}$: N/R Gender: 100% female	I: Active Lifestyle Intervention C: Usual care	I: 40 C: 40	Individual	24	✓	✓		EORTC QLQ-C30	No	**Total:** I>C **Physical:** I>C **Emotional:** I>C **Social:** I>C
Golsteijn et al. (2018)	Cancer type: Prostate and Colorectal M^{age}: 66.5 $M^{Months\ since\ diagnosis}$: N/R Gender: 13% female	I: OncoActive C: Waitlist	I: 229 C: 222	Online platform	16	✓			EORTC QLQ-C30	No	**Total:** NS **Physical:** I>C **Emotional:** N/R **Social:** N/R
Gorzelitz et al. (2022)	Cancer type: Endometrial M^{age}: 60.9 $M^{Months\ since\ diagnosis}$: 34.8 Gender: 100% female	I: Lifestyle intervention C: Waitlist	I: 64 C: 71	Face-to-face and YouTube videos	10	✓			FACT-EN	No	**Total:** NS **Physical:** NS **Emotional:** NS **Social:** NS
Hagstrom et al. (2016)	Cancer type: Breast M^{age}: 51.9 $M^{Months\ since\ diagnosis}$: 11.6 Gender: 100% female	I: Lifestyle intervention C: Usual care	I: 19 C: 20	Individual	16	✓			FACT-G	No	**Total:** I>C **Physical:** I>C **Emotional:** NS **Social:** NS
Herrero et al. (2006)	Cancer type: Breast M^{age}: 50.5 $M^{Months\ since\ diagnosis}$: 35.9 Gender: 100% female	I: Lifestyle intervention C: Usual care	I: 8 C: 8	Individual	8	✓			EORTC QLQ-C30	Yes	Compared mean change. **Total:** I>C **Physical:** I>C **Emotional:** N/R **Social:** N/R

Table 2.1. *continued*

Study	Population	Intervention and control	Post-treatment *N*	Mode of delivery	Duration (weeks)	Intervention components	QoL measure	QoL Life primary outcome?	QoL findings	Study	Population
Ho et al. (2020)	Cancer type: Colorectal M^{age}: 65.2 $M^{Months\ since\ diagnosis}$: N/R Gender: 36.8% female	I^1: Moving Bright, Eating Smart Diet + PA I^2: Moving Bright, Eating Smart Diet I^3: Moving Bright, Eating Smart PA C: Usual care	I^1: 55 I^2: 56 I^3: 56 C: 56	Individual, pedometer and telephone	52	✓ ✓	✓ ✓		FACT-G	Yes	**Total:** I^1>C **Physical:** N/R **Emotional:** N/R **Social:** N/R
Holtdirk et al. (2021)	Cancer type: Breast M^{age}: 49.9 $M^{Months\ since\ diagnosis}$: N/R Gender: 100% female	I: Optimune C: Usual care	I: 141 C: 165	Online platform	12	✓	✓	✓	WHOQOL-BREF	Yes	**Total:** I>C **Physical:** I>C **Emotional:** I>C **Social:** NS
Kampshoff et al. (2015)	Cancer type: Breast, Colon, Ovarian, Lymphoma, Cervix, Testis M^{age}: 53.7 $M^{Months\ since\ diagnosis}$: N/R Gender: 80% female	I^1: High Intensity Exercise I^2: Low to Moderate Intensity Exercise C: Waitlist	I^1: 91 I^2: 95 C: 91	Group	12	✓			EORTC QLQ-C30	No	**Total:** I^1>C **Physical:** I^1>C, I^2>C **Emotional:** NS **Social:** NS
Kim et al. (2011)	Cancer type: Breast M^{age}: 45.8 $M^{Months\ since\ diagnosis}$: 12.7 Gender: 100% female	I: Simultaneous Stage-Matched Exercise and Diet Intervention C: Usual care	I: 23 C: 22	Telephone and print	12	✓	✓		EORTC QLQ-C30	No	Compared mean change. **Total:** NS **Physical:** NS **Emotional:** NS **Social:** NS
Kim et al. (2019)	Cancer type: Colorectal M^{age}: 56.2 $M^{Months\ since\ diagnosis}$: 10.7 Gender: 100% female	I: Home-based exercise program C: Usual care	I: 30 C: 28	DVDs	12	✓			FACT-C	Yes	Compared mean change. **Total:** NS **Physical:** NS **Emotional:** NS **Social:** NS

Table 2.1. ***continued***

Study	Population	Intervention and control	Post-treatment *N*	Mode of delivery	Duration (weeks)	Intervention components	QoL measure	QoL Life primary outcome?	QoL findings	Study	Population
Koutoukidis et al. (2019)	Cancer type: Endometrial M^{age}: 62.1 $M^{\text{Months since diagnosis}}$: 14.4 Gender: 100% female	I: Shape Up following cancer treatment C: Usual care	I: 25 C: 24	Groups	8	✓	✓		EORTC QLQ-C30	No	Compared mean change. **Total:** NS **Physical:** NS **Emotional:** NS **Social:** NS
Koutoukidis et al. (2020)	Cancer type: Multiple Myeloma M^{age}: 64.3 $M^{\text{Months since diagnosis}}$: 16.5 Gender: 100% female	I: MASCOT C: Usual care	I: 38 C: 35	Individual	26	✓			FACT-G	No	Compared mean change. **Total:** NS **Physical:** NS **Emotional:** NS **Social:** NS
Kristensen et al. (2020)	Cancer type: Head and neck M^{age}: 64.3 $M^{\text{Months since diagnosis}}$: N/R Gender: 35.2% female	I: NUTRI-HAB C: Waitlist	I: 38 C: 35	Group	12	✓	✓	✓	EORTC QLQ-C30	No	Compared mean change. **Total:** NS **Physical:** NS **Emotional:** NS **Social:** NS
Kwiatkowski et al. (2017)	Cancer type: Breast M^{age}: 52.0 $M^{\text{Months since diagnosis}}$: N/R Gender: 100% female	I: SPA C: Usual care	I: 114 C: 108	Individual	2	✓	✓	✓	SF-16	Yes	**Total:** I>C **Physical:** N/R **Emotional:** N/R **Social:** N/R
Lahart et al. (2016)	Cancer type: Breast M^{age}: 53.6 $M^{\text{Months since diagnosis}}$: 9.5 Gender: 100% female	I: Home based Physical Activity intervention C: Usual Care	I: 37 C: 33	Group and telephone	26	✓			FACT-G	No	**Total:** NS **Physical:** NS **Emotional:** NS **Social:** NS

Table 2.1. ***continued***

Study	Population	Intervention and control	Post-treatment *N*	Mode of delivery	Duration (weeks)	Intervention components	QoL measure	QoL Life primary outcome?	QoL findings	Study	Population
Ligibel et al. (2012)	Cancer type: Breast, colorectal, and rectal M^{age}: 54.3 $M^{Months\ since\ diagnosis}$: N/R Gender: 92.6% female	I: AACT C: Usual Care	I: 48 C: 57	Telephone	16	✓			EORTC QLQC30	No	Compared mean change. **Total:** NS **Physical:** N/R **Emotional:** N/R **Social:** N/R
Littman et al. (2012)	Cancer type: Breast M^{age}: 56.4 $M^{Months\ since\ diagnosis}$: N/R Gender: 100% female	I: Yoga C: Waitlist	I: 30 C: 28	Group	24	✓			FACT-G	Yes	**Total:** NS **Physical:** NS **Emotional:** NS **Social:** NS
Livingston et al. (2015)	Cancer type: Prostate M^{age}: 66 $M^{Months\ since\ diagnosis}$: N/R Gender: 100% male	I: ENGAGE C: Usual Care	I: 46 C: 83	Individual	12	✓			EORTC QLQC30	No	**Total:** NS **Physical:** NS **Emotional:** NS **Social:** NS
Long Parma et al. (2022)	Cancer type: Breast M^{age}: 55 $M^{Months\ since\ diagnosis}$: 10.7 Gender: 100% female	I: Intervention C: Usual Care	I: 79 C: 80	Telephone	52		✓		PROMIS QoL	No	**Total:** NS **Physical:** NS **Emotional:** NS **Social:** NS
Mardani et al. (2021)	Cancer type: Prostate M^{age}: 69.9 $M^{Months\ since\ diagnosis}$: 10.7 Gender: 100% male	I: Intervention C: Usual Care	I: 35 C: 36	Print	12	✓			EORTC QLQC30	Yes	**Total:** NS **Physical:** I>C **Emotional:** NS **Social:** NS
McCarroll et al. (2014)	Cancer type: Endometrial M^{age}: 57.9 $M^{Months\ since\ diagnosis}$: 25.6 Gender: 100% female	I: SUCCEED C: Usual Care	I: 35 C: 36	Group	26	✓	✓		FACT-G	Yes	Compared mean change. **Total:** NS **Physical:** I>C **Emotional:** NS **Social:** NS

Table 2.1. ***continued***

Study	Population	Intervention and control	Post-treatment *N*	Mode of delivery	Duration (weeks)	Intervention components	QoL measure	QoL Life primary outcome ?	QoL findings	Study	Population
McGowan et al. (2013)	Cancer type: Prostate M^{age}: 68.4 M$^{\text{Months since diagnosis}}$: 29.0 Gender: 100% male	I^1: PROMOTE - self administered I^2: PROMOTE - telephone C: Usual care	I^1:102 I^2:103 C:98	I^1 Print I^2 Print and telephone	12	✓ ✓			SF-36	No	**Total:** N/A **Physical:** NS **Mental:** NS **Social:** NS
McKenzie et al. (2003)	Cancer type: Breast M^{age}: 56.6 M$^{\text{Months since diagnosis}}$: N/R Gender: 100% female	I: Intervention C: Waitlist	I: 7 C: 7	Individual	8	✓	✓		SF-36	No	**Total:** N/A **Physical:** NS **Emotional:** NS **Social:** NS
McNeil et al. (2019)	Cancer type: Breast M^{age}: 58.7 M$^{\text{Months since diagnosis}}$: N/R Gender: 100% female	I^1: BC-PAL Lower intensity I^2: BC-PAL Higher Intensity C: Usual Care	I^1:15 I^2:15 C:13	Wearable activity tracker	12	✓			FACT-B	No	**Total:** NS **Physical:** NS **Emotional:** NS **Social:** NS
Moraes et al. (2021)	Cancer type: Breast M^{age}: 54.6 M$^{\text{Months since diagnosis}}$: 41.7 Gender: 100% female	I: Resistance Training C: Waitlist	I: 12 C: 13	Individual	8	✓			SF-36	No	**Total:** NS **Physical:** I>C **Emotional:** NS **Social:** NS
Morey et al. (2009)	Cancer type: Breast, prostate, and colorectal M^{age}: 73.1 M$^{\text{Months since diagnosis}}$: 8.6 Gender: 100% female	I: RENEW C: Waitlist	I: 269 C: 289	Print, Telephone, SMS	52	✓	✓		SF-36	Yes	**Total:** N/A **Physical:** NS **Emotional:** NS **Social:** NS
Mulero Portela et al. (2008)	Cancer type: Breast M^{age}: 52.9 M$^{\text{Months since diagnosis}}$: N/R Gender: 100% female	I^1: Gym exercise I^2: Home exercise C: Usual Care	I^1:12 I^2:13 C:9	Individual	26	✓			FACT-B	No	**Total:** NS **Physical:** N/R **Emotional:** N/R **Social:** N/R

Table 2.1. ***continued***

Study	Population	Intervention and control	Post-treatment *N*	Mode of delivery	Duration (weeks)	Intervention components	QoL measure	QoL Life primary outcome ?	QoL findings	Study	Population
Murtezani et al. (2014)	Cancer type: Breast M^{age}: 52.0 $M^{Months\ since\ diagnosis}$: N/R Gender: 100% female	I: Exercise group C: Waitlist	I: 30 C: 32	Group	10	✓			FACT-G	Yes	**Total:** I>C **Physical:** I>C (NS when comparing change over time) **Emotional:** NS (I>C when comparing change over time) **Social:** I>C (NS when comparing change over time)
Naumann et al. (2012b)	Cancer type: Breast M^{age}: 53.6 $M^{Months\ since\ diagnosis}$: 8.0 Gender: 100% female	I^1: Group Exercise Counselling I^2: Individual Exercise Counselling C: Usual Care	I^1:14 I^2:12 C:10	I^1 Group I^2 Individual	9	✓ ✓		✓ ✓	FACT-B	Yes	Compared mean change. **Total:** I^2>C **Physical:** I^2>C **Emotional:** I^1>C, I^2>C **Social:** NS
Naumann et al. (2012a)	Cancer type: Breast M^{age}: 49.9 $M^{Months\ since\ diagnosis}$: 7.3 Gender: 100% female	I^1: Exercise I^2: Exercise and Counselling C: Usual Care	I^1:14 I^2:12 C:10	I^1 Individual I^2 Individual	8	✓ ✓		✓	EORTC QLQ-BR23	No	**Total:** NS **Physical:** NS **Emotional:** I^2>C **Social:** NS
Ohira et al. (2006)	Cancer type: Breast M^{age}: 53.0 $M^{Months\ since\ diagnosis}$: 22.5 Gender: 100% female	I: Weight Training for Breast Cancer Survivors C: Waitlist	I: 39 C: 40	Group	26	✓			CARES-SF	Yes	**Total:** NS **Physical:** C>I **Emotional:** N/A **Social:** N/A
O'Neill et al. (2018)	Cancer type: Esophageal, esophagogastric junction, or gastric M^{age}: 65.6 $M^{Months\ since\ diagnosis}$: N/R Gender: 37.8% female	I: RESTORE C: Usual care	I: 20 C: 19	Group	12	✓	✓	✓	EORTC QLQ-C30	No	**Total:** NS **Physical:** NS **Emotional:** NS **Social:** NS

Table 2.1. ***continued***

Study	Population	Intervention and control	Post-treatment *N*	Mode of delivery	Duration (weeks)	Intervention components	QoL measure	QoL Life primary outcome?	QoL findings	Study	Population
Park et al. (2015)	Cancer type: Breast and Colorectal M^{age}: 51.8 $M^{Months\ since\ diagnosis}$: 23.1 Gender: 88.3% female	I: Oncologist's Exercise Recommendation with Exercise Motivation Package C: Waitlist	I: 50 C: 59	Group, DVD, pedometer	4	✓			EORTC QLQ-C30	No	Compared mean change. **Total:** NS **Physical:** NS **Emotional:** NS **Social:** NS
Park et al. (2019)	Cancer type: Breast, Gynaecological, lymphoma, colorectal M^{age}: 51.9 $M^{Months\ since\ diagnosis}$: N/R Gender: 37.8% female	I: FIT C: Usual Care	I: 62 C: 64	Individual	24	✓			FACT-G	No	Divided groups by participants taking aromatase inhibitors, tamoxifen, and no endocrine therapy. **Total:** NS **Physical:** NS **Emotional:** I>C only for those not taking endocrine therapy **Social:** NS
Pisu et al. (2017)	Cancer type: Endometrial, ovarian, breast, colorectal M^{age}: 57.9 $M^{Months\ since\ diagnosis}$: 50.7 Gender: 100% female	I: Rhythm C: Waitlist	I: 62 C: 64	Individual	12	✓			SF-36	No	**Total:** N/A **Physical:** I>C **Emotional:** NS **Social:** NS
Prinsen et al. (2013)	Cancer type: Breast, head and neck, non-hodgkin, prostate, testicular, and thyroid M^{age}: 49.3 $M^{Months\ since\ diagnosis}$: 49.6 Gender: 100% female	I: CBT C: Waitlist	I: 23 C: 14	Individual	24	✓		✓	Sickness Impact Profile 8	No	**Total:** I>C **Physical:** N/A **Emotional:** N/A **Social:** N/A

Table 2.1. *continued*

Study	Population	Intervention and control	Post-treatment *N*	Mode of delivery	Duration (weeks)	Intervention components	QoL measure	QoL Life primary outcome?	QoL findings	Study	Population
Reeves et al. (2017)	Cancer type: Breast M^{age}: 55.3 $M^{\text{Months since diagnosis}}$: 15.9 Gender: 100% female	I: Living well after Breast Cancer C: Usual care	I: 40 C: 34	Telephone	26	✓	✓		SF-36	No	**Total:** N/A **Physical:** N/R **Emotional:** N/R **Social:** N/R **Other:** Physical Composite: NS Emotional composite: NS
Reeves et al. (2021)	Cancer type: Breast M^{age}: 55.0 $M^{\text{Months since diagnosis}}$: 10.7 Gender: 100% female	I: Lifestyle Intervention C: Usual care	I: 79 C: 80	Telephone	52	✓	✓		PROMIS QoL	No	**Total:** N/A **Physical:** N/R **Emotional:** N/R **Social:** N/R **Other:** Physical Composite: NS Mental composite: NS
Rogers et al. (2009)	Cancer type: Breast M^{age}: 53.0 $M^{\text{Months since diagnosis}}$: N/R Gender: 100% female	I: BEAT C: Usual care	I: 20 C: 19	Individual	12	✓			FACT-G	No	**Total:** NS **Physical:** NS **Emotional: NS** **Social:** NS (I>C when comparing change over time)
Rogers et al. (2015a)	Cancer type: Breast M^{age}: 54.4 $M^{\text{Months since diagnosis}}$: N/R Gender: 100% female	I: BEAT C: Usual care	I: 105 C: 108	Individual	12	✓		✓	FACT-G	No	**Total:** I>C **Physical:** I>C **Emotional:** I>C **Social:** NS

Table 2.1. ***continued***

Study	Population	Intervention and control	Post-treatment *N*	Mode of delivery	Duration (weeks)	Intervention components	QoL measure	QoL Life primary outcome?	QoL findings	Study	Population
Ruiz-Vozmediano et al. (2020)	Cancer type: Breast M^{age}: 50.1 $M^{\text{Months since diagnosis}}$: N/R Gender: 100% female	I: Intervention C: Usual Care	I: 31 C: 32	Group	26	✓	✓	✓	EORTC QLQ-C30	Yes	**Total:** NS **Physical:** NS (I>C when comparing change over time) **Emotional:** N/R **Social:** NS
Saarto et al. (2012)	Cancer type: Breast M^{age}: 52.4 $M^{\text{Months since diagnosis}}$: N/R Gender: 100% female	I: Intervention C: Usual Care	I: 263 C: 237	Group	52	✓			EORTC QLQ-C30	Yes	Compared mean change. **Total:** NS **Physical:** NS **Emotional:** NS **Social:** C>I
Sandel et al. (2005)	Cancer type: Breast M^{age}: 59.6 $M^{\text{Months since diagnosis}}$: N/R Gender: 100% female	I: Intervention C: Usual Care	I: 19 C: 16	Group	12	✓				Yes	**Total:** NS (I>C when comparing groups over time) **Physical:** N/R **Emotional:** N/R **Social:** N/R
Scott et al. (2013)	Cancer type: Breast M^{age}: 55.7 $M^{\text{Months since diagnosis}}$: N/R Gender: 100% female	I: Pragmatic lifestyle intervention C: Usual Care	I: 47 C: 43	Individual and print	26	✓	✓		FACT-B	No	**Total:** NS **Physical:** N/R **Emotional:** N/R **Social:** N/R
Shobeiri et al. (2016)	Cancer type: Breast M^{age}: 43.1 $M^{\text{Months since diagnosis}}$: NR Gender: 100% female	I: Lifestyle Intervention C: Usual care	I: 26 C: 27	Group	10	✓			EORTC QLQ-C30	Yes	**Total:** I>C **Physical:** I>C **Emotional:** I>C **Social:** NS
Short et al. (2015b)	Cancer type: Breast M^{age}: 55.0 $M^{\text{Months since diagnosis}}$: N/R Gender: 100% female	I^1: Move more for life tailored I^2: Move more for life targeted C: Usual Care	I^1:91 I^2:92 C:93	Print	12	✓ ✓			FACT-G	No	**Total:** NS **Physical:** NS **Emotional:** NS **Social:** NS

Table 2.1. *continued*

Study	Population	Intervention and control	Post-treatment *N*	Mode of delivery	Duration (weeks)	Intervention components	QoL measure	QoL Life primary outcome?	QoL findings	Study	Population
Singleton et al. (2022)	Cancer type: Breast M^{age}: 55.1 $M^{\text{Months since diagnosis}}$: N/R Gender: 100% female	I: EMPOWER-SMS C: Usual care	I: 64 C: 71	SMS	26	✓	✓	✓	EORTC QLQ-C30	No	**Total:** NS **Physical:** I>C **Emotional:** NS **Social:** NS
Speck et al. (2010b)	Cancer type: Breast M^{age}: 56.5 $M^{\text{Months since diagnosis}}$: 60.7 Gender: 100% female	I: EMPOWER-SMS C: Usual care	I: 64 C: 71	Individual	52	✓			SF-36	No	**Total:** N/A **Physical:** N/R **Emotional:** N/R **Social:** N/R **Other:** Physical Composite: NS Mental composite: NS for overall sample, however, I>C for those with lymphedema
Strunk et al. (2018)	Cancer type: Breast M^{age}: 53.1 $M^{\text{Months since diagnosis}}$: 44.8 Gender: 100% female	I: Intervention C: Waitlist	I: 26 C: 25	Group	52	✓			EORTC QLQ-C30	Yes	**Total:** NS **Physical:** NS **Emotional:** NS **Social:** NS
Swisher et al. (2015)	Cancer type: Breast M^{age}: 53.7 $M^{\text{Months since diagnosis}}$: 44.8 Gender: 100% female	I: Get Fit for the Fight C: Usual Care	I: 13 C: 10	Individual	12	✓	✓		FACT-B	No	**Total:** NS **Physical:** NS **Emotional:** NS **Social:** NS
Thorsen et al. (2005)	Cancer type: Lymphomas, breast, gynaecologic, or testicular M^{age}: 39.1 $M^{\text{Months since diagnosis}}$: N/R Gender: 68% female	I: Get Fit for the Fight C: Usual Care	I: 59 C: 52	Individual and print	14	✓			EORTC QLQ-C30	No	Compared mean change **Total:** NS **Physical:** NS **Emotional:** NS **Social:** NS

Table 2.1. ***continued***

Study	Population	Intervention and control	Post-treatment *N*	Mode of delivery	Duration (weeks)	Intervention components	QoL measure	QoL Life primary outcome ?	QoL findings	Study	Population
Toohey et al. (2018)	Cancer type: Breast, Ovarian, Appendix, Anal, Cervical, Liver, Oesophageal, Melanoma, Leiomyosarcoma M^{age}: 51.5 $M^{\text{Months since diagnosis}}$: N/R Gender: 88% female	I^1: Low volume high-intensity interval training I^2: Continuous low to moderate-intensity training C: Usual Care	I^1:24 I^2:21 C:12	Individual	12	✓ ✓			FACT-G	Yes	Compared within group effect sizes **Total:** I^1>C, I^1> I^2 **Physical:** I^1>C, I^2>C **Emotional:** I^1>C, I^1> I^2 **Social:** NS
Vallance et al. (2008)	Cancer type: Breast M^{age}: 58.0 $M^{\text{Months since diagnosis}}$: 39.0 Gender: 100% female	I^1: Physical Activity print I^2: Physical activity pedometer I^3: Physical activity combination C: Usual Care	I^1: 62 I^2: 69 I^3: 67 C: 68	I^1 Print I^2 Pedometer I^3 Combination		✓ ✓ ✓			FACT-B	No	**Total:** NS **Physical:** NS **Emotional:** NS **Social:** NS
Vallance et al. (2020)	Cancer type: Breast M^{age}: 62.0 $M^{\text{Months since diagnosis}}$: N/R Gender: 100% female	I: Get Fit for the Fight C: Waitlist	I: 40 C: 40	Face to face, wearable tracker, telephone	12	✓			FACT-G	Yes	**Total:** NS **Physical:** N/R **Emotional:** N/R **Social:** N/R
Vallerand et al. (2018)	Cancer type: Leukemia, Hodgkin Lymphoma, Non-Hodgkin Lymphoma M^{age}: 56.2 $M^{\text{Months since diagnosis}}$: 87.6 Gender: 61% female	I: telephone counselling exercise C: Usual Care	I: 26 C: 25	Telephone	12	✓		✓	SF-36	No	**Total:** N/A **Physical:** NS **Emotional:** NS **Social:** NS
van de Wiel et al. (2021)	Cancer type: Leukemia, Hodgkin Lymphoma, Non-Hodgkin Lymphoma M^{age}: 56.2 $M^{\text{Months since diagnosis}}$: 87.6 Gender: 61% female	I^1: Internet-based PA Support program (IPAS) I^2: IPAS + support C: Usual Care	I^1:24 I^2:28 C:32	I^1 Online platform I^2 Online platform and telephone	26	✓ ✓			SF-36	No	**Total:** N/A **Physical:** NS **Emotional:** NS (I>C when both interventions combined into one group) **Social:** NS

Table 2.1. ***continued***

Study	Population	Intervention and control	Post-treatment *N*	Mode of delivery	Duration (weeks)	Intervention components	QoL measure	QoL Life primary outcome?	QoL findings	Study	Population
von Gruenigen et al. (2009)	Cancer type: Breast and prostate M^{age}: 54.73 $M^{\text{Months since diagnosis}}$: 23.65 Gender: 48.9% female	I: Lifestyle Intervention C: Usual Care	I: 23 C: 22	Group	26	✓	✓	✓	FACT-G	No	**Total:** NS **Physical:** NS **Emotional:** NS **Social:** NS
Wang et al. (2021)	Cancer type: Breast M^{age}: 55.8 $M^{\text{Months since diagnosis}}$: 22.9 Gender: 100% female	I: Lifestyle Intervention C: Waitlist	I: 23 C: 22	Individual and DVD	18	✓			FACT-ES	No	Compared mean change. **Total:** NS **Physical:** I>C **Emotional:** NS **Social:** NS
Willems et al. (2017)	Cancer type: All M^{age}: 56.5 $M^{\text{Months since diagnosis}}$: NR Gender: 81% female	I: Kanker Nazorg Wijzer C: Waitlist	I: 188 C: 121	Online platform	26	✓	✓	✓	EORTC QLQ-C30	Yes	**Total:** NS **Physical:** NS **Emotional:** I>C (NS when missing data accounted for) **Social:** I>C (NS when missing data accounted for)
Winkels et al. (2017)	Cancer type: Breast M^{age}: 59.4 $M^{\text{Months since diagnosis}}$: 91.9 Gender: 100% female	I^{1}: Exercise I^{2}: Weight loss I^{3}: exercise + weight loss C: Usual Care	I^{1}: 62 I^{2}: 69 I^{3}: 67 C: 68	Group	52	✓ ✓	✓ ✓		SF-36	No	**Total:** N/A **Physical:** NS **Emotional:** NS **Social:** NS
Winters-Stone et al. (2016)	Cancer type: Prostate M^{age}: 56.5 $M^{\text{Months since diagnosis}}$: 6.4 Gender: 100% male	I: Kanker Nazorg Wijzer C: Waitlist	I: 32 C: 32	Individual	26	✓			SF-36	No	**Total:** N/A **Physical:** I>C **Emotional:** NS **Social:** N/R

Intervention Characteristics

Mode of delivery

A diverse range of delivery modalities were investigated in the included interventions. Most utilised *face-to-face delivery* (*n* = 84), of which approximately half (*n* = 43) were provided individually (Adams et al., 2018; Burnham & Wilcox, 2002; Casla et al., 2015; Courneya et al., 2003; Culos-Reed et al., 2010; De Luca et al., 2016; Dieli-Conwright et al., 2018; Ghavami & Akyolcu, 2017; Hagstrom et al., 2016; Herrero et al., 2006; Koutoukidis et al., 2020; Kwiatkowski et al., 2017; McKenzie et al., 2003; Moraes et al., 2021; Mulero Portela et al., 2008; Naumann et al., 2012a; Park et al., 2019; Pisu et al., 2017; Prinsen et al., 2013; Rogers et al., 2009; Rogers et al., 2015a; Speck et al., 2010b; Strunk et al., 2018; Swisher et al., 2015; Toohey et al., 2018; Winters-Stone et al., 2016), while the remainder were delivered via groups (Alibhai et al., 2014; Basen-Engquist et al., 2006; Bourke et al., 2011; Braakhuis et al., 2017; Broderick et al., 2013; Brown et al., 2021; Brown et al., 2022; Cramer et al., 2015; Cuesta-Vargas et al., 2014; Culos-Reed et al., 2006; Daley et al., 2007; Darga et al., 2007; Demark-Wahnefried et al., 2018; Fillion et al., 2008; Garcia-Soidan et al., 2020; Kampshoff et al., 2015; Koutoukidis et al., 2019; Kristensen et al., 2020; Lahart et al., 2016; Littman et al., 2012; Long Parma et al., 2022; McCarroll et al., 2014; Murtezani et al., 2014; Naumann et al., 2012b; O'Neill et al., 2018; Ohira et al., 2006; Park et al., 2019; Ruiz-Vozmediano et al., 2020; Saarto et al., 2012; Shobeiri et al., 2016; van de Wiel et al., 2021; Winkels et al., 2017). Twenty-five (22.7%) of these face-to-face interventions were supported by additional modalities, such as printed or emailed materials (Bail et al., 2018; Bourke et al., 2011; Braakhuis et al., 2017; Broderick et al., 2013; Scott et al., 2013; Thorsen et al., 2005), telephone (Fillion et al., 2008; Ho et al., 2020; Mulero Portela et al., 2008; Vallance et al., 2020), videos (Park et al., 2015; Wang et al., 2021) or a combination of these (Brown et al., 2018; Lahart et al., 2016; Long Parma et al., 2022).

Sixteen studies utilised a *digital health modality* (such as an online platform, or a mobile application). Within this group, wearable devices were utilised as either the primary delivery modality (Vallance 2008) or accompanying another delivery modality (Vallance 2020, Ho 2020, Broderick 2013, Vallance 2008). Nine interventions utilised the *telehealth,* of which 8 delivered content over the phone and 1 investigated SMS delivery (Singleton et al., 2022). Delivery modalities less frequently used included DVDs (Kim et al., 2011) and print (Mardani et al. 2021; McGowan et al., 2013; Short et al., 2015; Vallance et al., 2008).

Intervention duration

The duration of the interventions ranged from 2 to 104 weeks (*M* = 20, *Mdn* = 12). 50.9% of the interventions were delivered over 12 weeks or less, with the most common intervention durations being twelve weeks (31.8%), 26 weeks (15.5%) and 52 weeks (17.3%).

Health Behaviours Targeted

Physical Activity. The majority of included interventions addressed physical activity (*n* = 107, 93.9%). Twenty-two interventions targeted *aerobic activity* (e.g., walking, running, cycling, swimming, or dancing; Adams et al., 2018; Broderick et al., 2013; Brown et al., 2018; Brown et al., 2022; Burnham & Wilcox, 2002; Courneya et al., 2003; Cuesta-Vargas et al., 2014; Daley et al., 2007; Ghavami & Akyolcu, 2017; Murtezani et al., 2014; Park et al., 2019; Prinsen et al., 2013; Saarto et al., 2012; Shobeiri et al., 2016; Swisher et al., 2015; Toohey et al., 2018; Vallerand et al., 2018; von Gruenigen et al., 2009). Seven interventions focused on *resistance exercises* (e.g., lifting weights or body weight exercises; Garcia-Soidan et al., 2020; Hagstrom et al., 2016; Moraes et al., 2021; Ohira et al., 2006; Speck et al., 2010b). Thirty-four interventions promoted a *combination* of aerobic and resistance exercises (Alibhai et al., 2014; Bourke et al., 2011; Brown et al., 2021; Casla et al., 2015; Culos-Reed et al., 2010; De Luca et al., 2016; Dieli-Conwright et al., 2018; Galiano-Castillo et al., 2016; Herrero et al., 2006; Kampshoff et al., 2015; Kim et al., 2019; Koutoukidis et al., 2020; Kwiatkowski et al., 2017; Mardani et al., 2021; McKenzie et al., 2003; Morey et al., 2009; Mulero Portela et al., 2008; Naumann et al., 2012a; Naumann et al., 2012b; O'Neill et al., 2018; Park et al., 2015; Reeves et al., 2021; Ruiz-Vozmediano et al., 2020; Scott et al., 2013; Short et al., 2015b; Wang et al., 2021; Winkels et al., 2017; Winters-Stone et al., 2016). Four interventions practiced yoga (Cramer et al., 2015; Culos-Reed et al., 2006; Littman et al., 2012) and one intervention (Kristensen et al., 2020) involved a combination of aerobic, resistance and yoga exercises. Twenty-five interventions did not specify a particular exercise, instead focusing on increasing minutes of physical activity per week (Basen-Engquist et al., 2006; Golsteijn et al., 2018; Ho et al., 2020; Holtdirk et al., 2021; Kim et al., 2011; Lahart et al., 2016; Ligibel et al., 2012; McCarroll et al., 2014; McGowan et al., 2013; McNeil et al., 2019; Reeves et al., 2017; Rogers et al., 2009; Rogers et al., 2015a; Singleton et al., 2022; Thorsen et al., 2005; Vallance et al., 2008; Vallance et al., 2020; van de Wiel et al., 2021; Willems et al., 2017) or reducing sedentary time (Blair et al., 2021; Koutoukidis et al., 2019). Less common physical activity interventions included gardening (Bail et al., 2018; Demark-Wahnefried et al., 2018) and martial arts (Strunk et al., 2018).

Nutrition. Thirty-five (30.7%) of the included interventions contained a nutritional component. Of these interventions, twelve focused on *diet restriction* through decreasing certain food groups consumed, such as saturated fats, carbohydrates, red meat, and dairy (Braakhuis et al., 2017), or reducing the total daily calorie intake (Swisher et al., 2015). The common recommendations for daily calorie intake in the included interventions were between 1200 – 2000 kcal/day (Brown et al., 2022; Kwiatkowski et al., 2017; Winkels et al., 2017) or reducing the participants current calorie intake by 600 kcal (Scott et al., 2013). Comparatively, six interventions focused on *dietary change* and promoted increasing certain food groups (Bail et al., 2018; Demark-Wahnefried et al., 2018; Willems et al., 2017). The most common recommendations were 5 servings of vegetables, 2 servings of fruit per day, and increasing the intake of nuts, grains, and fish. Thirteen interventions utilised a *combination* of dietary restriction and dietary change strategies (Bourke et al., 2011; Brown et al., 2021; Ghavami & Akyolcu, 2017; Ho et al., 2020; Kim et al., 2019; Koutoukidis et al., 2019; Morey et al., 2009; Reeves et al., 2021; Ruiz-Vozmediano et al., 2020; von Gruenigen et al., 2009). Two interventions cited a *particular diet plan:* Long Parma et al. (2022) recommended an anti-inflammatory diet, which consists of regular consumption of herbs and spices (e.g., ginger, turmeric, garlic, and onion), fish, olive oil, fruit, colourful fruit and vegetables, and green and black tea. Similarly, Braakhuis et al. (2017) recommended the Mediterranean diet, which consists of the increasing the intake of herbs (e.g., garlic and onion), fruit and vegetables, fish, and legumes, while limiting the intake of red meat, dairy, and sweets. Six interventions reported including *non-specified* dietary guidance or counselling (Chang et al., 2020; Holtdirk et al., 2021; Kristensen et al., 2020; McCarroll et al., 2014; O'Neill et al., 2018; Singleton et al., 2022). Three interventions also included additional recommendations to *decrease alcohol consumption* (Bourke et al., 2011; Reeves et al., 2021; Scott et al., 2013).

Mental health. Overall, 18 of the 110 (16.4%) interventions featured a mental health component in their protocol. Six provided *mental health treatment* based on evidence based psychological therapies, such as cognitive behavioural therapy (Fillion et al., 2008; Holtdirk et al., 2021; Prinsen et al., 2013; von Gruenigen et al., 2009; Willems et al., 2017) or Mindfulness Based Stress Reduction (Ruiz-Vozmediano et al., 2020). Six interventions included *psycho-educational material* on social and emotional well-being (Singleton et al., 2022), stress management (Braakhuis et al., 2017; Rogers et al., 2015a), mindfulness (O'Neill et al., 2018), or psychological adjustment following a cancer diagnosis (Chang et al., 2020). One intervention utilised meditation following a yoga session (Cramer et al., 2015). Three interventions described the use of ‘psychological support’ or counselling but did not provide further details (Kwiatkowski et al., 2017; Naumann et al., 2012a; Naumann et al., 2012b).

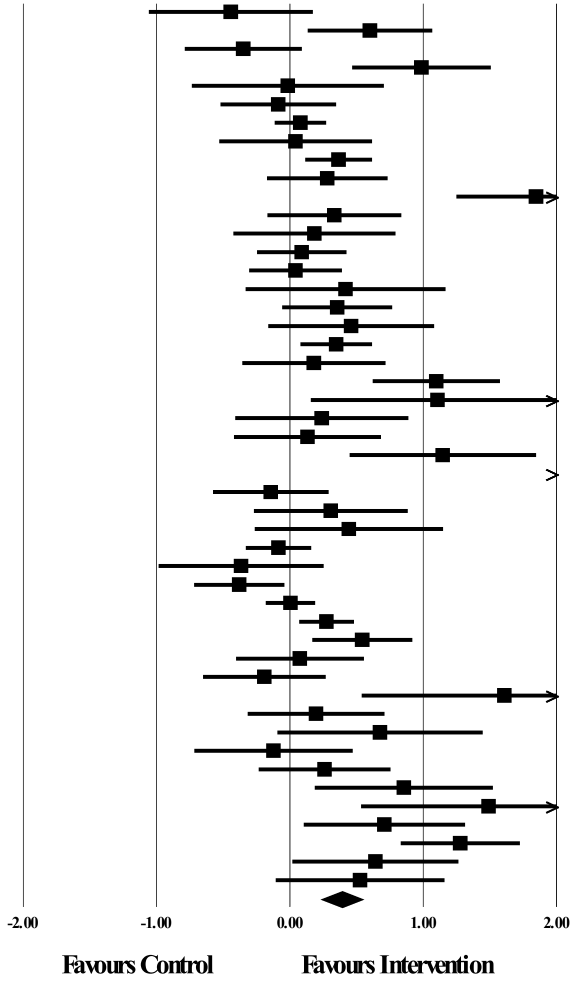
Meta-analysis of overall intervention effects

Post-treatment data was available for meta-analysis from 48 papers for total QoL (**Figure 2.2**), 50 for physical well-being (**Figure 2.3**), 50 for emotional well-being (**Figure 2.4**) and 48 for social well-being (**Figure 2.5**).

The overall pooled effect size of the interventions demonstrated a small significant, positive effect of healthy lifestyle interventions on cancer survivors’ total quality of life ($g = 0.32$, 95% CI [0.17, 0.48], $p >.001$), physical well-being ($g = 0.19$, 95% CI [0.01, 0.36], $p = 0.05$), emotional well-being ($g = 0.20$, 95% CI [0.10, 0.31], $p >.001$), and social well-being ($g = 0.18$, 95% CI [0.05, 0.31], $p = 0.01$) in comparison to waitlist or usual care controls. For the interventions reporting total QoL(Livingston et al., 2011; Prinsen et al., 2013; Short et al., 2015b), one (Short et al., 2015b) demonstrated a negative effect, and favoured the control group over the intervention group. Similar results were found for each of the subscale outcomes, three interventions demonstrated negative effects (favouring the control condition) for physical well-being (Livingston et al., 2011; Long Parma et al., 2022; Ohira et al., 2006), three for emotional well-being (Garcia-Soidan et al., 2020; Holtdirk et al., 2021; Livingston et al., 2011; Winkels et al., 2017), and two for social well-being (Short et al., 2015b). Consequently, these results should be interpreted with caution. According to Cohen’s criteria, substantial heterogeneity was observed for emotional well-being (Q = 142.99, p <.001; I^2 = 65.73) and considerable heterogeneity was observed for total QoL (Q = 236.19, p <.001; I^2 = 80.10), physical well-being (Q = 384.89, p <.001; I^2 = 87.27), and social well-being (Q = 248.98, p <.001; I^2 = 81.12); visual inspection of each forest plot demonstrates dispersion across zero.

Figure 2.2

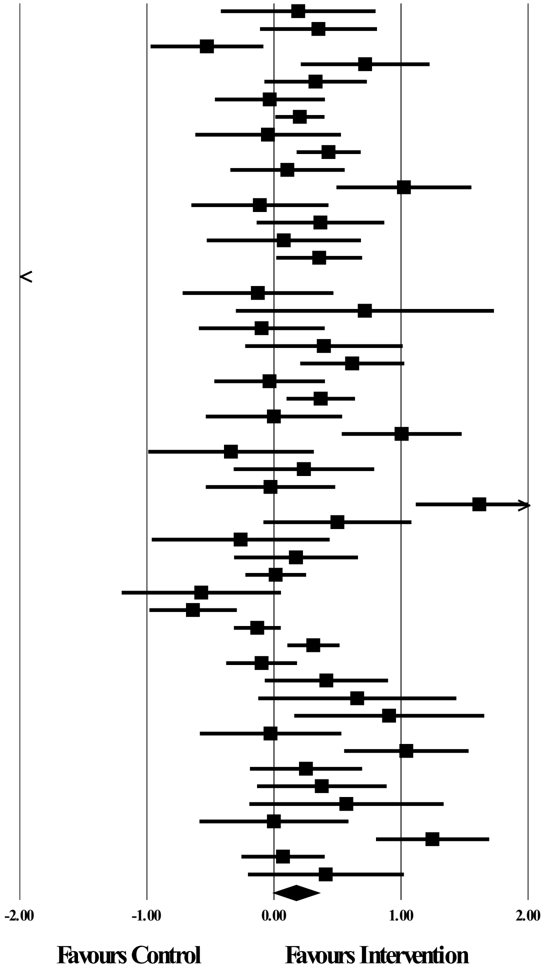
Forest plot of meta-analysis of effect sizes identified for each health behaviour intervention on post intervention Total QoL



Study name	Intervention	Statistics for each study Hedges's g	Lower limit	Upper limit	p-Value	Standard error	Variance	Z-Value
Broderick 2013	PEACH	-0.443	-1.059	0.173	0.159	0.314	0.099	-1.410
Daley 2007	Exercise Therapy	0.601	0.132	1.069	0.012	0.239	0.057	2.515
Ohira 2006	Weight Training for Breast Cancer Survivors	-0.350	-0.790	0.090	0.119	0.225	0.050	-1.557
Murtezani 2014	Exercise group	0.987	0.465	1.509	0.000	0.266	0.071	3.708
MCNEIL 2019	BC-PAL Higher intensity PA	-0.015	-0.736	0.706	0.967	0.368	0.135	-0.041
Lahart 2016	Home based PA intervention	-0.087	-0.522	0.347	0.694	0.222	0.049	-0.394
Willems 2017	Kanker Nazorg Wijzer	0.079	-0.115	0.273	0.426	0.099	0.010	0.795
vonGruenigen 2009	Intervention	0.042	-0.532	0.617	0.885	0.293	0.086	0.145
Kampshoff 2015	High and low intensity exercise	0.365	0.113	0.617	0.004	0.129	0.017	2.842
Kim 2019	Home-based exercise program	0.281	-0.172	0.734	0.224	0.231	0.053	1.215
Shobeiri 2016	Intervention	1.847	1.248	2.446	0.000	0.306	0.093	6.044
Brown 2022	Intervention	0.333	-0.170	0.836	0.194	0.257	0.066	1.298
Gorzelitz 2022	Intervention	0.184	-0.425	0.793	0.553	0.311	0.096	0.593
Singleton 2022	EMPOWER-SMS	0.089	-0.247	0.425	0.604	0.171	0.029	0.519
LongParma 2022	Intervention	0.042	-0.306	0.391	0.812	0.178	0.032	0.238
MuleroPortela 2008	Gym exercise	0.417	-0.333	1.168	0.276	0.383	0.147	1.090
Scott 2013	Pragmatic lifestyle intervention	0.355	-0.058	0.768	0.092	0.211	0.044	1.683
Hagstrom 2016	Intervention	0.460	-0.164	1.083	0.148	0.318	0.101	1.445
Rogers 2015	BEAT	0.347	0.078	0.617	0.012	0.138	0.019	2.524
Courneya 2003	Intervention	0.180	-0.358	0.718	0.512	0.275	0.075	0.655
Galiano-Castillo 2016	e-CUIDATE system	1.099	0.620	1.577	0.000	0.244	0.060	4.502
Bourke 2011	Intervention	1.107	0.156	2.059	0.023	0.485	0.236	2.281
Braakhuis 2017	low fat diet	0.239	-0.411	0.890	0.471	0.332	0.110	0.721
Koutoukidis 2019	Shape Up following cancer treatment	0.132	-0.420	0.684	0.640	0.282	0.079	0.468
Prinsen 2013	Cognitive Behaviour Therapy	1.147	0.446	1.848	0.001	0.357	0.128	3.209
Ghavami 2017	ACTIVE LIFESTYLE INTERVENTION	2.949	2.319	3.579	0.000	0.322	0.103	9.171
Vallance 2020	ACTIVATE	-0.144	-0.578	0.291	0.516	0.222	0.049	-0.649
Kim 2011	Simultaneous Stage-Matched Exercise and Diet Intervention	0.307	-0.271	0.885	0.297	0.295	0.087	1.042
Strunk 2018	Kyusho Jitsu	0.442	-0.264	1.149	0.220	0.361	0.130	1.227
Short 2015	Move more for life tailored	-0.086	-0.332	0.161	0.495	0.126	0.016	-0.682
Rogers 2009	BEAT	-0.366	-0.987	0.254	0.247	0.317	0.100	-1.157
Livingston 2015	ENGAGE	-0.380	-0.719	-0.040	0.028	0.173	0.030	-2.191
Golsteijn 2018	OncoActive	0.004	-0.182	0.190	0.966	0.095	0.009	0.043
Holtdirk 2021	Optimune	0.275	0.068	0.481	0.009	0.105	0.011	2.608
Ho 2020	Moving Bright, Eating Smart Diet + PA	0.543	0.167	0.919	0.005	0.192	0.037	2.827
Kristensen 2020	Nutri-Hub	0.075	-0.406	0.556	0.760	0.245	0.060	0.306
Mardani 2021	Intervention	-0.192	-0.653	0.269	0.414	0.235	0.055	-0.816
Burnham 2002	Intervention	1.609	0.538	2.680	0.003	0.546	0.299	2.944
Littman 2012	Yoga	0.197	-0.317	0.711	0.454	0.262	0.069	0.750
Swisher 2015	Get Fit for the Fight	0.676	-0.095	1.448	0.086	0.393	0.155	1.719
Cuesta-Vargas 2014	multimodal physiotherapy programme	-0.123	-0.718	0.472	0.685	0.303	0.092	-0.406
Culos-Reed 2010	Intervention	0.260	-0.236	0.756	0.304	0.253	0.064	1.029
Culos-Reed 2006	Yoga	0.855	0.186	1.523	0.012	0.341	0.116	2.505
DeLuca 2016	Intervention	1.491	0.533	2.449	0.002	0.489	0.239	3.050
O'Neill 2018	RESTORE	0.709	0.103	1.315	0.022	0.309	0.096	2.294
Dieli-Conwright 2018	Intervention	1.278	0.830	1.726	0.000	0.228	0.052	5.594
Cramer 2015	Yoga and meditation	0.641	0.017	1.266	0.044	0.319	0.101	2.013
Sandel 2005	Dance	0.527	-0.107	1.161	0.103	0.323	0.105	1.629
		0.386	0.242	0.529	0.000	0.073	0.005	5.256

Figure 2.3

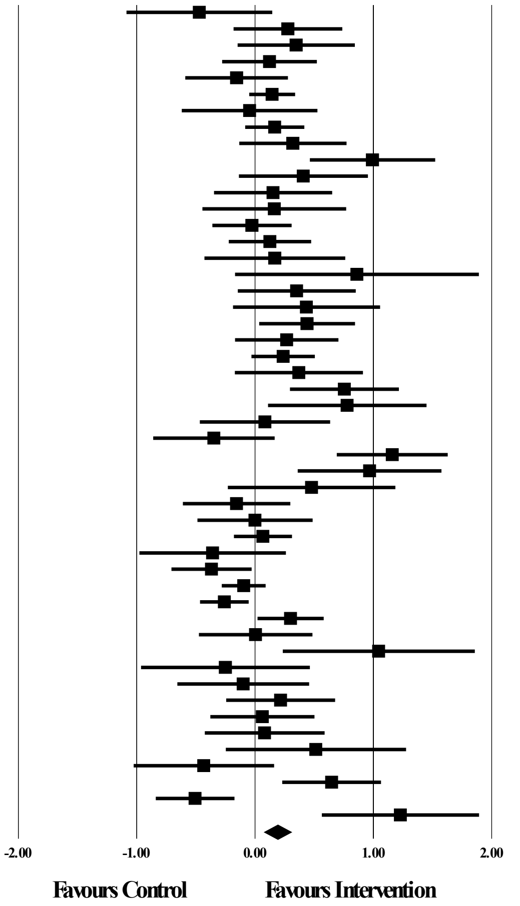
Forest plot of meta-analysis of effect sizes identified for each health behaviour intervention on post intervention physical well-being



Study name	Intervention	Statistics for each study						
		Hedges's g	Lower limit	Upper limit	p-Value	Standard error	Variance	Z-Value
Broderick 2013	PEACH	0.191	-0.418	0.801	0.538	0.311	0.097	0.615
Daley 2007	Exercise Therapy	0.351	-0.111	0.812	0.136	0.235	0.055	1.490
Ohira 2006	Weight Training for Breast Cancer Survivors	-0.527	-0.972	-0.083	0.020	0.227	0.051	-2.325
Murtezani 2014	Exercise group	0.718	0.210	1.226	0.006	0.259	0.067	2.772
Fillion 2008	Intervention	0.328	-0.076	0.732	0.111	0.206	0.042	1.591
Lahart 2016	Home based PA intervention	-0.032	-0.466	0.402	0.885	0.221	0.049	-0.145
Willems 2017	Kanker Nazorg Wijzer	0.204	0.009	0.399	0.040	0.099	0.010	2.054
vonGruenigen 2009	Intervention	-0.046	-0.620	0.528	0.875	0.293	0.086	-0.158
Kampshoff 2015	High and low intensity exercise	0.430	0.178	0.683	0.001	0.129	0.017	3.340
Kim 2019	Home-based exercise program	0.106	-0.345	0.558	0.644	0.230	0.053	0.462
Shobeiri 2016	Intervention	1.023	0.491	1.555	0.000	0.271	0.074	3.768
Vallerand 2018	telephone counseling exercise	-0.110	-0.651	0.431	0.689	0.276	0.076	-0.400
Brown 2022	Intervention	0.366	-0.138	0.870	0.154	0.257	0.066	1.425
Gorzelitz 2022	Intervention	0.078	-0.530	0.685	0.802	0.310	0.096	0.251
Singleton 2022	EMPOWER-SMS	0.356	0.018	0.695	0.039	0.173	0.030	2.062
LongParma 2022	Intervention	-4.976	-5.684	-4.267	0.000	0.362	0.131	-13.764
Demark-Wahnefried 2018	Harvest for health	-0.126	-0.720	0.469	0.679	0.303	0.092	-0.414
McKenzie 2003	Intervention	0.716	-0.300	1.732	0.167	0.518	0.269	1.381
Adams 2018	High Intensity Interval Training	-0.096	-0.592	0.400	0.704	0.253	0.064	-0.380
Hagstrom 2016	Intervention	0.393	-0.228	1.015	0.215	0.317	0.100	1.241
Casla 2015	Intervention	0.616	0.206	1.027	0.003	0.209	0.044	2.941
vandeWiel 2021	Internet-based PA Support program (IPAS)	-0.034	-0.471	0.402	0.877	0.223	0.050	-0.155
Rogers 2015	BEAT	0.369	0.099	0.638	0.007	0.138	0.019	2.676
Courneya 2003	Intervention	0.000	-0.537	0.537	1.000	0.274	0.075	0.000
Galiano-Castillo 2016	e-CUIDATE system	1.006	0.533	1.479	0.000	0.241	0.058	4.166
Braakhuis 2017	low fat diet	-0.338	-0.991	0.315	0.310	0.333	0.111	-1.016
Koutoukidis 2019	Shape Up following cancer treatment	0.236	-0.317	0.789	0.403	0.282	0.080	0.836
Winters-Stone 2016	Exercising Together	-0.027	-0.538	0.483	0.917	0.260	0.068	-0.104
Ghavami 2017	ACTIVE LIFESTYLE INTERVENTION	1.617	1.116	2.118	0.000	0.256	0.065	6.323
Kim 2011	Simultaneous Stage-Matched Exercise and Diet Intervention	0.499	-0.084	1.083	0.093	0.298	0.089	1.678
Strunk 2018	Kyusho Jitsu	-0.262	-0.963	0.439	0.464	0.358	0.128	-0.733
Ruiz-Vozmediano 2020	Intervention	0.174	-0.315	0.662	0.486	0.249	0.062	0.696
Short 2015	Move more for life tailored	0.014	-0.226	0.254	0.907	0.122	0.015	0.117
Rogers 2009	BEAT	-0.571	-1.199	0.057	0.075	0.320	0.103	-1.783
Livingston 2015	ENGAGE	-0.637	-0.981	-0.292	0.000	0.176	0.031	-3.618
Golsteijn 2018	OncoActive	-0.131	-0.317	0.055	0.167	0.095	0.009	-1.382
Holtdirk 2021	Optimune	0.310	0.104	0.517	0.003	0.105	0.011	2.943
Garcia-Soidan 2020	Aerobic	-0.097	-0.376	0.182	0.496	0.142	0.020	-0.681
Kristensen 2020	Nutri-Hub	0.413	-0.073	0.899	0.096	0.248	0.061	1.666
Moraes 2021	Resistence Training	0.656	-0.124	1.436	0.099	0.398	0.158	1.648
Pisu 2017	Rhythm	0.907	0.158	1.655	0.018	0.382	0.146	2.374
Blair 2021	Activpal	-0.026	-0.584	0.531	0.926	0.285	0.081	-0.092
Mardani 2021	Intervention	1.042	0.551	1.533	0.000	0.251	0.063	4.159
Bail 2018	Gardening	0.252	-0.190	0.695	0.264	0.226	0.051	1.118
Basen-Engquist 2006	Lifestyle program	0.378	-0.134	0.889	0.148	0.261	0.068	1.448
Swisher 2015	Get Fit for the Fight	0.571	-0.195	1.336	0.144	0.390	0.152	1.461
O'Neill 2018	RESTORE	0.000	-0.587	0.587	1.000	0.299	0.090	0.000
Dieli-Conwright 2018	Intervention	1.248	0.802	1.694	0.000	0.228	0.052	5.485
Winkels 2017	Exercise and Weightloss	0.071	-0.257	0.400	0.670	0.168	0.028	0.426
Cramer 2015	Yoga and meditation	0.408	-0.206	1.023	0.193	0.314	0.098	1.302
		0.169	0.001	0.336	0.048	0.085	0.007	1.977

Figure 2.4

Forest plot of meta-analysis of effect sizes identified for each health behaviour intervention on post intervention emotional well-being

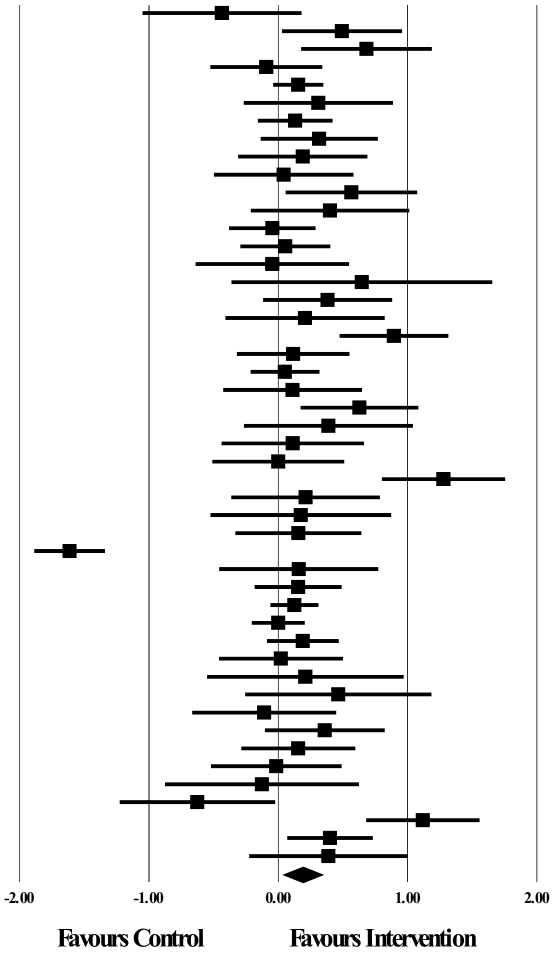


Study name	Intervention	Statistics for each study						
		Hedges's g	Lower limit	Upper limit	p-Value	Standard error	Variance	Z-Value
Broderick 2013	PEACH	-0.470	-1.087	0.147	0.135	0.315	0.099	-1.493
Daley 2007	Exercise Therapy	0.278	-0.182	0.738	0.236	0.235	0.055	1.185
Murtezani 2014	Exercise group	0.348	-0.148	0.844	0.169	0.253	0.064	1.376
Fillion 2008	Intervention	0.122	-0.279	0.524	0.550	0.205	0.042	0.598
Lahart 2016	Home based PA intervention	-0.155	-0.590	0.280	0.484	0.222	0.049	-0.699
Willems 2017	Kanker Nazorg Wijzer	0.145	-0.050	0.339	0.145	0.099	0.010	1.459
vonGruenigen 2009	Intervention	-0.046	-0.620	0.529	0.876	0.293	0.086	-0.156
Kampshoff 2015	High and low intensity exercise	0.166	-0.084	0.417	0.193	0.128	0.016	1.303
Kim 2019	Home-based exercise program	0.320	-0.134	0.774	0.167	0.232	0.054	1.382
Shobeiri 2016	Intervention	0.993	0.463	1.523	0.000	0.270	0.073	3.671
Vallerand 2018	telephone counseling exercise	0.409	-0.138	0.955	0.143	0.279	0.078	1.465
Brown 2022	Intervention	0.152	-0.348	0.652	0.551	0.255	0.065	0.597
Gorzelitz 2022	Intervention	0.163	-0.445	0.772	0.599	0.310	0.096	0.525
Singleton 2022	EMPOWER-SMS	-0.026	-0.362	0.310	0.881	0.171	0.029	-0.150
LongParma 2022	Intervention	0.126	-0.223	0.475	0.481	0.178	0.032	0.705
Demark-Wahnefried 2018	Harvest for health	0.168	-0.428	0.763	0.581	0.304	0.092	0.552
McKenzie 2003	Intervention	0.862	-0.170	1.893	0.102	0.526	0.277	1.637
Adams 2018	High Intensity Interval Training	0.353	-0.147	0.852	0.167	0.255	0.065	1.383
Hagstrom 2016	Intervention	0.435	-0.187	1.058	0.171	0.318	0.101	1.370
Casla 2015	Intervention	0.440	0.034	0.846	0.034	0.207	0.043	2.125
vandeWiel 2021	Internet-based PA Support program (IPAS)	0.268	-0.170	0.706	0.231	0.224	0.050	1.198
Rogers 2015	BEAT	0.238	-0.031	0.506	0.083	0.137	0.019	1.736
Courneya 2003	Intervention	0.370	-0.171	0.912	0.180	0.276	0.076	1.340
Galiano-Castillo 2016	e-CUIDATE system	0.755	0.294	1.216	0.001	0.235	0.055	3.210
Braakhuis 2017	low fat diet	0.779	0.109	1.450	0.023	0.342	0.117	2.277
Koutoukidis 2019	Shape Up following cancer treatment	0.084	-0.467	0.636	0.765	0.281	0.079	0.299
Winters-Stone 2016	Exercising Together	-0.347	-0.862	0.167	0.186	0.262	0.069	-1.323
Ghavami 2017	ACTIVE LIFESTYLE INTERVENTION	1.160	0.690	1.630	0.000	0.240	0.057	4.840
Kim 2011	Simultaneous Stage-Matched Exercise and Diet Intervention	0.968	0.360	1.576	0.002	0.310	0.096	3.121
Strunk 2018	Kyusho Jitsu	0.478	-0.230	1.186	0.186	0.361	0.131	1.323
Koutoukidis 2020	MASCOT	-0.155	-0.610	0.300	0.504	0.232	0.054	-0.669
Ruiz-Vozmediano 2020	Intervention	0.000	-0.488	0.488	1.000	0.249	0.062	0.000
Short 2015	Move more for life tailored	0.067	-0.179	0.313	0.594	0.126	0.016	0.533
Rogers 2009	BEAT	-0.359	-0.979	0.262	0.257	0.316	0.100	-1.133
Livingston 2015	ENGAGE	-0.368	-0.707	-0.028	0.034	0.173	0.030	-2.123
Golsteijn 2018	OncoActive	-0.095	-0.282	0.091	0.316	0.095	0.009	-1.003
Holtdirk 2021	Optimune	-0.259	-0.465	-0.053	0.014	0.105	0.011	-2.461
Garcia-Soidan 2020	Aerobic	0.301	0.020	0.581	0.035	0.143	0.020	2.103
Kristensen 2020	Nutri-Hub	0.005	-0.475	0.486	0.983	0.245	0.060	0.021
Moraes 2021	Resistence Training	1.046	0.234	1.858	0.012	0.414	0.172	2.524
Pisu 2017	Rhythm	-0.250	-0.964	0.464	0.493	0.364	0.133	-0.686
Blair 2021	Activpal	-0.099	-0.657	0.459	0.727	0.285	0.081	-0.349
Mardani 2021	Intervention	0.216	-0.245	0.678	0.358	0.235	0.055	0.919
Bail 2018	Gardening	0.063	-0.378	0.504	0.780	0.225	0.051	0.279
Basen-Engquist 2006	Lifestyle program	0.081	-0.425	0.588	0.753	0.259	0.067	0.315
Swisher 2015	Get Fit for the Fight	0.514	-0.248	1.277	0.186	0.389	0.151	1.322
O'Neill 2018	RESTORE	-0.432	-1.026	0.162	0.154	0.303	0.092	-1.427
Dieli-Conwright 2018	Intervention	0.648	0.229	1.066	0.002	0.213	0.046	3.035
Winkels 2017	Exercise and Weightloss	-0.506	-0.840	-0.173	0.003	0.170	0.029	-2.973
Cramer 2015	Yoga and meditation	1.230	0.564	1.895	0.000	0.339	0.115	3.622
		0.185	0.082	0.289	0.000	0.053	0.003	3.498

Figure 2.5

Forest plot of meta-analysis of effect sizes identified for each health behaviour intervention on post intervention social well-being

Study name	Intervention	Statistics for each study Hedges's g	Lower limit	Upper limit	p-Value	Standard error	Variance	Z-Value
Broderick 2013	PEACH	-0.435	-1.051	0.180	0.166	0.314	0.099	-1.386
Daley 2007	Exercise Therapy	0.492	0.028	0.957	0.038	0.237	0.056	2.077
Murtezani 2014	Exercise group	0.683	0.176	1.189	0.008	0.258	0.067	2.642
Lahart 2016	Home based PA intervention	-0.093	-0.527	0.342	0.676	0.222	0.049	-0.418
Willems 2017	Kanker Nazorg Wijzer	0.154	-0.041	0.348	0.121	0.099	0.010	1.550
vonGruenigen 2009	Intervention	0.310	-0.268	0.888	0.293	0.295	0.087	1.052
Kampshoff 2015	High and low intensity exercise	0.131	-0.159	0.421	0.375	0.148	0.022	0.887
Kim 2019	Home-based exercise program	0.317	-0.137	0.771	0.171	0.232	0.054	1.368
Shobeiri 2016	Intervention	0.190	-0.311	0.691	0.457	0.255	0.065	0.743
Vallerand 2018	telephone counseling exercise	0.043	-0.498	0.583	0.877	0.276	0.076	0.154
Brown 2022	Intervention	0.566	0.056	1.075	0.030	0.260	0.068	2.176
Gorzelitz 2022	Intervention	0.401	-0.213	1.015	0.200	0.313	0.098	1.280
Singleton 2022	EMPOWER-SMS	-0.046	-0.382	0.290	0.790	0.171	0.029	-0.266
LongParma 2022	Intervention	0.054	-0.295	0.403	0.761	0.178	0.032	0.304
Demark-Wahnefried 2018	Harvest for health	-0.046	-0.640	0.548	0.880	0.303	0.092	-0.151
McKenzie 2003	Intervention	0.646	-0.363	1.656	0.210	0.515	0.265	1.254
Adams 2018	High Intensity Interval Training	0.382	-0.118	0.882	0.134	0.255	0.065	1.497
Hagstrom 2016	Intervention	0.207	-0.410	0.824	0.511	0.315	0.099	0.657
Casla 2015	Intervention	0.895	0.474	1.316	0.000	0.215	0.046	4.167
vandeWiel 2021	Internet-based PA Support program (IPAS)	0.115	-0.322	0.552	0.605	0.223	0.050	0.517
Rogers 2015	BEAT	0.052	-0.216	0.320	0.704	0.137	0.019	0.381
Courneya 2003	Intervention	0.111	-0.427	0.648	0.686	0.274	0.075	0.404
Galiano-Castillo 2016	e-CUIDATE system	0.628	0.172	1.084	0.007	0.233	0.054	2.697
Braakhuis 2017	low fat diet	0.387	-0.267	1.041	0.246	0.334	0.111	1.161
Koutoukidis 2019	Shape Up following cancer treatment	0.112	-0.440	0.663	0.691	0.281	0.079	0.398
Winters-Stone 2016	Exercising Together	0.000	-0.511	0.511	1.000	0.260	0.068	0.000
Ghavami 2017	ACTIVE LIFESTYLE INTERVENTION	1.278	0.801	1.755	0.000	0.243	0.059	5.251
Kim 2011	Simultaneous Stage-Matched Exercise and Diet Intervention	0.211	-0.365	0.787	0.472	0.294	0.086	0.719
Strunk 2018	Kyusho Jitsu	0.174	-0.525	0.873	0.626	0.357	0.127	0.488
Ruiz-Vozmediano 2020	Intervention	0.155	-0.333	0.644	0.533	0.249	0.062	0.624
Short 2015	Move more for life tailored	-1.614	-1.888	-1.339	0.000	0.140	0.020	-11.513
Rogers 2009	BEAT	0.159	-0.458	0.775	0.614	0.314	0.099	0.504
Livingston 2015	ENGAGE	0.154	-0.183	0.491	0.371	0.172	0.030	0.894
Golsteijn 2018	OncoActive	0.125	-0.062	0.311	0.190	0.095	0.009	1.310
Holtdirk 2021	Optimune	0.000	-0.205	0.205	1.000	0.105	0.011	0.000
Garcia-Soidan 2020	Aerobic	0.190	-0.090	0.469	0.183	0.143	0.020	1.332
Kristensen 2020	Nutri-Hub	0.021	-0.460	0.501	0.933	0.245	0.060	0.085
Moraes 2021	Resistence Training	0.209	-0.552	0.970	0.590	0.388	0.151	0.539
Pisu 2017	Rhythm	0.464	-0.257	1.186	0.207	0.368	0.135	1.262
Blair 2021	Activpal	-0.109	-0.667	0.449	0.701	0.285	0.081	-0.383
Mardani 2021	Intervention	0.360	-0.104	0.824	0.129	0.237	0.056	1.519
Bail 2018	Gardening	0.155	-0.287	0.596	0.493	0.225	0.051	0.686
Basen-Engquist 2006	Lifestyle program	-0.015	-0.522	0.491	0.953	0.258	0.067	-0.059
Swisher 2015	Get Fit for the Fight	-0.126	-0.878	0.625	0.742	0.383	0.147	-0.330
ONeill 2018	RESTORE	-0.626	-1.227	-0.024	0.042	0.307	0.094	-2.038
Dieli-Conwright 2018	Intervention	1.119	0.680	1.557	0.000	0.224	0.050	4.997
Winkels 2017	Exercise and Weightloss	0.400	0.069	0.732	0.018	0.169	0.029	2.365
Cramer 2015	Yoga and meditation	0.388	-0.226	1.002	0.215	0.313	0.098	1.239
		0.185	0.044	0.326	0.010	0.072	0.005	2.566



Subgroup analyses

Table 2.2 summarises the results of the pre-specified subgroup analyses conducted to examine differences arising from the inclusion of a mental health component, mode of delivery, and the duration of the intervention on each of the QoL outcomes.

Mental health component. There were no significant subgroup associations between including a mental health component. Heterogeneity varied across these analyses: Heterogeneity was high/considerable on total QoL and emotional well-being subscales, whereas physical well-being and social wellbeing had no significant heterogeneity.

Modality. The mode of delivery subgroup analyses demonstrated a significant subgroup effect on Total QoL and physical well-being. For total QoL, the individual (g = 0.65, 96% CI [0.27, 1.03]) and group modalities (g = 0.35, 95% CI [0.14, 0.57]) were associated with significant positive effects (favouring the intervention group). No other delivery modality was significant. Conversely, on the physical well-being outcome, only the individual modality (g = 0.36, 95% CI [0.03, 0.68]) was associated with a significant positive effect (favouring the intervention). However, these results should be interpreted with caution due to covariation distribution. Only two or three trials were included in the analysis for the print, telehealth, and multiple subgroups. Therefore, we cannot confidentially conclude that this is a true subgroup effect. Heterogeneity notably reduced in the group modality subgroup with the social well-being outcome and reduced in the smaller groups across the analyses, specifically the telephone and print subgroups.

Intervention duration. There was a significant subgroup effect of intervention duration on the Physical well-being outcome. Shorter interventions (g = 0.33, 95% CI [0.18, 0.49]) were associated with a small positive effect and favoured the intervention group, whereas longer interventions (g = -0.04 [-0.35, 0.26]) did not demonstrate a significant effect. However, substantial unexplained heterogeneity remained within each of the subgroups.

Post hoc subgroup analyses. The post hoc subgroup analyses exploring additional sources of heterogeneity are also presented in **Table 2.2**. None of the post-hoc subgroup analyses identified significant associations across all outcomes. Heterogeneity remained high/considerable across these subgroup analyses, except for studies which used a specified QoL as their primary outcome on the social wellbeing subscale (I^2 = 15.20), and studies which used the SF to measure physical wellbeing (I^2 = 32.64) and social well-being subscales (I^2 = 22.69).

Table 2.2

Pre-specified and post hoc subgroup analyses

Meta-analysis	N Interventions	Sub-group (N interventions)	*Hedge's g* [95% CI]	Difference between subgroups: *Q*	Heterogeneity	
					I^2	*Q*
			Total QoL			
Mental Health	48	Yes (11)	0.28 [0.13, 0.43]	1.20, df = 1, *p* = 0.27	36.26	15.69, df = 10, *p* = .11
		No (37)	0.41 [0.22, 0.60]		83.67	220.41, df = 36, *p* <.001
Mode of delivery	47	Individual (16)	0.65 [0.27, 1.03]	15.48, df = 5, *p* =.01*	87.42	119.27, df = 15, *p* <.001
		Group (20)	0.35 [0.14, 0.57]		71.28	66.15, df = 16, *p* <.001
		Digital (5)	0.26 [-0.02, 0.53]		79.58	19.59, df = 4, *p* <.001
		Telehealth (2)	0.14 [-0.15, 0.44]		0	0.41, df = 5, *p* = 0.52†
		Print (2)	-0.11 [-0.33, 0.11]		0	0.16, df = 1, *p* = 0.69†
		Multiple (2)	0.21 [-0.46, 0.88]		81.75	5.48, df = 1, *p* = 0.02
Duration	48	≤12 (29)	0.35 [0.18, 0.51]	0.44, df = 1, *p* = 0.50	73.88	107.18, df =28, *p* <.001
		≥13 (19)	0.45 [0.19, 0.71]		86.01	128.68, df =17, *p* <.001

Table 2.2 continued

Meta-analysis	N Interventions	Sub-group (N interventions)	*Hedge's g* [95% CI]	Difference between subgroups: *Q*	Heterogeneity	
					I^2	*Q*
Multi component	48	Yes (18)	0.50 [0.26, 0.74]	1.36, df = 1, *p* = 0.24	80.85	88.77, df = 17, *p* <.001
		No (30)	0.32 [0.14, 0.50]		79.84	143.88, df = 29, *p* <.001
Measure	43	FACT (26)	0.33 [0.16, 0.49]	0.93, df = 1, *p* = 0.33	64.44	70.30, df = 25, *p* <.001
		EORTC QLQ-C30 (17)	0.48 [0.20, 0.77]		88.92	144.39, df = 16, *p* <.001
Level of measure	48	Primary (18)	0.42 [0.21, 0.63]	0.16, df = 1, *p* = 0.69	76.63	72.73, df = 17, *p* <.001
		Secondary (30)	0.37 [0.17, 0.56]		82.00	161.07, df = 29, *p* <.001
			Physical Well-being			
Mental Health	50	Yes (14)	0.24 [0.15, 0.33]	0.34, df = 1, *p* = 0.56	0	11.39, df = 13, *p* =0.58†
		No (36)	0.17 [-0.07, 0.40]		90.95	370.32, df = 35, *p*<.001
Mode of delivery	49	Individual (16)	0.36 [0.03, 0.68]	15.95, df = 4, *p* = 0.003*	83.93	93.31, df = 15, *p*<.001
		Group (22)	-0.03 [-0.36, 0.31]		91.30	241.28, df = 21, *p*<.001
		Digital (6)	0.20 [-0.06, 0.46]		80.01	25.01, df = 5, *p*<.001
		Telehealth (3)	0.27 [-0.05, 0.58]		26.95	2.74, df = 2, *p* = 0.26†

Table 2.2 continued

Meta-analysis	N Interventions	Sub-group (N interventions)	*Hedge's g* [95% CI]	Difference between subgroups: *Q*	Heterogeneity	
					I^2	*Q*
		Print (2)	0.51 [-0.50, 1.51]		92.64	13.58, df =1, *p*<.001
Duration	50	≤12 (27)	0.33 [0.18, 0.49]	46.73, df = 1, *p* = 0.03*	69.07	84.06, df = 26, *p*<.001
		≥13 (23)	-0.04 [-0.35, 0.26]		92.48	279.11, df = 22, *p*<.001
Multi component	50	Yes (23)	0.29 [0.16, 0.42]	1.87, df = 1, *p* = 0.17	52.59	46.40, df = 22 *p* = .002
		No (27)	0.07 [-0.22, 0.35]		91.96	323.57, df = 26, *p*<.001
Measure	55	FACT (17)	-0.07 [-0.52, 0.38]	3.72, df = 2, *p* = 0.16	93.44	243.93, df = 16, *p*<.001
		EORTC QLQ-C30 (16)	0.39 [0.13, 0.64]		85.67	104.71, df = 15, *p*<.001
		SF (15)	0.16 [0.01, 0.31]		32.64	20.78, df =14, *p*=0.11†
Level of measure	48	Primary (15)	0.31 [0.11, 0.52]	1.87, df =1, *p* = 0.17	73.75	53.33, df = 14, *p* <.001
		Secondary (35)	0.10 [-0.13,0 0.33]		89.57	326.11, df = 34, *p* <.001
			Emotional Well-being			
Mental Health	50	Yes (14)	0.14 [-0.04, 0.31]	0.39, df = 1, *p* = 0.53	61.75	33.99, df = 13, *p* = .001
		No (36)	0.21 [0.08, 0.36]		67.45	107.54, df = 35, *p* <.001

Table 2.2 continued

Meta-analysis	N Interventions	Sub-group (N interventions)	*Hedge's g* [95% CI]	Difference between subgroups: Q	Heterogeneity	
					I^2	Q
Mode of delivery	49	Individual (17)	0.30 [0.08, 0.51]	3.27, df = 4, p = 0.51	66.27	47.44, df = 16, p <.001
		Group (21)	0.12 [-0.05, 0.28]		62.71	53.63, df = 20, p <.001
		Digital (6)	0.08 [-0.16, 0.32]		76.24	21.05, df = 5, p =.001
		Telehealth (3)	0.41 [-0.17, 0.98]		75.82	8.27, df = 2, p =.02
		Print (2)	0.10 [-0.12, 0.32]		53.74	2.16, df = 1, p = .14†
Duration	50	≤12 (27)	0.23 [0.08, 0.39]	0.84, df = 1, p = 0.36	68.45	82.42, df = 26, p <.001
		≥13 (23)	0.14 [-0.01, 0.28]		63.25	59.87, df = 22, p <.001
Multi component	50	Yes (23)	0.21 [0.04, 0.38]	0.13, df = 1, p = 0.72	71.92	78.36, df = 22, p <.001
		No (27)	0.17 [0.04, 0.30]		59.73	64.56, df = 26, p <.001
Measure	49	FACT (18)	0.22 [0.06, 0.37]	0.50, df = 2, p = 0.78	49.11	33.40, df = 17, p =.01
		EORTC QLQ-C30 (16)	0.23 [0.04, 0.43]		75.61	61.51, df = 15, p <.001
		SF (15)	0.14 [-0.05,0.33]		55.88	31.73, df = 14, p = .004

Table 2.2 continued

Meta-analysis	N Interventions	Sub-group (N interventions)	*Hedge's g* [95% CI]	Difference between subgroups: *Q*	Heterogeneity	
					I^2	*Q*
Level of measure	50	Primary (14)	0.33 [0.13, 0.53]	2.89, df = 1, *p* = 0.09	71.43	45.50, df = 13, *p* <.001
		Secondary (36)	0.13 [0.004, 0.25]		63.02	94.65, df = 35, *p* <.001
			Social Well-being			
Mental Health	48	Yes (13)	0.07 [-0.03, 0.17]	2.15, df = 1, *p* = 0.14	0	9.72, df = 12, *p* = 0.64†
		No (35)	0.23 [0.03, 0.43]		85.70	237.70, df = 34, *p* <.001
Mode of delivery	48	Individual (16)	0.40 [0.18, 0.62]	7.30, df = 4, *p* = 0.12	65.20	43.11, df = 15, *p* <.001
		Group (21)	0.16 [0.04, 0.28]		26.88	6.84, df = 20, *p* = .15†
		Digital (6)	0.13 [-0.01, 0.26]		56.97	11.62, df = 5, *p* = 0.02
		Telehealth (3)	0.03 [-0.23, 0.28]		0	0.58, df = 2, *p* = 0.75†
		Print (2)	-0.63 [-2.57, 1.30]		98.06	51.46, df = 1, *p* = 0.99†
Duration	48	≤12 (26)	0.15 [-0.10, 0.39]	0.35, df = 1, *p* = 0.56	86.89	190.68, df = 25, *p* <.001
		≥13 (22)	0.23 [0.09, 0.36]		57.19	49.05, df = 21, *p* <.001
Multi component	48	Yes (22)	0.21 [0.06, 0.35]	0.13, df = 1, *p* = 0.72	59.14	51.39, df = 21, *p* <.001

Table 2.2 continued

Meta-analysis	N Interventions	Sub-group (N interventions)	*Hedge's g* [95% CI]	Difference between subgroups: *Q*	Heterogeneity	
					I^2	*Q*
Measure	47	No (26)	0.16 [-0.05, 0.37]	0.25, df = 2, p = 0.88	87.98	153.14, df = 25, p <.001
		FACT (17)	0.14 [-0.24, 0.51]		91.05	178.68, df = 16, p <.001
		EORTC QLQ-C30 (16)	0.22 [0.07, 0.37]		67.31	45.89, df = 15, p <.001
Level of measure	48	SF (14)	0.24 [0.09, 0.39]	0.85, df = 1, p = 0.36	22.69	16.82, df = 13, p = .21†
		Primary (14)	0.24 [0.13, 0.36]		15.20	15.33, df = 13, p = 0.29†
		Secondary (34)	0.14 [-0.06, 0.33]		85.48	227.33, df = 33, p <.001

* Indicates that the difference between groups is p <0.05

† Indicates that heterogeneity in this group is not significant

Narrative synthesis of interventions on QoL

Twenty-two studies investigating 31 interventions were excluded from the meta-analysis as they did not provide post-treatment means and standard deviations (Alibhai et al., 2014; Baruth et al., 2015; Brown et al., 2018; Brown et al., 2021; Chang et al., 2020; Fernandez-Lao et al., 2013; Herrero et al., 2006; Kwiatkowski et al., 2017; Ligibel et al., 2012; McCarroll et al., 2014; Morey et al., 2009; Naumann et al., 2012b; Park et al., 2015; Park et al., 2019; Reeves et al., 2021; Saarto et al., 2012; Speck et al., 2010b; Thorsen et al., 2005; Toohey et al., 2018; Vallance et al., 2008; Wang et al., 2021). Total QoL was reported in 14 studies evaluating 19 interventions. Of these, five (26.3%) interventions demonstrated significant improvements compared to control (Brown et al., 2018; Herrero et al., 2006; Kwiatkowski et al., 2017; Naumann et al., 2012b; Toohey et al., 2018). For physical well-being, 10 of the 25 interventions (40%) reporting this outcome showed significant improvements compared to control (Baruth et al., 2015; Brown et al., 2018; Chang et al., 2020; Herrero et al., 2006; McCarroll et al., 2014; Toohey et al., 2018). In terms of emotional well-being, six of the 24 interventions (25%) reported greater improvements in the intervention group (Baruth et al., 2015; Brown et al., 2018; Naumann et al., 2012b; Toohey et al., 2018), though in one study (Park et al., 2019) this benefit was only found in a subgroup of participants (those not currently taking endocrine therapy). Lastly, for social well-being, only one out of 25 interventions reported significant improvements compared to a waitlist intervention (Chang et al., 2020). Moreover, Saarto and colleagues (Saarto et al., 2012) found that an aerobic exercise intervention demonstrated significantly *less* change over time in social well-being compared to the usual care control group.

Three studies investigated five interventions with a mental health component, all of which showed significant improvements in at least one area of QoL. Three of the interventions utilised an individual counselling group and demonstrated significant improvements in total QoL (Kwiatkowski et al., 2017; Naumann et al., 2012b), physical well-being (Naumann et al., 2012a; Naumann et al., 2012b), and emotional well-being (Naumann et al., 2012b) compared to the control groups. Naumann and colleagues (Naumann et al., 2012b) also investigated group counselling, which demonstrated significant improvements in physical well-being compared to the control group. Lastly, one intervention investigated by Chang and colleagues (2020) involved an e-health booklet on psychological adjustment after cancer and this intervention demonstrated significant improvements in physical well-being and social well-being compared to the control group.

In terms of mode of delivery, all interventions that demonstrated significant improvements in all QoL measures utilised face-to-face delivery (individual n = 6, group n = 3; Brown et al., 2018; Chang et al., 2020; Herrero et al., 2006; Kwiatkowski et al., 2017; Naumann et al., 2012b; Toohey et al., 2018), with the exception of one telehealth intervention implemented by Baruth and colleagues (2015), which demonstrated significant improvements in physical well-being and emotional well-being in comparison to the control group.

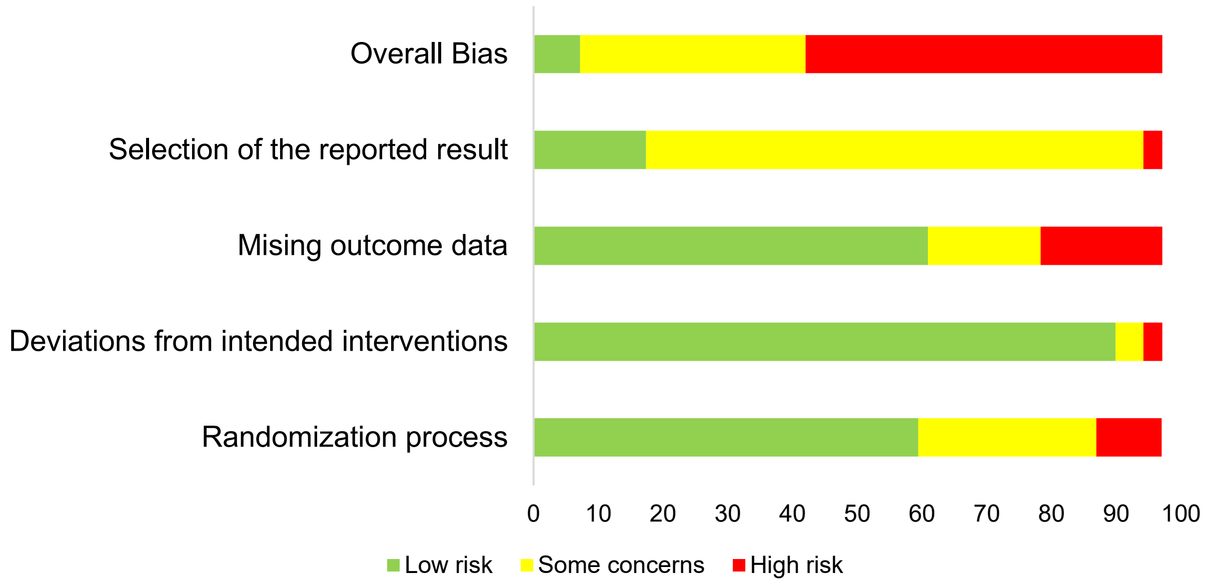
Finally, with regards to duration, 17 interventions were offered over 12 weeks or less. Of these interventions, four (23.5%) demonstrated improvements in total QoL (Herrero et al., 2006; Kwiatkowski et al., 2017; Naumann et al., 2012b; Toohey et al., 2018), seven (41.2%) demonstrated significant improvements in physical well-being (Baruth et al., 2015; Chang et al., 2020; Herrero et al., 2006; Naumann et al., 2012a; Naumann et al., 2012b; Toohey et al., 2018), four (23.5%) demonstrated significant improvements in emotional well-being (Baruth et al., 2015; Naumann et al., 2012b; Toohey et al., 2018), and one (5.8%) demonstrated significant improvements in social well-being (Chang et al., 2020) compared to the control group. Fourteen interventions were delivered over 13 weeks or more. Only one (7.1%) intervention demonstrated improvements in total QoL (Brown et al., 2018), three (21.4%) demonstrated improvements in physical well-being (Brown et al., 2018; Brown et al., 2021; McCarroll et al., 2014), and one (7.1%) demonstrated improvements in emotional well-being in comparison to the control group (Brown et al., 2018).

Risk of Bias

The results from the risk of bias assessment are presented in **Appendix C** and a visual representation is provided in **Figure 2.6**. Overall, the risk of bias was high for 55.9% of papers included in the meta-analysis. Domain 5, selection of the reported result, was the biggest contributor for risk of bias concerns, as most of the studies did not publish prespecified measurements or a data analysis plan. Consequently, only 5 studies were rated as having low risk of bias.

Figure 2.6

Risk of bias assessment for included domains as percentages across all studies included in the meta-analysis.



Publication bias

Publication bias was indicated by the Egger's regression intercept for the Total QoL outcome, 1.90, 95% CI [0.40, 3.40], *p* = .01, and the Emotional Well-being subscale, 1.92, 95% CI [0.09, 3.75], *p* = .04.

Discussion

This meta-analysis addressed the first aim of this thesis by updating and extending the current evidence for the use of healthy lifestyle interventions to improve the QoL in post-treatment cancer survivors. Overall, results from the meta-analysis indicate a small but significant effect in favour of healthy lifestyle interventions positive impact on total quality of life and on the dimensions of physical well-being, emotional well-being, and social well-being compared to a usual care or waitlist control. However, there was notable heterogeneity among the included studies and the majority did not find a significant effect of the intervention on all QoL outcomes. This finding was corroborated by studies included in the narrative synthesis, where out of 22 healthy lifestyle interventions examined, 17 did not differ from the usual care or waitlist control groups in each of the QoL domains. The observed heterogeneity in the results aligns with the inconsistencies found in previous research on this topic (Heredia-Ciuró et al., 2022; Roberts et al., 2017).

A unique contribution of this study was to investigate whether the association between the intervention and QoL is moderated by key intervention characteristics, primarily the inclusion of a mental health component. There was no evidence that the inclusion of a mental health component impacted the association between participation in a healthy lifestyle intervention and QoL. Consequently, there is a discrepancy between what cancer survivors request to be part of a healthy living program and support from current research on these interventions impact on QoL. A potential explanation is that improving physical well-being through physical activity and diet also addresses emotional well-being and overall QoL (Patsou et al., 2017). However, it is premature to discount the usefulness of including a mental health component, given the small number of studies which continued to display high levels of heterogeneity. Consequently, more evidence is required to appropriately answer this question. Alternatively, including a mental health component may have benefits in other areas, such as addressing barriers experienced by cancer survivors in participating in physical activity and a nutritious diet (Cho & Park, 2018; Ventura et al., 2013). Furthermore, as identified in **Chapter 1**, psychosocial issues are one of the most prominent unmet needs described by cancer survivors (Lisy et al., 2019) and including a component addressing these has the potential to make cancer survivors feel more supported following treatment. Therefore, future reviews might consider investigating whether including a mental health component increases in a healthy lifestyle intervention is associated with increased physical activity and diet outcomes or promotes more positive qualitative feedback compared to interventions compared to interventions which do not.

In contrast, mode of delivery and intervention duration emerged as predictors of intervention efficacy. Face-to-face delivery, either individually or in a group format, were associated with significantly higher total QoL. Individual face-to-face delivery was also associated with significantly higher physical well-being. Similarly, shorter interventions delivered over twelve weeks or less were associated with greater improvements in physical well-being. This finding aligns to some extent with the findings from a meta-analysis completed by Ferrer et al. (2011), which investigated exercise interventions for cancer survivors and also found that intervention duration was inversely associated with QoL outcomes. However, Ferrer et al. (2011) found one exception to this relationship where the *intensity* of the intervention moderated outcomes, such that longer interventions (i.e., 26 weeks) with *higher* intensity exercise were associated with greater changes in QoL than shorter interventions (i.e., 8 weeks) and/or interventions with lower intensity exercise. Thus, while select longer interventions may be beneficial, collectively the weight of evidence from both prior and current meta-analyses support the implementation of short-term and face-to-face delivered healthy lifestyle interventions at the completion of cancer treatment, particularly for those looking to improve their physical well-being.

Nagpal et al. (2021) have previously recommended that adherence is an important consideration when evaluating the efficacy of exercise interventions, due to the implications on whether participants receive the recommended ‘dose.’ Shorter durations and face-to-face modalities may promote greater engagement and adherence by minimizing time commitments and enhancing accountability (McPhate et al., 2013; Short et al., 2017). Further, interventions involving intense exercise may necessitate supervision to ensure participant safety and offer the advantage of increased accountability and tailoring. However, adherence data was not extracted in either the current study, nor the meta-analysis conducted by Ferrer et al. (2011). To date, no research has directly compared the degree of adherence to shorter verses longer for healthy lifestyle interventions in the cancer survivor or relevant populations, such as older individuals or individuals with other chronic health conditions. Consequently, future primary research should consider comparing the same healthy lifestyle interventions with differing durations or delivery modalities to investigate adherence and its relationship to QoL outcomes. Future reviews should consider extracting adherence data to investigate its relationship with other intervention characteristics and outcomes. This meta-analysis provides preliminary evidence to suggest that interventions delivered via telephone or online can lead to comparable outcomes to face-to-face interventions, however more studies are required to compare the different delivery modalities on QoL in cancer survivors.

Limitations

Although the overall meta-analysis and subgroup analyses yielded significant findings, these results should be interpreted with caution due to high levels of heterogeneity, limited power, high risk of bias, and lack of follow up data. High levels of heterogeneity are commonly reported in meta-analyses on this topic. Notable heterogeneity continued across the pre-defined subgroup analyses, with only a reduction observed in individual subgroups, typically characterised by a low number of included studies (i.e., fewer than 10 studies). Additionally, the current meta-analysis may have limited power to detect an effect of the healthy lifestyle interventions on QoL, as less than one third of the included studies were designed to measure QoL. Consequently, the majority of the included studies may not be adequately powered to detect an effect on QoL. We attempted to address these limitations through post-hoc subgroup analyses investigating multi- verses single-component interventions, whether QoL was measured as a primary or secondary outcome, and the type of outcome used, however, nil differences or reductions in heterogeneity were observed. Additionally, the validity of the results may be impacted by the quality of the studies, as the majority of them presented with a high risk of bias. Finally, as this current meta-analysis did not extract follow-up data, we are unable to evaluate whether the effects on QoL are maintained after the intervention period.

Additionally, there may be clinical factors that may moderate the effect of healthy living interventions on QoL in cancer survivors that were not explored in this study. A recent follow up analysis conducted by Schleicher et al. (2022) identified that breast cancer survivors participating the BEAT intervention who had a longer time since diagnosis (>24 months) and those who did not have a history of chemotherapy demonstrated greater increases in QoL. Schleicher et al. (2022) suggested that this may be due to perceived physical functioning, as cancer survivors with a more recent diagnosis may be experiencing acute side effects from treatment, such as fatigue and nausea. Future systematic reviews and meta-analyses should consider time since diagnosis and treatment type potential moderating factors of the effect of healthy living interventions on cancer survivors QoL.

Conclusion

Overall, the current meta-analysis suggests that participating in any healthy lifestyle intervention following cancer treatment is likely to have positive benefits on QoL. Interventions which are of a shorter duration (that is, 12 weeks or less) or delivered face-to-face may have a greater impact on the efficacy of such interventions. However, this modality will be constrained by the accessibility and sustainability barriers outlined in **Chapter 1,** including the cost and resources required to deliver these programs, lack of established referral pathways (Kennedy et al., 2021), and low engagement of cancer survivors due to competing priorities and/or high levels of fatigue (Corbett et al., 2018). It also remains premature to dismiss digital modalities, given only a few randomised control trials to date have investigated alternative delivery modalities. Furthermore, there were few randomised control trials conducted that investigated the inclusion of a mental health component to healthy lifestyle interventions. Consequently, there is a need for future research to develop and rigorously evaluate healthy lifestyle interventions which also address mental health and utilise accessible delivery modalities. These findings therefore provide the foundation for the development of an online healthy lifestyle program, which is the focus of **Chapter 3**.

Chapter 3.

Co-designing Healthy Living after Cancer Online, an online nutrition, physical activity, and psychosocial intervention for post-treatment cancer survivors.[2]

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[2] Findings from this chapter have been published and can be found in **Appendix D**

Leske, M., Koczwara, B., Blunt, J., Morris, J., Eakin, E., Short, C.E., Daly, A., Degner, J. & & Beatty, L. (2022). Co-designing Healthy Living after Cancer Online: an online nutrition, physical activity, and psychosocial intervention for post-treatment cancer survivors. *Journal of Cancer Survivorship*. https://doi.org/10.1007/s11764-022-01284-y

Author contributions

Morgan Leske contributed 15%, 80%, 75%, Lisa Beatty contributed 15%, 2.5%, 10%, Bogda Koczwara contributed 10%, 2.5%, 2.5%, Elizabeth Eakin contributed 10%, 0%, 2.5%, Camille Short contributed 10%, 0%, 2.5%, Jon Degner contributed 10%, 0%, 2.5%, Anthony Daly contributed 10%, 0%, 2.5%, and Jason Blunt contributed 10%, 15%, 2.5%, Julia Morris contributed 10%, 0%, 0% to the research design, data collection and analysis, and writing and editing, respectively.

Abstract

Purpose: The aim of the present study was to co-design Healthy Living after Cancer *Online* (HLaC *Online*), an online intervention supporting cancer survivors to set and meet their healthy living goals.

Methods: Adapted from an initial telephone-delivered Healthy Living after Cancer program, wireframes (PDF black and white mock-ups) of the proposed online program were presented in a series of focus groups and interviews to the project's co-design stakeholder group, which consisted of cancer survivors, oncology health care professionals, and representatives from cancer support organisations. Stakeholders were prompted for feedback on the wireframe and given end-user scenarios to encourage deeper engagement with the co-design process. Transcriptions underwent thematic analysis to determine which features of the program needed change or expansion.

Results: 27 participants took part in one of 8 focus groups or 10 interviews. Five themes were identified relating to (a) website design elements, (b) promoting and maintaining long term engagement, (c) relatability and relevance, (d) navigating professional support, and (e) family and peer support. Recommended changes, such as simple activities and guidance videos, were integrated into the HLaC *Online* prototype.

Conclusions: Involving end-users in the co-design process ensured the intervention's relevance and specificity to the needs of cancer survivors. The feedback generated from this chapter will inform the website development of HLaC *Online*.

Introduction

As **Chapter 2** identified, that healthy living interventions yield small improvements in cancer survivors Quality of Life (QoL), however, those that are delivered face-to-face or over a shorter period are associated with greater effects. Further, this chapter identified that more research is required on digital health modalities and healthy living interventions that target mental health alongside physical health behaviours. As explored in **Chapter 1,** of the twenty-one digital health interventions that have been developed to address health behaviours in cancer survivors in the last decade (Ferrante et al., 2020; Frensham et al., 2018; Galiano-Castillo et al., 2016; Mayer et al., 2018; Roberts et al., 2017), only one has previously utilised co-design (Williams et al., 2022). Co-design involves end-users at each stage of intervention development, resulting in an intervention that is both sensitive to consumer's specific needs and preferences and follows best-practice principles recommended by the United Kingdom's Medical Research Council (MRC) for consumer-led development and evaluation of complex interventions (Skivington et al., 2021). This thesis followed the five-phase Stanford University's Design Thinking Research Process (Woods et al., 2017) for co-design, comprised of *empathising* (i.e., understanding the users everyday life), *defining* (i.e., what end-users want covered in the program), *ideating* (i.e., the idea generation of specific content and features to be included in the program), *prototyping* (i.e., developing a basic layout of the program) and *testing* (i.e., providing the program to a new group of end-users to evaluate).

The first round of co-design was conducted prior to this dissertation and addressed the empathising and defining phases (Grant et al., 2021). The Healthy Living after Cancer *Online* (HLaC *Online*) research team met with a group of stakeholders and presented them with the previous telephone-delivered program and tasked them to identify required adaptations. Stakeholders identified that the new HLaC *Online* program should target not only physical activity, healthy eating, and weight management, but also offer support for mental health, fatigue management, and peer support. Additionally, stakeholders reported that the intervention should offer a flexible format and long-term accessibility.

The present study extended these findings and addressed the second aim of this thesis by conducting the third and fourth phase of the co-design process – ideate and prototype – through a second round of stakeholder engagement. This round involved presenting and receiving feedback on a wireframe, that is, a visual guide representing a skeletal framework containing all the proposed content, of HLaC *Online*. Wireframes are an established methodology for ideating and prototyping interventions, and have been used in the co-design of digital health interventions for people with cancer (Lipson-Smith et al., 2019), knee osteoarthritis (Mrklas et al., 2020), and heart failure (Woods et al., 2017). Specifically, the second round of stakeholder engagement sought to clarify cancer survivors needs for healthy living guidance and support, and whether these needs would be met by the new program, identify potential barriers for program engagement, and develop strategies to best support users.

Methods

Participants

Participants were recruited through two sources. First, stakeholders from the first round of engagement (Grant et al., 2021) were invited to return for the second round of stakeholder engagement. These participants included Australian cancer survivors, oncology healthcare professionals, and non-government organisation cancer support representatives. Second, additional participants were identified and invited through snowball sampling of round 1 stakeholder participants' networks. Reasons for not returning for the second round of stakeholder engagement for cancer survivors included no longer being interested (n = 4), engagement not occurring at a good time (n = 1), or personal reasons (n = 1). Three cancer survivors did not respond to contact. Reasons for not returning for healthcare professionals and cancer support representatives included no longer being interested (n = 2), no longer working in cancer (n = 1), or cancelling after focus group was rescheduled (n = 1).

Wireframe

The wireframe of HLaC *Online* was developed based on the telephone-delivered Healthy Living after Cancer program (Eakin et al., 2020) and the findings from the first round of co-design (Grant et al., 2021). An example of the wireframe is presented in **Appendix E**. The wireframe comprised nine modules, including five from the original telephone-based program (goal setting, physical activity, healthy eating, maintaining a healthy weight, staying on track) and four newly developed modules (mental health, fatigue management, finding the new normal, and peer support). Each module consisted of psychoeducation, interactive activities, and links to reputable resources (e.g., non-governmental cancer support organisation websites, such as Cancer Council Australia). Behaviour change techniques presented in the wireframe were based on Social Cognitive Theory (Bandura, 2004) and included self-monitoring behaviours, goal setting, identifying health behaviour change facilitators, rating importance and confidence in making health behaviour change, exploring outcome expectancies of health behaviour change, action planning (i.e., breaking goals down into smaller, actionable steps), and problem-solving barriers to health behaviour change. In addition, the Mental Health module included activities based on Cognitive Behavioural Therapy (e.g., thought records, and identifying and challenging unhelpful thoughts), and mindfulness / relaxation. Finally, the finding the new normal and peer support modules included survivor testimonial videos.

Data collection

All stakeholders completed informed consent before participating. Focus groups (M = 87 minutes, SD = 24) and interviews (M = 72 minutes, SD = 10) were conducted between October and December 2020. Due to ongoing social distancing requirements of COVID-19 restrictions, stakeholders participated either via small face-to-face focus groups (n = 2 - 3 per group) or an online focus group or interview held on a secure videoconferencing platform, Webex. Two cancer survivor stakeholders were interviewed via telephone due to internet difficulties. Stakeholders were provided with a summary of key findings from round 1 of stakeholder engagement and presented with the HLaC *Online* wireframe.

Stakeholders were invited to provide feedback on the new content, along with one of the original modules from the telephone-delivered Healthy Living after Cancer, which was randomly selected for each focus group and interview. A semi-structured topic guide was utilised to facilitate feedback (see **Appendix F**), along with a persona task to facilitate discussion about how potential users might use the program and how they could best be supported. This task involved the stakeholders developing a hypothetical user of the program and included a description of their name, age, gender, cancer diagnosis, and healthy living goals. An example persona is provided below.

Norma is a 53-year-old, female bowel cancer survivor who has recently completed cancer treatment, which included surgery, radiotherapy, and chemotherapy. Norma's healthy living goals include returning to an active lifestyle, to be able to play with her young grandchildren, and returning to work.

Data analysis

Audio recordings from the focus groups and interviews were transcribed verbatim. Transcriptions underwent inductive thematic analysis using the qualitative data analysis software, NVivo 12 (2018). Inductive thematic analysis was chosen to determine which features of the program should be considered for change or expansion based on the stakeholder's feedback. Two authors (ML, JB) independently undertook thematic analysis on a subset of the transcripts (n = 8) to develop a preliminary coding framework. The coding framework was refined through discussion with authors with extensive qualitative research experience (BK and LB) to finalise and diagram the themes and subthemes. The final coding framework was then used to analyse all transcripts by a single author (ML).

Results

Participants

A total of 29 stakeholders (14 cancer survivors, 13 healthcare professionals, and 2 cancer support representatives) participated in one of seven focus groups or nine interviews, resulting in 16 transcripts. This equated to 71% of our original stakeholder group continuing their involvement from round 1, along with one additional healthcare professional and one cancer support representative. The stakeholder characteristics is presented in **Table 3.1**.

The majority of cancer survivors were female (n = 8, 57.1%) and aged between 44 and 81 years (*M* = 61, *SD* = 12.17). The most common cancer diagnosis was breast cancer (n = 6, 42.9%), followed by prostate cancer (n = 3, 21.4%), rectal cancer (n = 2, 14.3%), cervical cancer (n = 1, 7.1%), and Hodgkin’s Lymphoma (n = 1, 7.1%). Most health care professionals were nurses (n = 7, 53.8%), but included medical oncologists (n = 2, 15.4%), a clinical psychologist (n = 1, 7.7%), and a physiotherapist (n = 1, 7.7%). Cancer support representatives included a support group representative and a representative from Cancer Council SA’s support services.

Table 3.1

Characteristics of stakeholder group

	Cancer survivors		HCP and NGO Representatives	
	n	%	n	%
Gender				
Female	8	57.1	12	85.7
Male	6	42.9	2	14.3
Most recent cancer diagnosis				
Breast	6	42.9	-	-
Prostate	3	21.4	-	-
Rectal	2	14.3	-	-
Cervical	1	7.1	-	-
Hodgkin’s Lymphoma	1	7.1	-	-
Profession or NGO representing				
Nurse	-	-	7	53.8
Medical Oncologist	-	-	2	15.4
Representative from a non-governmental cancer support organisation	-	-	2	15.4
Clinical Psychologist			1	7.7
Physiotherapist	-	-	1	7.7

Overview of themes and subthemes

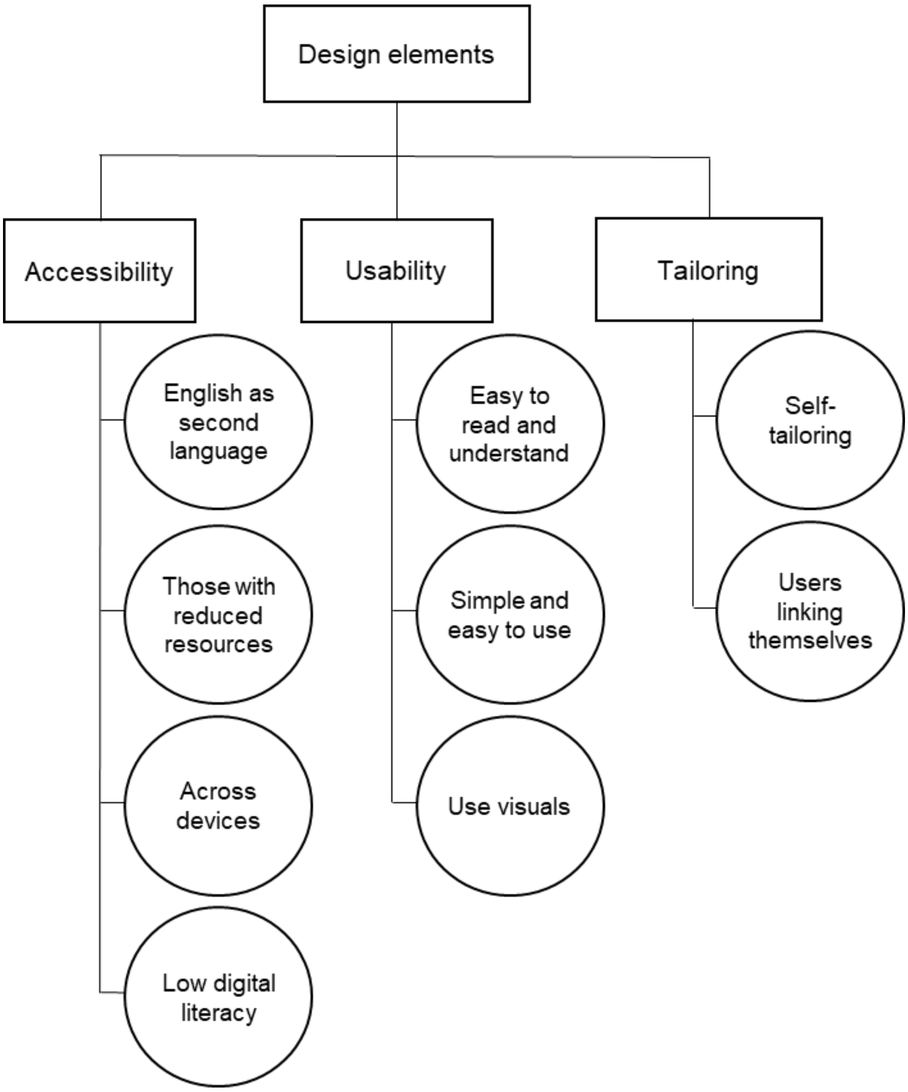
A total of 5 themes and 16 subthemes emerged from the thematic analysis. Overall, the wireframe received positive feedback from participants. All participants agreed that the program addressed key concerns of cancer survivors and praised the addition of modules based on their previous feedback. Five themes emerged relating to (a) website design elements, (b) promoting and maintaining long term engagement, (c) relatability and relevance, (d) navigating professional support, and (e) family and peer support.

Theme 1: Website design elements

As **Figure 3.1** shows, this theme related to how the web-program will be designed to increase accessibility, usability, and the ability to self-tailor the program.

Figure 3.1

Website design elements subthemes



Accessibility

One key subtheme that emerged was that HLaC *Online* must be developed in a way that ensures it is *accessible* to the diverse cancer survivor population. All stakeholder groups strongly endorsed that the program should be designed in a way to accommodate different devices and levels of digital literacy. Cancer survivors more frequently endorsed the use of different language settings so that the program is accessible to those for whom English is their second language.

"I come from basically Pakistan, and I speak another language. So, it would be good, when you're living here if you can find somebody who can speak your language also. If you can't speak English, which is, you know, if you're just alone by yourself and it's all English and you do not have the information… that would be a good idea to put in other languages, or to show that everybody's included" (CS03).

In comparison, the healthcare professionals frequently highlighted that any suggested healthy lifestyle changes, such as the type of exercise, must be accessible to users with limited resources. This was especially important when considering potential users who live in rural and remote communities.

"With the aerobic work, a lot of people only really have walking as their accessible option because they can't get to a pool, they're not into jogging, and they can't ride a bike. So, I think you need to sort of perhaps, particularly focus on the walking side of aerobic because that is the again that was easily accessible for the majority of people" (HCP06).

Usability

It was important to stakeholders that HLaC *Online* is *user friendly*; the website must be simple to use and easy to navigate, and information provided both easy to read and understand. Stakeholders promoted the use of visuals, such as videos, images, and diagrams, to reduce the reading burden on users.

"*The most important resource would be actual patient experience, you know. Short videos is what I would sort of you know would recommend given this, the nature of the situation as well as how technology is taken over. To reading through lots, through lots and lots of text, I don't think they have much of an uptake overall*" (HCP05)

The wireframe received mixed feedback as to whether these needs were met. Overall, the stakeholders thought the program appeared easy to use, however, some activities may have been too complex for a self-directed program. One common piece of feedback from all groups was the need to simplify the thought record, where users can record and challenge their thoughts.

"I just wonder if it's too complicated. I think the mindfulness, I think is something that people can engage in quite easily. And this to me, like I get it, but I'm wondering how many people will engage in it or it'll just be a bit too complicated" (HCP02).

Self-tailor

It was important to all stakeholder groups that HLaC *Online* offer users the ability to self-tailor the information, such that they can choose when and how they access the information and complete activities.

"It's fine because I think if think people will just read it, look at it and read it and choose the one that pertains to them at that time. And for some people, fatigue management might be first and for someone else it might be exercise. So, just have them all and then people will do what they want to do anyway" (HCP11).

Cancer survivors more frequently suggested that the program be designed in a way that users could print and complete activities by hand. This was only mentioned once in the Healthcare professional group and was not mentioned by cancer support representatives.

"*Those might be something that we can look at where they can download the page for instance because some people are writers too. Some people are, not a lot of us are keyboard warriors and a lot of people enjoy writing on something instead of a keyboard.*" (CS11).

Theme 2: Promoting and maintaining long-term adherence

This theme, presented in **Figure 3.2**, related to feedback about how to engage users and maintain long-term adherence to the program and health behaviour changes.

All groups frequently endorsed the use of strategies to increase the adherence and usage of the program. During the persona task, a common description of a potential user was someone who is initially very engaged with the program and making healthy changes, however, this behaviour would gradually taper off. For example:

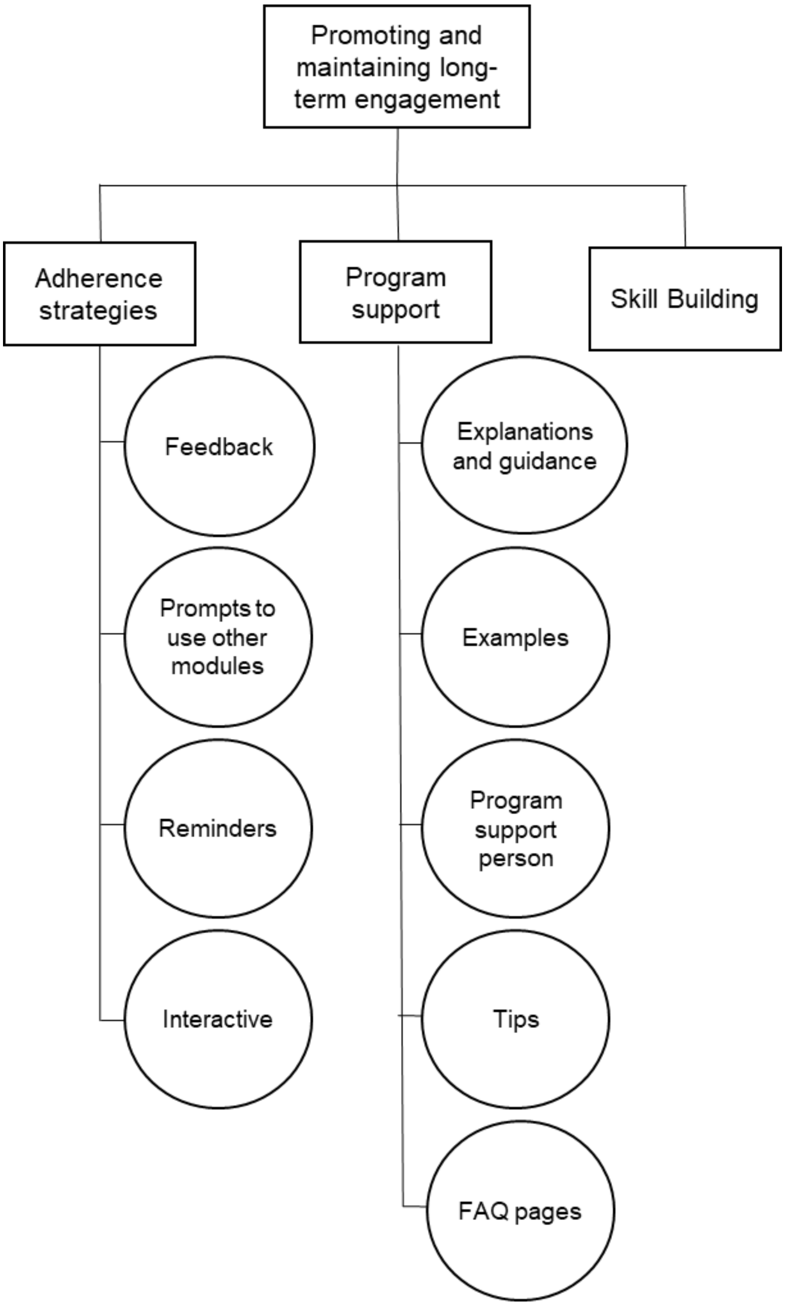
"He initially he would be in it for a number of weeks and then he has to be obviously encouraged to continue it. And that's probably where he might get off

track. But, you know, in the initial stage, you'll probably be all gung ho about it. But in the weeks down the track he might get a bit blasé, or anything are not happening quick enough at all certainly falls into a trap. Getting into the junk food again" (CS01)

Common recommendations to address these issues and increase engagement included using adherence strategies, promoting skill building, and providing program support. Each of these is outlined in detail below.

Figure 3.2

Promoting and maintaining long-term adherence subthemes



Adherence strategies

A variety of strategies to increase engagement and adherence with the program were suggested, including feeding back previously input information into later activities, encouragements throughout the program, prompts to use other areas of the program, interactive elements (e.g., activities, videos, audio files, and animations), and reminders to use the program. For example:

> “*Do they get the results of their trackers? Would that be included in the email? So, you've done so many steps. You know, we encourage great work. We encourage you to do and more or loss this much weight. So, it's like data being fed back to them as well as encouragement to keep going*” (HCP04).

There was mixed feedback for the frequency of reminders to use HLaC *Online*. However, the majority of stakeholders agreed that participants should be engaging with the program at least once a week, and reminders should be sent accordingly. One cancer survivor and one healthcare professional suggested this could be tailored, with the user able to determine the frequency of reminders.

Program support

All stakeholder groups suggested some level of guidance on *how* to use the program, although this was more frequently endorsed by cancer survivors. Cancer survivors’ most frequently suggested form of guidance involved having a person to discuss the content with, either via regular phone calls or someone to contact when they require assistance.

> *“You could have regular phone calls from a cancer council nurse. Or text messaging service that help him. See how he's doing with his goals and helping sort of just keep him a bit motivated”* (CS07).

> *“I think it's pretty comprehensive and easy to use, but maybe if there was sort of a, I don't know, if someone you could contact, send an email, or ring or whatever so if you got any further questions or they want some more information that isn't there”* (CS14)

Other frequent suggestions included providing other forms of program support, such as guidance videos introducing each module, the use of pre-completed examples, and tips on how to apply the skills learnt in participants’ daily lives. Two cancer survivor groups suggested a frequently asked question page, which was not mentioned by healthcare professionals or cancer support representatives.

Skill building

One element of the program praised by stakeholders was the inclusion of activities that build skills to help the user make lifestyle changes, rather than only providing information about what changes are required. All groups identified that this is especially helpful for developing mental health strategies (e.g., the mindfulness meditations and the thought record).

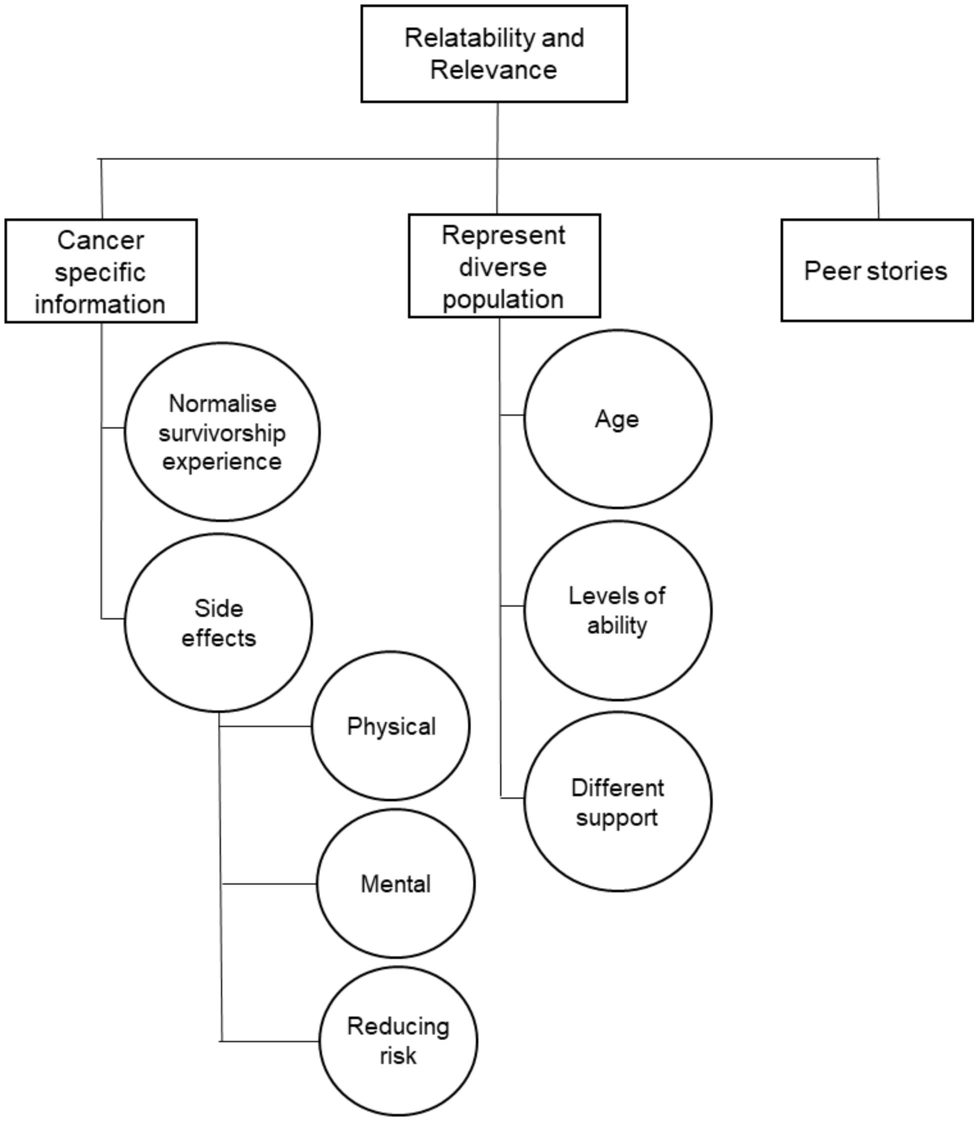
“You've got the resources there and those mindfulness meditations if they are no longer than about, you know, three to four minutes then that's ideal. Especially for people that start doing it” (CS07).

Theme 3: Relatability and relevance

Stakeholders emphasised that HLaC *Online* should normalise the after-treatment experience by including cancer-specific information and representative images of the diverse cancer survivor population. This theme is presented in **Figure 3.3**.

Figure 3.3

Relatability and relevance subthemes



Cancer specific information

One concern that was frequently emphasised by all groups was ensuring that the program would be relatable and relevant to cancer survivors. It was important that the information and examples used within the program are cancer specific.

"So, perhaps this section might just need to be a bit more impactful for people with cancer. Perhaps a little bit less. I mean there's some good things in there but

maybe a bit more to kind of really connect it to a person with cancer what their experiences are" (NGO02).

The need to normalise the survivorship experience was frequently identified by all stakeholder groups. Cancer survivors often discussed their own experience completing treatment and the emotional impact of no longer seeing oncology healthcare professionals as frequently, as well as the expectations from friends and family to quickly return to normal. All stakeholder groups felt strongly that this 'new normal' needed to be captured within the program.

Moreover, healthcare professionals more frequently identified the need for the program to include more education about the mental and physical impact of cancer and its associated treatment.

"…I think it probably should be picked up somewhere in the program to acknowledge the side effects, the impact of the side effects and how to try to rectify them, or how to, yeah, work through them." (HCP08).

Finally, all stakeholders endorsed including information about the benefits of engaging in a healthy lifestyle, particularly around reducing the risk of cancer- and treatment-related side effects.

"And just, I guess educating them on what good choices are, what benefits do you get from eating this sort of food, rather than don't have this because it's bad for you. Everyone knows that. It's everywhere. You don't need that… They are going to be thinking what can I be eating that's gonna stop me from getting cancer again" (HCP02).

Represent a diverse population

The stakeholders advocated that HLaC *Online* should include images that represent the diverse cancer survivor population, including representing the variety in age, gender, ethnicity, and levels of ability and fitness.

"*Yeah, so making maybe one of the start points or one of the picture representations a little bit more relatable to some of the people who aren't very fit*" (HCP04).

Peer stories

Stakeholders reported it would be beneficial to include peer stories within the program. Short videos of peer stories were included in the wireframe in the finding the new normal and the peer support modules. However, stakeholders suggested adding a peer support video into each of the main sections, so that users can relate to someone who has been through a similar experience and how they made changes to achieve a healthy lifestyle.

"The videos with actual people telling their experiences, I think that will probably have the maximum impact. And because people will listen rather than kind of wade through loads and loads of text" (HCP06).

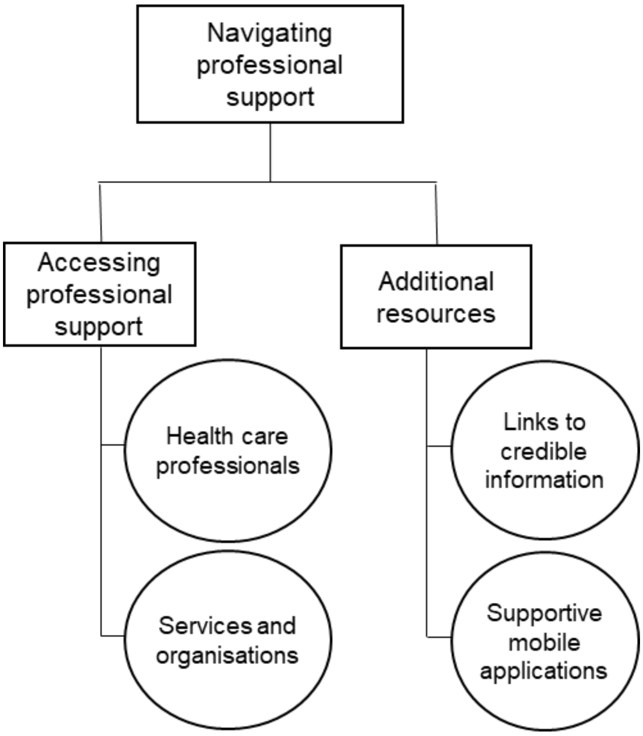
"People have, you know, someone to relate to. They sort of be like oh wow I went through that as well" (CS14).

Theme 4: Navigating Professional Support

This theme, presented in **Figure 3.4**, covered the feedback relating to information about professional support access and providing links to additional resources.

Figure 3.4

Navigating Professional Support subthemes



Accessing Professional Support

All stakeholders emphasised the need for further information about professional support that is available to cancer survivors. Specifically, they suggested that information about how to access relevant health professionals and services was an important inclusion for each of the modules. This was particularly relevant to cancer survivors, who discussed their own experiences finding a mental health professional.

"I mean I've found talking to my GP, he had trouble finding somebody that kind of. I mean I specifically wanted to try and talk to someone that, you know, dealt with people that had cancer and could relate to a lot of the things. So, for me, I mean, it would be great if there was something very specific in there, you know, give me a guess a list of practitioners that dealt with that" (CS04).

Further, the cancer survivor group were interested in providing more information about other supportive services and organisations, particularly in the areas of mental health.

"And you have some links too for people [to] expand on if they need to. You know beyond blue or, you know, Black dog institute or whatever. So, having those numbers there and Lifeline all that. You know, having that there as backup underneath all of all of this stuff for people that are having dark thoughts" (CS07).

Additional resources

The stakeholder groups suggested embedding links to credible information. Cancer survivors in particular emphasised that this program should be viewed as a starting point for healthy lifestyle change, and it should provide links to additional resources or mobile applications for users who wish to continue exploring ideas introduced in the program.

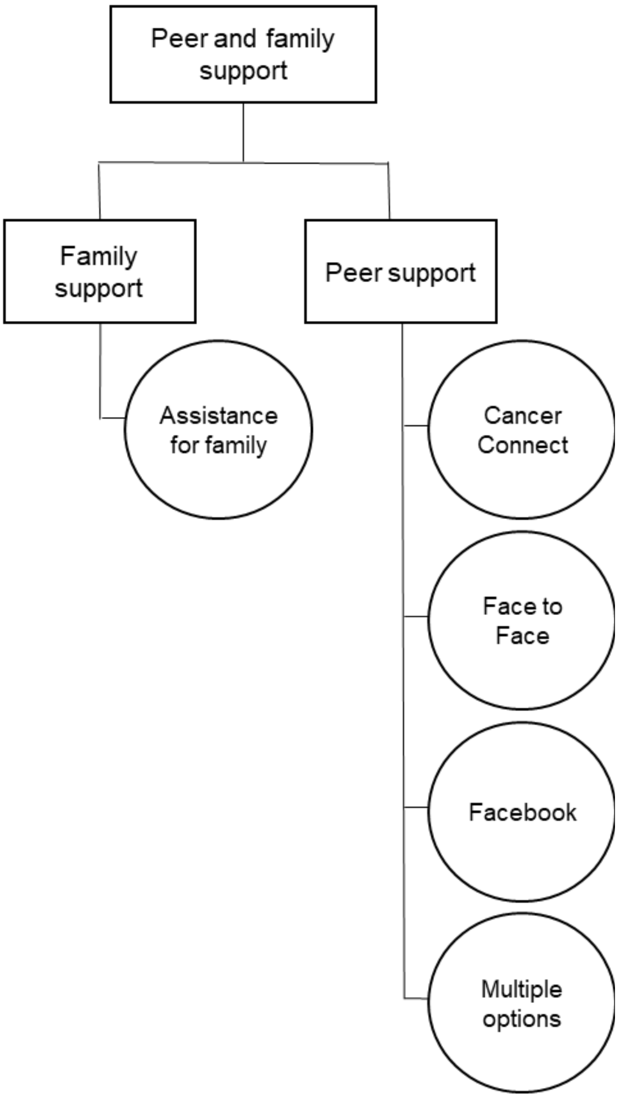
"Look at what the Cancer Councils already got and put some links in to those resources would be really good idea to be supportive rather than reinvent the wheel" (HCP08).

Theme 5: Peer and family support

The peer and family support theme encompassed (a) the stakeholders' need to involve families in the program, both as a supporter of the cancer survivor and as individuals in need of support themselves, and (b) to incorporate other various forms of peer support into the program. This theme is presented in **Figure 3.5**.

Figure 3.5

Peer and family support subthemes



Family support

Offering support for families within the program was strongly identified as a need by the healthcare professionals and cancer support representatives. They recommended providing support either via the cancer survivors' user portal or by offering family members the opportunity to also sign up to use the program.

"*What about the carers and what about the family members? They would really benefit from this. If you can click it can go, I'm the parent I'm the patient slash I'm the carer. Because, if the carer can do this and understand their emotions, often a patient and carer or patient and loved one that are looking at one another for support"* (HCP03).

Peer support

Providing multiple avenues for peer support in the program was frequently identified by cancer survivors.

"Because we all have different ways of looking for peer support. Some are one-on-one, some people like face-to-face support groups or can do it online, or sort of being online anonymously, you know, not like you and I, but where they can just use the discussion board. So, there's a real wide variety of how people connect with a peer support group" (CS11).

Cancer survivors provided recommendations for users to access peer support, often based on their own experiences of the peer support that they found helpful. These recommendations included face-to-face support (e.g., support groups) and Facebook groups. Healthcare professionals and cancer support representatives more frequently recommended peer support services offered by their organisations, such as Cancer Connect (a free telephone peer support service offered by various Cancer Councils).

Discussion

This study fulfilled the *ideate* and *prototype* stages of the Stanford University's Design Thinking Process co-design framework (Woods et al., 2017) by providing stakeholders with the opportunity to critique a prototype wireframe of the proposed HLaC *Online* program. Consistent with the first round of co-design, stakeholders continued to emphasise the importance of addressing mental health, fatigue management, and peer support (Grant et al., 2021). However, the present study extended these previous findings and identified several new themes relating to program usability and support features: (a) specific website design considerations, (b) strategies for promoting and maintaining long term user engagement, (c) enhancing relatability and relevance, (d) incorporating professional support, and (e) addressing the need for family and peer support.

A frequent observation made by all stakeholder groups was that maintaining engagement may pose a significant challenge to HLaC *Online*, a self-managed intervention. The majority of stakeholders described typical online program users as highly engaged within the first few weeks of a program, before gradually tapering off in interest and engagement. Consequently, the majority of the feedback focused on program features to encourage uptake and longer-term adherence to HLaC *Online*. These findings support previous investigations into engagement design features, which have consistently found that interventions should be easy to use, relevant to the target population, and include personalisation features, avenues for social support, and some level of guidance through, for example, reminders or a web-support contact (Borghouts et al., 2021; Sharpe et al., 2017).

The stakeholder co-design process generated modifications to several aspects of the program, including simplifying activities viewed as too complex for a self-directed format, allowing consumers to self-select program reminder frequency, and providing further information on locating support from peers and healthcare professionals. These findings were induced and strengthened by the iterative nature of the co-design methodology, in which the current prototype was derived from findings from the meta-analysis and the initial consultation of stakeholders, and prototype-feedback was then sought from that same group of stakeholders. As a result, stakeholders were enabled to provide guidance as to whether the needs identified in the first round of engagement had been sufficiently met and which needs required further consideration or development.

The involvement of different stakeholder groups, rather than a single group, enhanced the *ideate* and *prototype* stages of co-design (Woods et al., 2017). Involving stakeholders who may be involved in the implementation of HLaC *Online* (e.g., through recommendation or program support) in addition to end-users, enabled diverse feedback to be collated from cancer survivors, healthcare professionals and cancer support representatives. Feedback provided by cancer survivor stakeholders largely focused on how to make the intervention relevant and accessible to the diverse cancer survivor population who will ultimately be the end-users of the program (i.e., through additional peer stories, different language settings, and printable options). In contrast, the healthcare professional and cancer support representatives drew from their expertise on how to best support users to make and sustain healthy lifestyle and long-term behaviour changes (i.e., beyond the intervention period of twelve weeks). This diversification of feedback ensured that suggested behaviour changes are accessible to all cancer survivors (e.g., focusing on walking instead of weighted exercises) and that it included information about the potential cancer- and treatment-related side-effects that can complicate the behaviour change process. The benefit of including multiple stakeholder groups, particularly healthcare professionals and representatives from support organisations, has been noted in previous digital health intervention research (Grynne et al., 2021).

Limitations

Restrictions on stakeholders' consultation time and limited cultural and professional diversity in the stakeholder group are two limitations of this study. Focus groups and interviews were time consuming, and engagement often felt rushed, especially with busy healthcare professionals. Consequently, stakeholders may have lacked adequate time to review each wireframe page in depth and only able to provide feedback based on their first impressions. Alternative co-design methodologies to reduce such time-constraints that could be considered in the future include providing the summary of the findings from the previous engagement, providing the wireframe ahead of engagement to allow more discussion time (Mrklas et al., 2020), or asking participants to complete and provide feedback on a set number of activities included in the program (Lipson-Smith et al., 2019). Further, the participant sample had inadequate representation of different cultures, such as Aboriginal and Torres Strait Islander Australians or Culturally and Linguistically Diverse (CaLD) Australians. Further developments made to HLaC *Online* based on current stakeholder feedback may not suit the needs of Aboriginal and Torres Strait Islander or other culturally diverse Australian cancer survivors. Future iterations of the HLaC *Online* program should consider engaging stakeholders from Aboriginal and Torres Strait Islander and other cultural group communities, to ensure the program is culturally safe and meets the unique needs of these communities. Additionally, the study may have been improved with involvement of website design experts (e.g., computer programmer and graphic designer), who may have provided additional ideas about what would work within the program which end-user stakeholder could provide their perspectives on. This limitation will be addressed in the next stage of program development, whereby website design experts will be involved in the development of the HLaC *Online* website.

In summary, continuing the co-design process through a second round of stakeholder engagement has further refined the development of HLaC *Online*. The next steps will involve incorporating specific feedback and advice provided by the stakeholder group into the website development of HLaC *Online* to ensure that the content best meets the needs of cancer survivors and supports their undertaking of the self-directed intervention. The website development and the initial feasibility and usability evaluation of HLaC *Online* is presented in the next chapter.

Chapter 4.

A single-arm feasibility evaluation of a co-designed, online healthy living intervention for post-treatment cancer survivors: Healthy Living after Cancer Online.

Morgan Leske contributed 55%, 100%, 80%, Lisa Beatty contributed 15%, 0%, 10%, Bogda Koczwara contributed 10%, 0%, 2.5%, Elizabeth Eakin contributed 5%, 0%, 0%, Camille Short contributed 2.5%, 0%, 0%, Jon Degner contributed 2.5%, 0%, 0%, Anthony Daly contributed 2.5%, 0%, 2.5%, and Jason Blunt contributed 2.5%, 0%, 0% to the research design, data collection and analysis, and writing and editing, respectively.

Abstract

Introduction: This study aimed to finalise the development and examine the preliminary feasibility of Healthy Living after Cancer *Online* (HLaC *Online*), a co-designed physical activity, nutrition, and psychosocial intervention for post-treatment cancer survivors, using a single-arm trial.

Methods: A mixed-methods design was used, including pre-post questionnaires and a semi-structured telephone interview. Australian cancer survivors, <5 years post-diagnosis, were invited to participate in HLaC *Online* for 12 weeks. Feasibility of the HLaC *Online* was measured via intervention uptake, usage, usability, satisfaction, and attrition.

Results: Of the 15 cancer survivors who enrolled in HLaC *Online*, 11 were eligible to participate. Five (45%) participants dropped out before interacting with HLaC *Online*. The remaining participants (*n* = 6, 45%) on average accessed 3.33 (*SD* = 3.01) of nine modules and one completed all modules. Five (45%) participants completed the post-treatment questionnaire. Perceived usability of HLaC *Online* was varied (*M* = 64.17, range = 42.5 – 77.50). Qualitative feedback indicated that topics were relevant and helpful. However, participants reported difficulty with staying motivated due to cancer related symptoms and perceived time investment of the program. One suggestion was to have a guide assist the user with website orientation, goal setting, and accountability.

Conclusion: Low uptake and usage of HLaC *Online* may be attributed to technology and individual barriers. Future research will investigate addressing these barriers with brief human support.

Introduction

In **Chapter 3**, this thesis presented the *ideate* and *prototype* stages of the Stanford Design Thinking Process (Woods et al., 2017) for the co-design of HLaC *Online*. Following being presented a wireframe prototype, stakeholders recommended that HLaC *Online* needed to be user-friendly and interactive, include strategies for promoting and maintaining long term user engagement, enhance relatability and relevance to the cancer survivor population, incorporate professional support by providing information about how to access to relevant healthcare professionals and links to additional support, and addressing the need for family and peer support.

Building on these findings, the present study aimed to finalise the development of HLaC *Online* program and complete the *Test* phase of the co-design process (Woods et al., 2017) by evaluating the initial feasibility and usability of the program. To achieve this, a small subset of new end-users (i.e., post-treatment cancer survivors) were given access to HLaC *Online* with the primary aim of understanding their usage and user experience of the program over a 12-week period. As the overall objective of this thesis was to develop an online resource to support post-treatment cancer survivors in making healthy lifestyle changes to improve Quality of Life (QoL), the secondary aim of this study was to assess indicators of preliminary efficacy, including changes to QoL, physical activity, diet quality, fatigue, psychological distress, cancer related symptoms, and fear of cancer recurrence.

Methods

Intervention

Website Build

The wireframe and the feedback provided by stakeholders in **Chapter 3** was provided to website developers, iugo Pty Ltd, to commence the website build on WordPress, a commonly used website platform. Based on stakeholders feedback, key website design features included: a responsive design for use on different devices, guidance videos to assist users completing activities, use of a mood rating as an alternative to the thought record, more information regarding the unique impacts of cancer and its treatment, guidance in each module on how to access relevant healthcare professions, links to reputable websites for additional information, email reminders to prompt the usage of HLaC *Online*, and multiple options for accessing peer support.

Following the website build, launch delays were encountered due to changes to Flinders University's recommendations for website hosting and information security. Specifically, identifying information collected when signing up to HLaC *Online* (i.e., name and email address) was required to be separated from health information gathered in questionnaires (i.e., a previous cancer diagnosis), by administering the questionnaire via an external survey platform, Qualtrics. To achieve this, upon sign up, participants were provided with a unique identification number generated and recorded by the website and were asked to manually input this number in the Qualtrics questionnaire. The HLaC *Online* website was also required to undergo a penetration test, that is a simulated cyber-attack, to ensure that data was not accessible to non-administration users of the website. The website passed this test.

HLaC Online

HLaC *Online* is a 12-week web-based intervention designed to support post-treatment cancer survivors to achieve their healthy living goals (*www.healthylivingaftercancer.org*). Consistent with the wireframe presented in **Chapter 3**, the finalised HLaC *Online* program takes a holistic view of health and includes nine modules targeting goal setting, finding the new normal after cancer treatment, physical activity, healthy eating, mental health, fatigue management, maintaining a healthy weight, peer support, and staying on track (see module content in **Table 4.1**). The intervention, adapted from the telephone delivered program (Eakin et al., 2017), is based on the core determinants of Social Cognitive Theory, including health knowledge, perceived self-efficacy, outcome expectancies of health behaviours, and perceived facilitators and barriers of behaviour change (Bandura 2004). Within the intervention, participants are provided with *psychoeducation* on the benefits of a healthy lifestyle following cancer treatment, and supported to develop evidence-based *behaviour change skills* through goal setting, self-monitoring, problem solving barriers and setbacks, stimulus control, identifying and accessing social supports, and self-reward (Eakin et al., 2020).

Table 4.1

HLaC Online module content

Module	Description	Activities
My Goals	Covers techniques based on motivational interviewing and goal setting to support participants in the identification of health behaviours to change and the development of their healthy living goals. To ensure that the participants goals are clear and reachable, this module utilised SMART goals, that is, goals that are: • **S**pecific (what are they trying to achieve?) • **M**easurable (how will they measure their progress?) • **A**ctionable (what do they need to achieve this goal?) • **R**ealistic (are they able to achieve this goal?) • **T**imely (when will they achieve this goal?)	• What are your aims for participating the Healthy Living after Cancer Online? • List positives and negatives of current health behaviours and changing behaviours. • Why is change important to me? • Create your own SMART goals. • Develop an action plan (i.e., three actionable steps to achieve SMART goal).

Table 4.1 *continued*

Module	**Description**	**Activities**
Finding the new normal	Provides information about the common experiences of ending treatment, including different myths, e.g., ‘I should feel well’, and ‘I should not need support’ (Cancer Council Cancer Council Australia, 2021), treatment related side effects (e.g., fatigue, pain, loss of self-esteem), and returning to work.	• Video series of cancer survivors sharing their experience of completing treatment. • Links to a return-to-work plan and information about how workplaces can support returning to work.
Physical activity	In line with the Clinical Oncology Society of Australia’s (2018) position statement on physical activity, HLaC *Online* recommends meeting or exceeding 30 minutes per day of moderate to vigorous physical activity. Participants are encouraged to engaged in both planned and incidental physical activity (e.g., taking the stairs instead of the lift). This module covers: (a) the benefits of exercise, (b) different types of physical activity (aerobic exercise, strength training, flexibility), (c) how to build a strength training session (including push muscles such as chest, shoulders, and triceps; and pull muscles such as back and biceps, a lower body exercise (i.e.,	• Video of cancer survivors sharing their experience engaging in physical activity after treatment. • What benefits would you get from being more active? • What kind of physical activity do you enjoy? Instructional videos of weighted or body weight exercises. Accessing support for exercise (e.g., exercise physiologist or personal trainer)

Table 4.1 ***continued***

Module	Description	Activities
	quads, hamstrings, and calves), a core and balance exercise, and a cool down). To ensure that the exercises are accessible to all participants, this module primarily focuses on exercises that do not require equipment.	
Healthy eating	The major dietary aims of HLaC *Online* are to: (1) increase intake of fruit, vegetables, and wholegrains; (2) reduce intake of added sugars and saturated fats; (3) limit portion sizes and making healthy food choices. The module provides information on food guidelines, making food swaps, and portion control (i.e., lowering the size or number of serves).	• Video of cancer survivors sharing their experience on making healthier food choices. • How to read a food label. • Which food swaps will you try? • What eating away from home strategies will you try? • Accessing support from a dietitian

Table 4.1 ***continued***

Module	**Description**	**Activities**
Mental Health	Focuses on the emotional experience of finishing cancer treatment. Specifically, this module highlights the wide range of emotions participants experience, including the re-emergence of life stressors that have been deferred, coping with treatment-related side effects or body changes (e.g., scaring from surgery), and common mental health concerns (depression, anxiety, fear of cancer recurrence or cancer progression, and distress about body image). This module also provides strategies for managing distress based on cognitive behaviour therapy and mindfulness-based stress reduction.	• Thought challenge record • How to practice mindfulness • Audio recordings of guided meditations • Accessing support from a counsellor or psychologist
Fatigue management	Provides information about the common symptoms of fatigue, possible causes, and strategies for daily and long-term fatigue management.	• Using the 'Three P's' for daily energy management: plan, prioritise, and pace

Table 4.1 ***continued***

Module	**Description**	**Activities**
Maintaining a healthy weight	Assists the participant in identifying whether they are in a healthy weight range and provides two subsequent sections on weight loss or weight gain. The section on weight loss provides information about modest weight loss (i.e., 5 – 10% of initial body weight) by reducing energy intake by 2000kj per day. Strategies to reduce energy intake included portion control and lowering energy density (i.e., by replacing high energy dense foods, such as high fat or sugar foods, with low energy dense foods, such as fruit and vegetables). The weight gain section covers strategies that help with loss of appetite (e.g., establishing a regular eating pattern and small frequent meals), food swaps to increase energy intake, and food type nutritional supplements.	• Finding out if you are a healthy weight using a BMI calculator and measuring your waist.

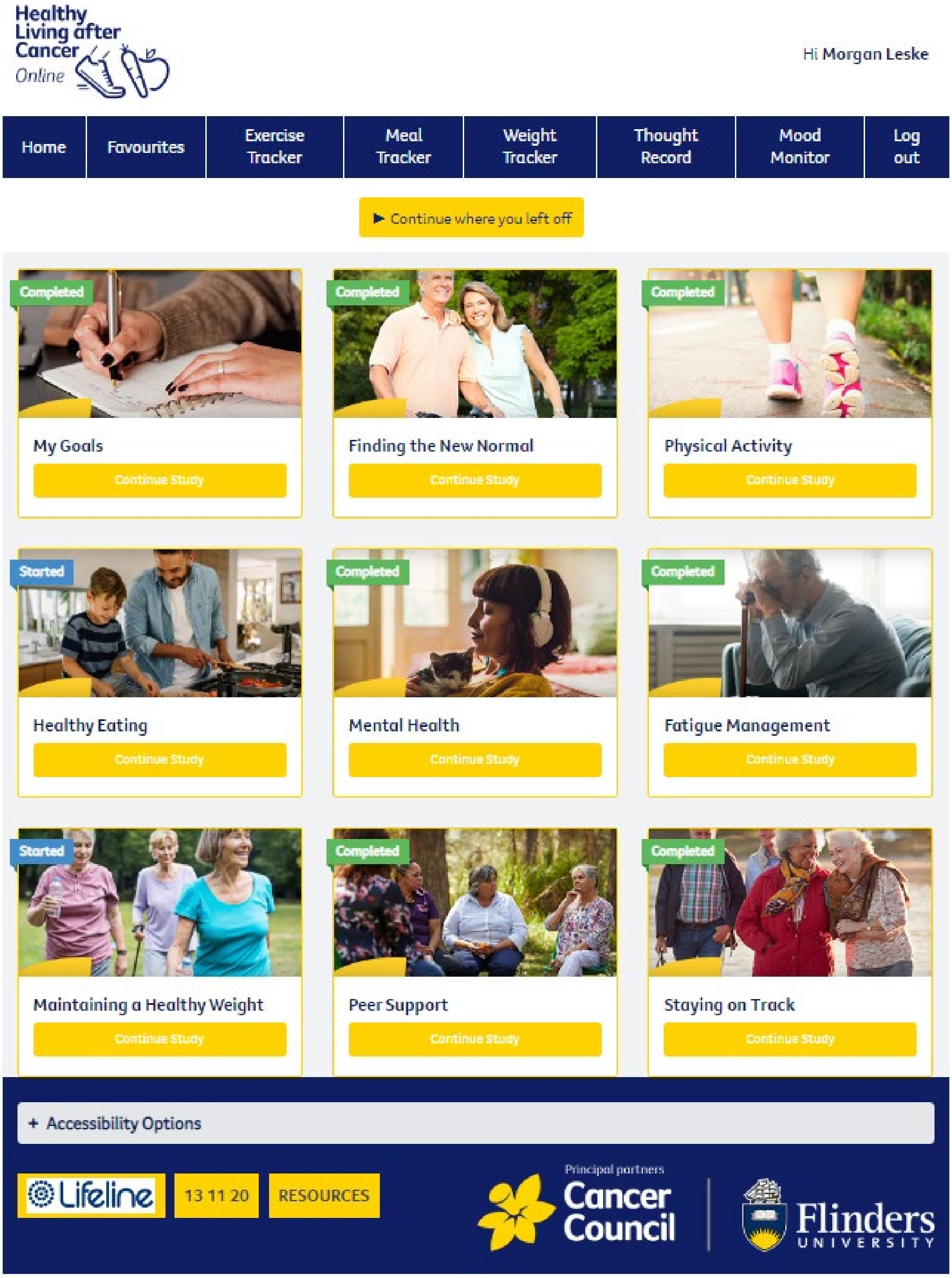
Table 4.1 ***continued***

Module	**Description**	**Activities**
Peer support	This module provides information about different peer support avenues, including support groups, volunteer opportunities to support others with cancer (e.g., Cancer Voices), Cancer Connect (a telephone service offered by Cancer Council to connect people with a trained volunteer with a similar cancer diagnosis), the Cancer Council Online Community and Facebook groups.	• Links to each state Cancer Council support group pages • Link to Cancer Voices Australia • Link to the Cancer Council Online Community
Staying on track	This module aims to support participants in maintaining their healthy lifestyle changes. This module includes information about habit formation, planning ahead for events where you may stop engaging in health behaviours (e.g., holidays), what to do if you experience a ‘slip,’ getting support from others, and celebrating success.	• Where is your best source of support for healthy living? • How will you celebrate your success?

Following an introduction video which described the features included in HLaC *Online,* all nine modules were made immediately accessible to participants, as displayed in **Figure 4.1**. The introduction video encouraged participants to complete the *My Goals* module to identify their aims in participating in the intervention and begin developing their healthy living goals. The module content was presented in a multimedia format and includes written psychoeducation with audio-conversion options, imagery, videos, downloadable audio files, and interactive worksheets. Based on stakeholder feedback, each module commenced with a guidance video describing the module content and how to complete each activity with relevant examples for cancer survivors. The *Physical Activity*, *Healthy Eating,* and *Mental Health* modules also conclude with information about how to access additional support from a relevant health care professional. The header of each page included a 'favourites' feature, where participants save relevant content, and five trackers to support participants to self-monitor progress toward their healthy living goals: exercise, meal, weight, mood, and thought trackers. The *exercise* and *meal* trackers encouraged participants to record their daily aerobic, strength, and flexibility exercise and food intake which was displayed in a weekly table. The exercise tracker also included a line graph which enabled participants to visualise their change in exercise over the total intervention period. The weight tracker allowed participants to record the date and their weight and was recorded in a table. Participants could use the *mood* monitor to track their daily mood (ranging from sad to happy) and fatigue (ranging from tired to energetic) in a line graph which displayed each month. Finally, the *thought* record was directly associated with an activity in the *Mental Health* module based on Cognitive Behaviour Therapy, where participants can record and challenge unhelpful thoughts. To promote engagement in the program, participants received an automatic email notification encouraging them to accessing the program following one and two weeks of not logging into the program. More examples of the webiste are presented in **Appendix H**.

Figure 4.1

HLaC Online home screen



Feasibility and usability evaluation

Design

This study utilised a mixed methods design, including a single arm, pre-post trial and a post-intervention qualitative interview. This design follows recommendations by the United Kingdom's Medical Research Council (MRC) framework for evaluating the feasibility of complex interventions (Skivington et al., 2021).

Participants

The eligibility criteria were consistent with the study investigating the previous telephone-delivered HLaC program (Eakin et al., 2020) to enable a comparison between the two interventions. Participants were eligible to participate if they were:

- Australian adults (≥18 years old), diagnosed with localised, non-metastatic cancer of any type treated with curative intent within the last five years.
- Completed primary treatment (i.e., surgery, chemotherapy, radiation, immunotherapy). Participants currently receiving hormonal treatment or Herceptin were still eligible.
- No contraindications to engaging in unsupervised physical activity, including active heart disease, breathing problems, planned knee or hip replacement, or pregnancy.
- No cognitive or mental health impairments that would hinder program participation.
- Sufficient English comprehension to enable program participation.

Participants with metastatic disease or had not completed primary treatment were excluded as there is content that addresses the unique challenges of the *post treatment* phase of survivorship, such as the Fining the New Normal module, that may not be appropriate for those still undergoing treatment. As this is the first pilot trial of HLaC *Online,* the target sample size was 12 as per the methods presented by Woods et al. (2017).

Procedure

This study was approved by the Cancer Council Victoria Human Research Ethics Committee (HREC 2106) and registered with the Australian New Zealand Clinical Trials Registry (ACTRN12622001111763). Participants were recruited via several channels between August 2021 and March 2022. First, the study was promoted on Facebook via two organic posts on Cancer Council SA's Facebook account. Additionally, cancer support networks and groups associated with Cancer Council SA were contacted to assist with recruitment, by distributing a plain language summary and/or flyer promoting the study to any cancer survivors in their network. The study was also circulated in the Breast Cancer Network Australia's review and survey group. Eligible participants completed a battery of self-reported questionnaires via Qualtrics at baseline and 12 weeks after accessing the intervention (post-intervention). Following the completion of the baseline survey, participants were manually granted access to the HLaC *Online* website by the PhD candidate within two business days.

After the post-intervention assessment, participants were invited to participate in a semi-structured telephone interview to provide their feedback on HLaC *Online*.

Measures

Participant Characteristics.

Sociodemographic information. Sociodemographic items included age, gender, marital status, ethnicity (i.e., country of birth and language spoken at home), Aboriginal and Torres Strait Islander status, educational attainment, geographical remoteness, and socio-economic status (SES). SES was assigned based on participant's postcode at the time of the survey, using the Index of Relative Socio-economic Advantage and Disadvantage (IRSAD; ABS 2021). IRSAD is a ranking system developed by the Australian Bureau of Statistics Census data that indicates relative advantage or disadvantage of an area compared to other areas in Australia. Participants were categorised into one of five SES groups, whereby the lowest quintile represented the lowest scoring 20% of areas on the IRSAD or the most disadvantaged areas, and the highest quintile represented the highest scoring 20% of areas on the IRSAD or the most advantaged areas.

Clinical history. Self-reported clinical data included cancer type, time since diagnosis, age at diagnosis, treatment types, BMI, other comorbidities, medication use, smoking status, and alcohol intake. Cancer type was measured by asking participants their primary cancer diagnosis and included 11 response options. Nine of these response options included the most prevalent cancers in Australia (i.e., Breast, Prostate, Head and neck, Colorectal, Lymphoma, Lung, Brain, Leukaemia, and Ovarian), with two remaining options for ‘other, please describe’ and ‘unsure’ (AIHW, 2019). Time since diagnosis was calculated by subtracting participants’ date of diagnosis from the date of survey completion. Age at diagnosis was calculated by computing the date difference between date of birth and date of diagnosis.

Participants were asked to report what cancer treatment(s) they received, including surgery, chemotherapy, radiotherapy, and immunotherapy. BMI was calculated by dividing the participants reported weight in kilograms by their reported height in metres squared.

Primary Outcome: Feasibility. The feasibility of HLaC *Online* was determined by: (1) intervention uptake; (2) usage of the intervention; (3) usability of the intervention; and (4) attrition at the post treatment survey.

Uptake. Uptake was measured using Google Analytics web traffic analysis platform to determine the percentage of people who visited the HLaC *Online* website who subsequently registered and log onto the program.

Usage. Built in analytic software on the HLaC *Online* website was used to track participant usage of the website, including the number of times participants logged in, the number of unique pages viewed, and the number of modules accessed and completed.

Usability. The System Usability Scale (Brooke, 1996) was used to quantitatively capture the usability of HLaC *Online*. The System Usability Scale is a 10-item standardised questionnaire to assess the perceived usability of a website. Each item has five responses that range from strongly agree to strongly disagree. The items alternate in positive (i.e., "*I thought Healthy Living after Cancer Online was easy to use*) and negative tones (i.e., "*I found Healthy Living after Cancer Online unnecessarily complex*"). There have been several attempts to provide normed data and adjective interpretation of the SUS (Bangor et al., 2008; Bangor et al., 2009). This study will utilise Sauro-Lewis curved grading system generated from 241 industrial usability studies utilising the SUS (Sauro & Lewis, 2016). This grading system utilises 68 as the centre, indicating average user experience. The grades and corresponding SUS values are presented in **Table 4.2**.

Table 4.2

Sauro-Lewis curved grading system for SUS

Grade	SUS	Percentile Range
A+	84.1 – 100	96 – 100
A	80.8 – 84.0	90 – 95
A-	78.9 – 80.7	85 – 89
B+	77.2 – 78.8	80 – 84
B	74.1 – 77.1	70 – 79
B-	72.6 – 74.0	65 – 69
C+	71.1 – 72.5	60 – 64
C	65.0 – 71.0	41 – 59
C-	62.7 – 64.9	35 – 40
D	51.7 – 62.6	15 – 34
F	0 – 51.6	0 – 14

Attrition. Attrition is defined as non-completion of post-intervention assessment and was assessed by the proportion of participants who completed the follow up questionnaire.

Satisfaction. Interview participants were provided with a topic guide (**Appendix H**) comprising questions that would be covered in the interview. These questions asked about their satisfaction with HLaC *Online*, as well as the perceived usability of the program. Participants were also asked to provide feedback on what they would change about the program, to inform future iterations of HLaC *Online*. The interviews were conducted, audio recorded, and transcribed by the PhD candidate.

Secondary outcomes: efficacy signals.

Quality of life. QoL was measured using the Functional Assessment of Cancer Therapy- General (FACT-G; Cella et al., 1993). The FACT-G is a widely used QoL measure that is considered appropriate for patients and survivors of any form of cancer. This measure consists of 27 items that yields a total QOL score and four subscale scores for *physical wellbeing* (e.g., “I have a lack of energy”), *social/family wellbeing* (e.g., “I feel close to my friends”), *emotional welling* (e.g., “I feel sad”), and *functional wellbeing* (e.g., “I am able to enjoy life”). Participants were asked to rate on a 5-point Likert scale the degree in which the item applied to them over the past *7 days*. Response options included 0 = *Not at* all, 1 = *A little bit,* 2 = *Some of the time*, 3 = *Quite a bit*, and 4 = *Very much*. All items on the physical and emotional subscales are reverse scored, with the exception of one emotional well-being subscale item (“I am satisfied with how I am coping with my illness”). The subscale scores are summed, multiplied by the number of items in the scale, and divided by the number of items answered by the participant. The total QoL score is generated by summing the subscale scores. The emotional well-being subscale score ranges from 0 to 24; the physical, social/family, and functional well-being subscale scores range from 0 to 28; while total QoL ranges from 0 to 108. Higher scores indicate better QoL. The FACT-G has demonstrated convergent validity through a strong correlation with the Functional Living Index - Cancer (r = .79; Cella et al., 1993; Schipper et al., 1984) and moderate correlations with the SF-36 subscales and composite scores (r = 0.34 – 0.60; Overcash et al., 2001). This measure has also previously demonstrated acceptable test-retest reliability in the initial scale development (r = 0.82 – 0.92; Cella et al., 1993) and in subsequent studies (r = 0.60 – 0.83; Weitzner et al., 1995). In previous studies, the FACT-G has demonstrated acceptable internal consistency, with Cronbach's alpha coefficients for the subscales and the total score ranging from .71 to .88 (Victorson, Barocas, Song, & Cella, 2008). In the current study, the subscales and the total scores demonstrated acceptable reliability (*physical wellbeing α* = .81; *social/family wellbeing α* = .86; *emotional welling α* = .83; *functional wellbeing α* = .83; *Total QoL score α* = .88).

Physical activity. Physical activity was measured using a self-administered version of the Active Australia Survey (Australian Institute of Health and Welfare [AIHW], 2003). This 8-item survey is designed to measure various types of leisure-time physical activity. Participants were asked to report the number of times and number of hours and/or minutes spent including walking, gardening or heavy yard work, and vigorous and moderate physical activity each week. The Active Australia Survey defines vigorous physical activity as physical activity that made the participant breathe harder, puff or pant (e.g., jogging, cycling, aerobics, competitive tennis) and moderate physical activity as all other physical activity not covered by the other activities (e.g., gentle swimming, social tennis, golf). To reduce the risk of over-reporting, individual items scoring above 840 minutes were recoded to 840 minutes. The data derived from this survey can be used to describe a number of physical activity outcomes, including number of physical activity sessions and total time spent in each activity. To remain consistent with the study investigating the telephone-delivered HLaC, the current study calculated the total time spent in moderate and vigorous physical activity (MVPA) using the following equation:

Walking time + moderate activity time + 2 x vigorous activity time

The Active Australia survey has acceptable test-retest reliability in a sample of Australian middle-aged women (total minutes/week: Spearman's rho = 0.64; Brown et al., 2008). Furthermore, the Active Australia Survey was used in the efficacy testing of the telephone-delivered HLaC (Eakin et al., 2020) and other cancer research (Eakin et al., 2007; Singh et al., 2020).

Daily sitting time. Sitting time was assessed using the two items from the International Physical Activity Questionnaire (IPAQ; Craig et al., 2003). Participants estimated how much time spent sitting while at work, at home, doing coursework, and during leisure time on a weekday and a weekend day over the last 7 days. In a multinational sample, the IPAQ sitting items demonstrated acceptable test-retest reliability (ρ = 0.72 - 0.82). These items have evidence of criterion validity in UK and US populations through small to moderate correlations with accelerometer counts (ρ = 0.24 – 0.50; Rosenberg et al., 2008). As this measure only includes two items, split half reliability was used to evaluate internal consistency (Eisinga et al., 2013). For the current study, these two items demonstrated acceptable split half reliability with a Spearman-Brown estimate of 0.93.

Diet quality. Diet quality was measured using the Fat and Fibre Behaviour Questionnaire (FFBQ; Reeves et al., 2015). The FFBQ is a 20-item questionnaire that asks participants to report their eating habits over the last month. The questionnaire yields a fat index, a fibre index, and a total index. Two fibre index response items were open response (“How many serves of vegetables do you usually eat each day?” and “How many serves of fruit do you usually eat each day?”). For nine items, participants indicated how often they ate certain foods (e.g., “How often do you eat chips, French fries, wedges or fried potatoes?”) on a 5-point Likert scale. Response options included 1 = *6 or more days;* 2 = *3 – 5 days*; 3 = *1 – 2 days*; 4 = *Less than a week*; 5 = *Never*. For the remaining nine items, participants indicated the frequency of eating behaviours on a 5-point Likert scale. These response options included 1 = *Never;* 2 = *Rarely*; 3 = *Occasionally/sometimes*; 4 = *Usually*; 5 = *Always*. Three items are reverse coded (i.e., "How often do you eat legumes, such as baked beans, lentils, split peas, dried beans, four bean mix," "How often do you eat a high-fibre breakfast cereal," and "When eating bread (as toast, sandwiches, or a snack) how often do you spread butter or margarine on it?"). The fat and fibre indexes were calculated by summing their relevant items and dividing this number by the number of valid responses and the total index was calculated by summing all items and dividing this number by the number of valid responses. Scores on each index range from 1 to 5, where higher scores indicate healthier behaviours. The FFBQ has demonstrated good test-retest reliability for the fat index (r = 0.90), fibre index (r = 0.93) and the total index (r = 0.91). In Australian adults with type 2 diabetes and/or hypertension, all three indexes of the FFBQ are moderately correlated (*r* = -0.42 – -0.56) with the relevant nutrients on the Food Frequency Questionnaire. In breast cancer survivors, the FFBQ has demonstrated small correlations with a 24-hour dietary recall (Total fat r = -0.29, Fibre r = 0.25, Total and Energy r = 0.30; Whelan et al., 2017). The FFBQ was used in the efficacy testing of the telephone-delivered HLaC (Eakin et al., 2020). Due to a coding error on Qualtrics, the full scale could not be used in the current study. However, two open-ended items measuring fruit and vegetable consumption was retained and utilised as an indicator of diet quality.

Fatigue. Fatigue was measured using the Functional Assessment of Chronic Illness- Fatigue (FACIT-F; Smith et al., 2010). The FACIT-F is a 40-item measure which combines the 27-item FACT-G with 13 additional items to assess self-reported fatigue (e.g., ("I feel fatigued") and its impact on daily functioning. Participants indicate the degree in which each item applied to them over the last *7* days on a 5-

point Likert scale, with response options including 0 = *Not at* all, 1 = *A little bit,* 2 = *Some of the time*, 3 = *Quite a bit*, and 4 = *Very much*. The 13 additional items are calculated as a fatigue subscale by summing the items, multiplying by 13, and dividing this number by the number of valid responses. Scores can range from 0 to 52, whereby higher scores indicate *less* fatigue and less impact on daily functioning. The FACIT-F has been used in other studies investigating the efficacy of physical activity intervention for cancer survivors (Pinto et al., 2015; Short et al., 2015b; Yu et al., 2020). The FACIT-F has demonstrated high internal consistency (α = .95) and test-retest reliability (*r* = 0.87) in American cancer patients (Yellen et al., 1997). In that sample, the FACIT-F demonstrated evidence of convergent validity with strong correlations with the Piper fatigue scale (*r* = -0.75) and the Profile of Mood States fatigue subscale (*r* = -0.74). In the current study, the FACIT-F demonstrated acceptable internal consistency (α = .93).

General distress. Psychological distress was measured using the total scale score of the 21-item version of Depression, Anxiety and Stress Scale (DASS-21; Lovibond & Lovibond, 1995). The DASS-21 is a widely used scale that yields a sub-scale score for three areas of psychological distress, including depression (e.g., “I felt down-hearted and blue”), anxiety (e.g., “I felt I was close to panic”), and stress (e.g., “I found it hard to wind down”), and a total distress score. Participants were asked to indicate on a 4-point Likert scale the degree in which the item applied to them over the last week. The response options included 0 = *Did not apply to me at all;* 1 = *Applied to me to some degree, or some of the time*; 2 = *Applied to me to a considerable degree, or a good part of time*; and 3 = *Applied to me very much, or most of the time.* The total distress score was calculated by summing all items. Scores range from 0 – 63, whereby higher scores indicated higher levels of distress.

The DASS-21 has demonstrated acceptable test-retest reliability in older adults (Depression r = 0.59, anxiety r = 0.65, and stress r = 0.77; Gomez et al., 2014) and evidence of convergent validity with moderate to large correlations with the Beck Depression Inventory (*r* = 0.62 - 0.79), Beck Anxiety Inventory (*r* = 0.51 - 0.85) and State-Trait Anxiety Inventory (r = 0.55 - 0.71; Antony et al., 1998). In the current study, the total scale score had acceptable internal consistency (α = .95).

Cancer related symptoms. The severity and interference of cancer related symptoms was assessed using the MD Anderson Symptom Inventory (MDASI; Cleeland et al., 2000). The severity of ten core symptoms were measured: fatigue, sleep disturbance, distress, shortness of breath, poor memory, poor appetite, drowsiness, sadness, and numbness. Participants were asked to indicate the severity of these symptoms over the past month on a scale from 0 (not present) to 10 (as bad as you can imagine). Six items measured symptom interference in various areas of a cancer survivors' life, including general activity, mood, work (including work around the house), relationships, walking, and enjoyment of life. Participants rated how much their symptoms interfered with these areas on an 11-point Likert scale from 0 (did not interfere) to 10 (interfered completely). A mean item score was calculated for the 10 severity items and 6 interference items, whereby higher scores indicate greater severity or interference. The MDASI has demonstrated acceptable internal consistency for general symptoms in previous studies (α = .85; Cleeland et al., 2000) and in the current study (α = .92).

Fear of cancer recurrence. Fear of cancer recurrence was measured using the 4-item Concerns About Recurrence Questionnaire (CARQ-4; Thewes et al., 2015). The first item asks participants to rate how often they worry about a recurrence of cancer on an 11-point Likert scale between 0 (none of the time) to 10 (all of the time). The second and third item assesses the degree of intrusion and distress caused by fear of cancer recurrence on an 11-point Likert scale between 0 (not at all) to 10 (a great deal). The fourth item asks participants to quantify their perceived risk of cancer recurrence from 0 to 100% and this score is transformed into a score between 0 to 10. Items were summed to calculate a score between 0 to 40, whereby higher numbers represent more fear of cancer recurrence. In Australian breast cancer survivors (Thewes et al., 2015), this measure demonstrated acceptable concurrent and convergent validity with moderate to strong correlations with the Fear of Cancer Recurrence Inventory ($r = 0.78$), the DASS ($r = 0.46$), the Whitely Index 7-item short form measuring health anxiety ($r = 0.35$), and the Generalised Anxiety Disorders Questionnaire – version 4 ($r = 0.50$). In that same sample, the CARQ-4 demonstrated acceptable internal consistency ($\alpha = .87$) and test-retest reliability ($r = 0.74$; Thewes et al., 2015). The CARQ-4 demonstrated acceptable internal consistency in the current study ($\alpha = .83$).

Statistical analysis

Quantitative data

Quantitative data analysis was conducted on IMB SPSS Statistics, version 28 (IBM, 2021). Descriptive statistics were used to summarise participant's sociodemographic and clinical characteristics and feasibility outcomes. Chi-squared analyses and independent samples t-tests were conducted to compare baseline differences between post-intervention questionnaire completers and non-completers. Differences between groups were considered significant if $p < 0.05$.

Matched paired-samples t-tests with estimates of Cohen's *d*, corrected for correlated observations, were utilised to examine pre- and post-intervention scores for QoL, physical activity, sitting time, diet quality, fatigue, psychological distress, cancer related symptom severity and interference, and fear of cancer recurrence. Due to the small sample size, for all analyses, the results were interpreted with respect to the magnitude of effect sizes, rather than inferential statistics. The interpretation of Cohen's *d* utilised the benchmarks of 0.2, 0.5, and 0.8 indicating small, medium, and large effects, respectively (Cohen, 2013). Negative effect sizes indicate higher mean scores at post-intervention.

Qualitative data

A six phase thematic analysis as described by Braun and Clarke (2022) was utilised to further understand the participant experience using HLaC *Online* program over the 12-week period and summarise their recommendations for changes to the program to ensure it meets the needs of post-treatment cancer survivors. These phases include: (1) familiarisation with the data set; (2) coding; (3) generating initial themes; (4) reviewing and developing themes; (5) refining and naming themes; and (6) producing a report. Audio recordings from the telephone interviews were transcribed verbatim to generate the data set and initiate the familiarisation phase. As the purpose of this study was to determine the feasibility of HLaC *Online,* deductive thematic analysis was utilised for the initial codes. Specifically, Bowen and colleagues have proposed eight areas of focus of feasibility studies. Three areas, acceptability (i.e., the extent to which the HLaC *Online* was deemed suitable, satisfactory, and attractive by participants), demand (i.e., the usage or intended usage of HLaC *Online* by participants), and practically (i.e., the required resources, time, and commitment for participants ability to engage in the HLaC *Online* program), were chosen to guide code identification and sorting, as these were the most relevant to understanding the user experience with the program. In stages three to five, inductive analysis was utilised to develop and refine themes under these areas to allow for the generation of specific recommendations for improving the feasibility of HLaC *Online*.

Throughout the analysis, to manage potential author / program creator bias towards overly focusing on positive or negative feedback, and to ensure that the themes accurately represented the qualitative data, the themes were presented and further refined with another author (LB) who had experience in qualitative analysis in the field of developing and evaluating online psycho-oncology interventions.

Results

Table 4.3 presents the demographic and clinical information of 11 participants who enrolled in the study. Overall, most participants were female, had previously received a breast cancer diagnosis, were tertiary educated, lived in an urban area, and were in the 4th Quintile for SES. Six participants reported between one and three additional medical conditions, most common of which were hypertension (n = 2) and osteoporosis (n = 2).

Table 4.3

Participant demographic and clinical information for the pre-post pilot feasibility trial.

Characteristic	*M* (*SD*)
Age	57.86 (9.84)
BMI	27.88 (5.95)
Age at diagnosis	55.73 (9.25)
Time since diagnosis (years)	1.56 (0.99)
	n (%)
Gender	
Female	9 (81.82)
Male	2 (18.28)
Relationship status	
Married	7 (63.67)
Divorced	2 (18.18)
Widowed	2 (18.18)
Educational achievement	
Secondary school	2 (18.18)
TAFE	3 (27.27)
Tertiary	5 (45.45)
Employment Status	
Employed	6 (54.55)
Retired	3 (27.27)
Unable to work	2 (18.18)
Country of Birth	
Australia	8 (72.73)
South Africa	2 (18.18)
England	1 (9.09)
Geographical remoteness	
Urban	7 (63.67)
Regional/rural	4 (36.36)

Table 4.3 continued

Characteristic	*n* (%)
SES	
1st Quintile	1 (9.09)
2nd Quintile	2 (18.18)
3rd Quintile	1 (9.09)
4th Quintile	5 (45.55)
5th Quintile	2 (18.18)
Country of Birth	
Australia	8 (72.72)
South Africa	2 (18.18)
England	1 (9.09)
Cancer type	
Breast	7 (63.67)
Other[c]	4 (36.36)
Completed Treatment	
Yes	7 (63.67)
No/Unsure[d]	4 (36.36)
Treatment received[b]	
Surgery	4 (36.36)
Chemotherapy	5 (45.55)
Radiotherapy	7 (63.67)
Immunotherapy	1 (9.09)
Hormonal therapy	4 (36.37)

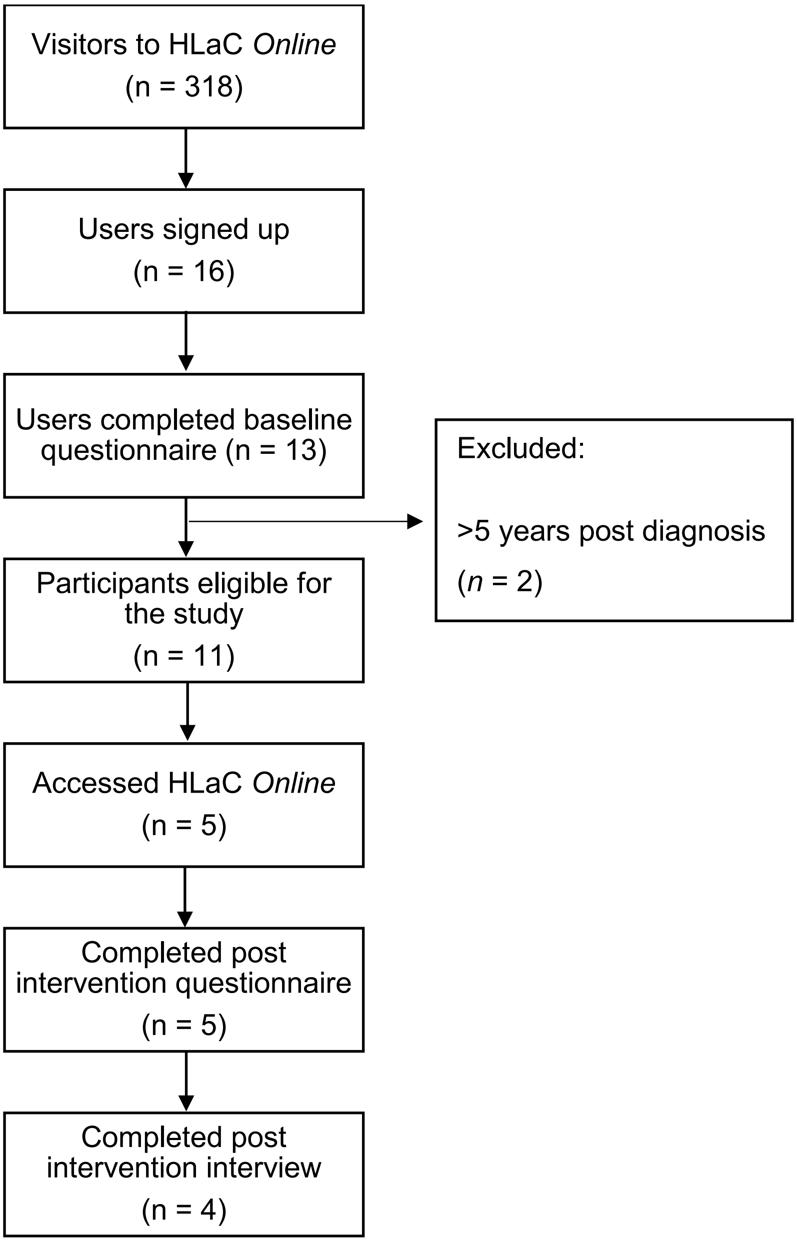
N/A indicates assumptions were violated to conduct a chi-square analysis (i.e., 25% of cell counts <5).
- indicates no participants in this group.
[a] United Kingdom (n = 11), India (n = 2), Canada (n = 2), New Zealand (n = 1), South Korea (n = 1), Peru (n = 1), and Pakistan (n = 1).
[b] Multiple responses allowed.
[c] Colorectal (n = 1), head and neck (n = 1), lymphoma (n = 1), and prostate (n = 1).
[d] All participants which selected ‘No’ or ‘Unsure’ for currently undertaking treatment indicated they were currently on hormonal treatment.

Feasibility outcomes

Uptake. Figure 4.2 presents the participant flow from the unique visitors to the website, users who registered on the website, and participants who complete baseline questionnaire and the post-intervention questionnaire and interview. Overall, 5% (n = 16) of unique visitors to the website registered for HLaC *Online*, of which 11 (68.8%) completed the baseline questionnaire and were eligible to participate. Following baseline, five participants (45%) never logged into HLaC *Online*. As these participants did not commence HLaC *Online*, the automated email reminder process was not triggered, such that they never received login email reminders.

Figure 4.2

Participant flow chart



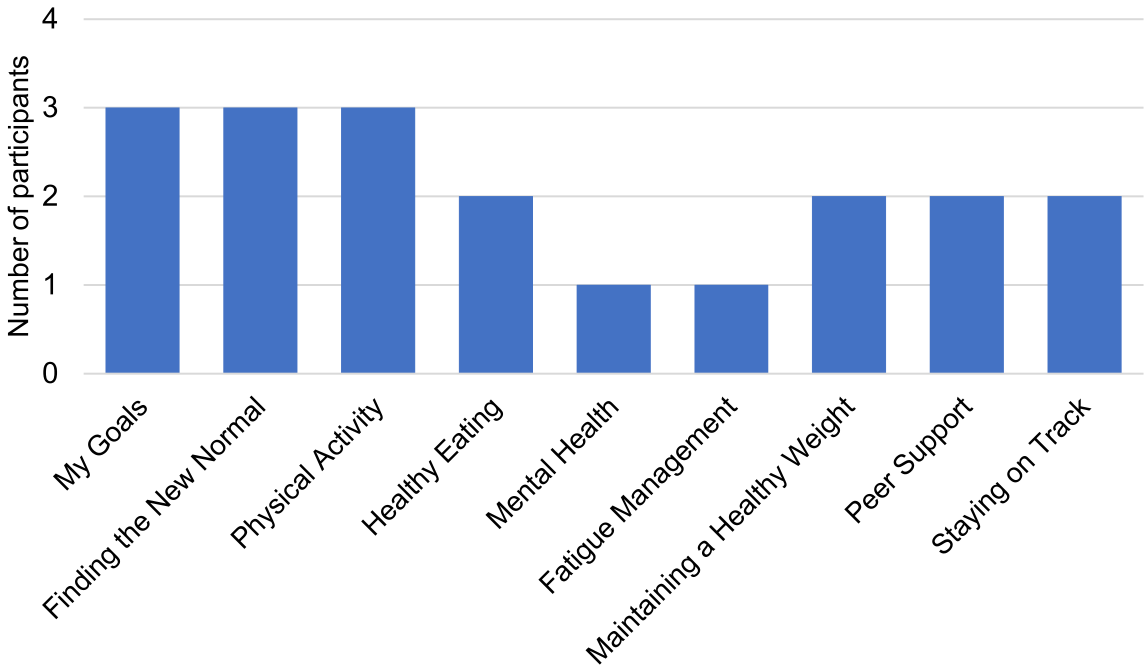
Attrition. Six (54.5%) participants did not complete the post intervention questionnaire. The average MVPA of participants who did not complete the post intervention questionnaire (*M* = 260.0 minutes, *SD* = 193.18) was lower than participants who did complete the post intervention questionnaire (*M* = 406.0 minutes, *SD* = 457.69), *d* = 0.43). No other differences in sociodemographic, clinical or psychosocial characteristics were observed between participants who did versus those who did not complete the post-intervention questionnaire.

Usage. The usage of HLaC *Online* of remaining participants who logged into program following the baseline questionnaire (n = 6, 55%) varied. On average, participants accessed 3.33 (SD = 3.01) of nine available modules. The majority of participants (91%) accessed between one to four modules, and, of these, two participants completed one module. Only one participant accessed and completed all nine modules and used all five trackers.

Figure 4.3. presents the number of participants who accessed specific modules. The most popular modules were *Finding the New Normal*, *My Goals* and *Physical Activity* modules, each accessed by three participants. On average, participants accessed 8.46 pages (*SD* = 17.11, *range* = 0 – 57). The average number of logins was 4.3 (*SD* = 8.83, *range* = 0 – 29). Participants accessed the program for varying durations (one day (n=3); 4 weeks (n=1), 8 weeks (n=1), and 12 weeks (n=1).

Figure 4.3

Overview of number of participants who accessed each module.



Website Usability. Perceived usability of HLaC *Online* was varied. Three participants rated usability between a C and a B+, indicating above average user experience. However, one participant rated the usability of the program as an F.

Indicative effect sizes

Indicative effect sizes are presented in **Table 4.4**. At post-intervention, participants reported an increase in MVPA and the number of vegetable servings per day, and a decrease in psychological distress. In contrast, at post-intervention, participants reported a deterioration in Global QoL, Functional Well-being, Emotional Well-being, and Fatigue. Although, each of these effect sizes demonstrated a moderate effect, the 95% confidence intervention cross zero, indicating substantial variability in participants change over time. All other outcomes did not demonstrate an effect of change over time.

Table 4.4

Pre-post effect sizes for indicators of efficacy outcomes (N = 5)

Scale	Baseline *M* (*SD*)	Post-intervention *M* (*SD*)	Cohen's *d*	95% CI	
				Lower	Upper
Quality of life					
Global	83.20 (9.73)	78.67 (5.73)	0.45	-0.40	1.30
Physical Well-Being	22.2 (3.70)	21.83 (1.11)	0.08	-0.72	0.88
Social Well-Being	22.00 (5.54)	21.63 (3.51)	0.10	-0.56	0.77
Functional Well-Being	19.20 (5.68)	17.00 (4.00)	0.42	-0.65	1.50
Emotional Well-Being	19.80 (2.86)	18.20 (1.64)	0.60	-0.53	1.72
Fatigue	37.00 (10.65)	34.00 (9.70)	0.91[a]	-0.20	1.93
MVPA (minutes)	406.00 (457.69)	618.00 (545.64)	-0.42[a]	-2.20	1.36
Average daily sitting time (minutes)	298.29 (175.60)	267.43 (149.50)	0.30[a]	-0.62	1.18
Diet Quality					
Vegetable servings / day	2.80 (0.84)	3.20 (1.34)	-0.45[a]	-1.35	0.50
Fruit servings / day	3.00 (0.71)	3.20 (0.84)	0.00	-0.88	0.88
Psychological Distress	23.60 (20.90)	8.40 (5.73)	0.67[a]	-0.49	1.84
Fear of cancer recurrence	12.20 (9.76)	11.40 (5.55)	0.06	-0.46	0.59
Symptom Severity	3.96 (1.92)	3.78 (1.27)	0.09	-0.59	0.76
Symptom interference	3.20 (2.66)	2.99 (1.32)	0.03	-0.22	0.29

Note: negative effect sizes indicate a higher score at post-treatment

[a] indicates that the effect size direction shows improvements at post intervention

Qualitative findings

Of the eleven participants, three participated in a telephone qualitative interview and one responded to the qualitative questions via email. On average, interviews went for 29.83 minutes (range = 23– 39 minutes). The mean age (*M* = 53.69, *SD* = 2.52) and time since diagnosis (*M* = 1.27, *SD* = 0.70) was reflective of the overall sample. Three participants had breast cancer, and one had lymphoma. Three participants were currently employed, and one participant was unable to work.

Acceptability

Overall, one participant reported that they were satisfied with the program, whereas the remaining three participants reported being neither satisfied nor unsatisfied, citing limited use of the program. No participants recommended any changes about the look of the program. Subthemes relevant to the acceptability of HLaC *Online* include the program design and HLaC *Online* meeting some, but not all informational needs.

Program design. Participants reported that the acceptability of HLaC *Online* was influenced by the self-directed nature of the program and the online platform used to host the program. Two participants indicated that the primary benefit of a self-directed program was the ability to choose which modules to access based on their individual needs. However, participants acknowledged that, at times, they were unsure what to do next and they missed subsequent content that may have been useful. One participant reflected that the thought record could have been useful during a recent hospital check-up, stating:

> *"I should have had a look at this and used this tool. It probably would have helped"* (Breast Cancer Survivor 1).

Similarly, one participant, who primarily accessed the program on a laptop, indicated that the accessibility of HLaC *Online* would have been improved by delivering the program on a mobile application.

"I think if it was easier [to] access. So maybe on my phone. I don't know if there's a sort of app thing on my phone, but it would be easier to just click on. So, if you sit somewhere and wait in the doctors waiting room or wherever you are in the moment, you can go onto your phone and watch it or read a bit because I think it could be used as a bit of mindfulness as well. I think it has a lot of potential, but the accessibility for me was like a process and was just in the too hard basket" (Breast Cancer Survivor 3).

HLaC *Online* meets some but not all informational needs. Mixed feedback was received from participants regarding whether HLaC *Online* met their informational needs.

Two participants identified that the information and tips provided in the *Physical Activity* or *Healthy Eating* module was useful and led to behaviour change.

"It makes you think about things that maybe you don't. Either you don't or you don't want to… Because my husband and I would have [previously] thrown a ham sandwich together and off we go to work. And I said, right, I'm not eating that anymore. And the things about exercise and making you think like 'how much did I actually walk this week?' And when you stop and think about it, you realise that you actually hadn't done enough. So, it's those two things [that] have probably had the biggest impact on me because it's changed what I'm eating, but it's also made me go and join an exercise programme because I know I'm not walking enough now" (Lymphoma Survivor)

One participant reported that HLaC *Online* largely confirmed information they already knew and "*reiterated that I'm on the right track for longevity*" (Breast Cancer Survivor 1). This participant also reflected that they were interested in learning more about the scientific evidence behind the recommendations, such as the relationship between certain foods and exercises on the risk of cancer recurrence, however, they also acknowledged that not all users would be interested in this information.

> *"I think some people don't want to know, but I think if there's a validation. Because see like I used to drink, you know not a heck [of a lot]… I used to love alcohol, but now I know the reasons why you shouldn't be drinking. And I know the science behind it, and that certainly helps confirm why you shouldn't [drink alcohol]."* (Breast Cancer Survivor 1)

Other topics requested by participants to be covered in HLaC *Online* include returning to work, different types of exercises (e.g., high intensity exercises), and information to provide to family and friends about life after cancer treatment.

Demand

The two subthemes relevant to the demand of HLaC *Online* were participant's self-assessment that their needs were already met by other applications or services and the participant's observation that the *Finding the New Normal* module was the most frequently used module.

Needs already met by other digital health applications or services. Two participants identified that they did not use certain modules or trackers, as they were already involved with other services (e.g., engaged with a psycho-oncologist) or already utilised other digital health applications (e.g., FitBit). Throughout their interviews, both participants demonstrated a high level of health literacy and indicated frequent use of other health and digital health resources.

"I suppose there's been an app on the phone for your steps and so that keeps [track]. I've put my weight into that one, so I have tracked it in other ways" (Breast Cancer Survivor 1)

"And I think with the fatigue stuff, I was already getting help with that with [treating hospital]. That was on the cancer fatigue program, so I probably didn't focus too much on that one" (Lymphoma Survivor).

Finding the new normal – the most frequently used module. All participants indicated that they accessed the Finding the New Normal module and when asked what aspects of HLaC *Online* were most useful to them, all participants responded with the cancer survivor testimonial videos.

"I relate very well to that, and I've really enjoyed hearing those stories. And the other thing I found quite useful around hearing their stories is hearing several of them use the same words I used when I was explaining how I felt, and I was surprised. It felt like somebody has put my words in their mouth." (Breast Cancer Survivor 3).

Practicality

Participants reported several barriers to using HLaC *Online* and as a result, provided guidance on strategies that would assist future participants with engaging in the program.

Barriers to program usage. Participants identified three barriers to engaging with HLaC *Online,* including cancer related symptoms, perceived time burden/lack of time, and website glitches.

Two participants reported that cancer / treatment related side effects, specifically fatigue, cancer-related cognitive impairment, and vision difficulties, impacted their ability to use the HLaC *Online* program.

"I was firmly on track to look at all the resources and then I just had a lack of energy. Like I felt I had to reserve the energy and motivation that I have for my daily requirements and that was just an extra thing that I just didn't have the time or energy for" (Breast Cancer Survivor 3).

Three participants indicated that a significant barrier to engaging with HLaC *Online* was the perceived time burden of the program. All three of these participants reported a lack of time as they were currently employed.

"Now that I'm back to work, I went into it the other day and I just thought I haven't got time. There's a lot there… And you kind of feel like you have to do it all. So, I think the programme is good, but I think that you really need to have the capacity, the brain capacity, and the time to do it." (Lymphoma Survivor).

Finally, one participant reported a website glitch impacted on their ability and willingness to use the program.

"There's one module that I've actually tried to complete twice, and it keeps telling me I haven't. And so, I click submit and then it brings me back to that module again and I'm pretty sure I've completed everything in there. And that sort of thing when you work full time and I'm studying. And I just thought, OK, I can't. I can't spend any more time on this." (Lymphoma Survivor).

Support for engagement with HLaC *Online*. Three participants reported finding the email reminders helpful to remain engaged in the HLaC *Online* program. One participant stated that *"without them I probably would have completely forgotten"* (Lymphoma Survivor).

One participant did not recall receiving the reminder but acknowledged that "*Might have been beneficial as a trigger with a bit of you know, post chemo brain and whatever excuse I can make"* (Breast Cancer Survivor 1).

Another participant recommended that the email reminders be changed to text messages, as they don't often read their emails.

Another engagement strategy recommended by one participant was a support person to go through the program with the participant. This recommendation emerged in the context of the participant reflecting on their experience with side effects post treatment and navigating life after cancer treatment. The participant suggested that a support person who understood where the user was at in their journey could act as a guide for which modules to use, setting up healthy living goals, and act as a motivator.

"To have someone to say, oh this is [a] wonderful resource. Let's today watch this video and then next week say 'oh you talked about you want to lose weight, there's a resource about diet and so on. Let's watch that and then we talk about blah blah blah'. And help me with those goals. In my head it's a great tool and it would help motivate me, but I just didn't have the energy to get myself to do it. So, it's like I need somebody that has a little engine, like an E bike, you know that could just get that assistance in going up the hill. I just could not do it on my own." (Breast Cancer Survivor 3).

Synthesis of quantitative and qualitative results

Quantitatively, low uptake and usage of HLaC *Online* and wide variability of the program's perceived usability was observed. Qualitative feedback indicated that the underutilisation of HLaC *Online* could largely be attributed to competing priorities. Further, these priorities appeared to vary depending on where participants were in their cancer survivorship trajectory. Participants who were experiencing enduring cancer-related side effects, particularly fatigue, cognitive impairment, and psychological distress, indicated that they prioritised their activities of daily living. Consequently, they did not have the energy or intrinsic motivation to log in and use the HLaC *Online* program. These participants also provided the recommendations of additional support and improved accessibility of the program. Alternatively, participants who had a greater time since diagnosis or were not experiencing as severe cancer-related symptoms identified work as a competing priority and indicated that they had already had their needs met by other programs and services.

However, a key explanation of the low usage and the variability of perceived usability of the HLaC *Online* is the self-directed nature of the program. Participants at times indicated a degree of content overwhelm and not knowing what to do next. Looking at participants pattern of usage, the three modules presented at the top of the screen were the most frequently accessed, suggesting participants followed the default module-order as a means of navigating this indecision.

Discussion

This study represents the *test* stage of the Stanford University's Design Thinking Process (Woods et al., 2017) by building upon the findings from previous stages to develop and test the preliminary feasibility of the HLaC *Online* program, using a single-arm mixed methods design. Our findings supported the included new modules, and the engagement strategies derived from previous stakeholder feedback. Specifically, the *Finding the New Normal* module was developed and refined from the previous stakeholder consultation and proved to be one of the most accessed modules of HLaC *Online* and received the most positive feedback from current participants. Similarly, email reminders, also recommended by stakeholders, proved useful to the participants who received them. However, HLaC *Online* demonstrated low participant uptake and engagement, and high rates of attrition at the post intervention questionnaire. Furthermore, we received mixed feedback from participants about the perceived usability of, and satisfaction with, the program. While there was not enough evidence to support the feasibility of implementing HLaC *Online* in its current format, the current study identified areas for improvement, including addressing technology barriers and refining strategies for promoting user engagement.

The low engagement with HLaC *Online* emerged as a key barrier to the program's feasibility. In the current study, almost half of participants did not log into the program following being granted access. In comparison, similar online intervention supporting healthy lifestyle change in cancer survivors demonstrated a considerably higher engagement rate, with 82 – 94% of participants logging into the program's website at least once (Forbes et al., 2015; Rees-Punia et al., 2022; Willems et al., 2017). Nevertheless, we observed that once participants did log into HLaC *Online*, their usage of available modules was comparable to those in previous studies. Technology barriers, specifically the lack of automation in accessing the website, may provide an explanation for this discrepancy in engagement rates. To ensure the information security guidelines were met for this program, participant questionnaire data was stored separately from the HLaC *Online* platform and required (a) potential users to enter a code to complete their baseline questionnaire, and (b) the research team to manually grant access once participants completed their baseline questionnaire. Consequently, this process formed two hurdles, and potential points of disengagement, for participants who wanted and/or expected streamlined access. Furthermore, the lack of immediate access to the website may have resulted in disengagement due to loss of interest, forgetting about the program, or a negative perception of the program if they were expecting immediate access as seen in other commercial online programs. Furthermore, participants who never logged into the program did not activate (or therefore receive) the automated email reminders programmed into the website to assist with user engagement. These challenges may also be compounded by the experience of cancer-related symptoms (i.e., fatigue and cognitive impairment) and low intrinsic motivation described by the participants who provided feedback. These findings map onto and extend the model of user engagement in online behaviour change interventions proposed by Short and colleagues' (2015b). This model suggests that engagement is influenced by the individual's environment (e.g., time, internet access, online environment), the individual themselves (e.g., biopsychosocial factors, current and past behaviours, expectations of the program, and affect), and intervention factors (e.g., persuasive design, usability, and personal relevance). Additional individual barriers identified in this chapter that need to be considered when implementing online behaviour change interventions in the cancer survivor population is the experience of cancer and cancer treatment-related side effects, particularly fatigue and cancer-related cognitive impairment. Experiencing these symptoms appeared to decrease engagement in HLaC *Online* by (1) reducing the participants intrinsic motivation to participate in the program and health behaviours and (2) impacting the participants ability to absorb the intervention content and complete activities. Baseline symptom severity has previously been identified as a barrier to engagement in digital *mental* health interventions (Borghouts et al., 2021). A similar pattern may be emerging in the lifestyle intervention space, whereby the experience of the symptoms themselves are preventing engagement in interventions that are designed to improve them. Therefore, additional engagement and support strategies are required to assist participants in the cancer survivor population to engage in online interventions.

Additionally, there was low uptake HLaC *Online* was observed in the current study. During the intervention period, 318 people visited the HLaC *Online* website, of which only 16 signed up and 11 were eligible. This low uptake rate was not surprising, as our primary recruitment strategy was via social media advertising. While social media advertising provides the opportunity to reach a wider pool of potential participants, there is a high potential that people who are not eligible for the study visit the site (Morgan et al., 2013). An alternative indicator of uptake is utilising an initial screening tool and determining the uptake of participants who have been screened eligible (Frandsen et al., 2016). However, this method is also limited, as it does not capture individuals that self-screen out. Larger implementation studies investigating uptake of an online intervention might consider simple pre-screening questions when entering the prior to signing up (Frandsen et al., 2016).

The indicators of preliminary efficacy demonstrated some promising signals for MVPA, vegetable consumption, and psychological distress, however, these findings coincided with reductions in Global QoL, Functional Well-being, Emotional Well-being and fatigue. It is important to note that these findings are based on a small sample (*n* = 5) and the effect sizes had large confidence intervals. Therefore, these results need to be interpreted with caution. On average, participants increased their MVPA by approximately 212 minutes and their vegetable intake by half a serve. These changes are comparable to the telephone-delivered Healthy Living after Cancer intervention, which demonstrated a smaller increase in MVPA (148-minutes), but a greater increase in vegetable intake (one serve; Eakin et al., 2020). In addition, participants also demonstrated a 15-point decrease in psychological distress. In contrast, participants reported lower Emotional Well-being after the intervention period. This inconsistency may be the result of differences between general distress and distress related to illness (Cella et al., 1993). Specifically, while participants may experience a reduction in general psychological distress, they continue to experience distress related to their previous cancer diagnosis. This cancer-related distress could be attributable to the observed reductions in Functional Well-being and an increase in fatigue symptoms (Cella et al., 2004). However, due to the small sample size, single-group design of the current study, and the wide variability in responses, it cannot be determined if these changes occurred because of engaging in HLaC *Online* or other extraneous variables.

One question to emerge from this study is how best to measure adherence / engagement with digital programs like HLaC *Online?* As explored in **Chapter 1**, the benefits of a digital health interventions is the ability to target multiple health behaviour and for participants to self-tailor the modules accessed (Kuijpers et al., 2013). Therefore, we would not expect participants to access all nine available modules in HLaC *Online.* This self-tailoring is illustrated in the participants usage and feedback in the current study, whereby they identified that they accessed modules most applicable to them and that some of the other behaviours were already addressed by other applications or services. Therefore, future studies should capture participants *intended* use of the intervention to then compare their *actual* use of the intervention, to assess the effectiveness of self-tailoring and determine their adherence to the intervention.

Continuing the engagement with end-users in the iterative design of HLaC *Online* not only confirmed that the design features derived from previous stakeholder feedback met the needs of cancer survivors, but also generated further modifications required to enhance the feasibility and usability of the program. Specifically, one recommendation involved having a guidance person to help with program navigation and goal establishment. While guidance videos were provided to assist with program navigation, these may not have been enough for participants still experiencing significant cancer related symptoms. Including some level of human support may assist with (a) accountability, (b) any difficulties using the program, and (c) engaging in the targeted health behaviour, while offering opportunities for tailored feedback, and fostering social support that is known to lead to health behaviour change (Santarossa et al., 2018). Different levels of human support and intervention guidance has been explored alongside online physical activity interventions in cancer populations. MacDonald et al. (2020) investigated weekly telephone calls in an 8-week rehabilitation intervention for cancer survivors and reported that 77% of participants logged into the program at least once. Similarly, Evans et al. (2021b) investigated two points of phone contact (i.e., week one and week three) over an 8 week exercise intervention for men with advanced prostate cancer. One hundred percent of participants accessed the first module of the program and logins to the program were more frequent at week one and three. Critical next steps of the design of HLaC *Online* involves returning to the *ideate* phase of the Stanford Design's Thinking Process (Woods et al., 2017) by reviewing these results with stakeholders at Cancer Council SA to ensure that the suggested human support element is logistically possible and feasible to deliver within their service to in the future.

Limitations

Limitations that need to be considered when interpreting results include the small sample size, absence of feedback from participants who dropped out before engaging with the program, the collection of usability feedback at the end of the program, and errors in coding the FFBQ. The small sample largely comprised women with a history of breast cancer. While a large sample was not required for initial feasibility testing, a larger sample may have generated a greater range of feedback from a more diverse population that represents variations in gender, cancer diagnosis, and health literacy. Furthermore, participants who dropped out prior to interacting with the program also did not respond to invitations for feedback interviews. Consequently, it was not possible to gather feedback to confirm whether the reasons explored above reflect why they did not access the program. In addition, collecting feedback on HLaC *Online*'s usability only at the end of the 12-week intervention may have diluted the magnitude of the impact. At times, participants reported not remembering their module usage or different features of the program and were unable to provide detailed feedback. This limitation was compounded by the use of a general measure to quantitatively investigate the website's perceived usability, as we were unable to determine which features specific to HLaC *Online* impacted upon perceived usability. To address these latter two limitations, future research should consider strategies to collect usability feedback during the intervention period by scheduling interviews when participants disengage from the program or by collecting or by asking participants for feedback after accessing a module and/or a tracker. One convenient and familiar way to collect feedback during the intervention period is use familiar 5 star rating accompanied by a free text response for users to identify what was useful / not useful about the specific module or website feature (Evans et al., 2021a; Perski & Short, 2021). Finally, due to an error in coding the FFBQ on Qualtrics, we were unable to generate scores for fat and fibre intake. These limitations collectively provide useful avenues for iterative changes in future research design.

In conclusion, while this study did not provide evidence to support the feasibility of HLaC *Online* in its current format*,* the continued engagement with end-users identified and provided recommendations on areas for improvement. Future research investigating the feasibility of complex, self-directed interventions should consider measuring *intended* vs *actual* module use, incorporate opportunities for participants to provide usability feedback during the intervention period, and consider adding guidance. Incorporating this feedback and testing the final iteration of *HLaC Online* in a pilot RCT form the foundation for the next Chapter.

Chapter 5.

Does adding brief telephone coaching calls to Healthy Living after Cancer *Online* improve feasibility and preliminary efficacy? A pilot randomised controlled trial

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Morgan Leske contributed 50%, 85%, 80%, Lisa Beatty contributed 20%, 15%, 10%, Bogda Koczwara contributed 5%, 0%, 5%, Elizabeth Eakin contributed 5%, 0%, 0%, Camille Short contributed 15%, 0%, 0%, Jon Degner contributed 2.5%, 0%, 0%, and Anthony Daly contributed 2.5%, 0%, 5% to the research design, data collection and analysis, and writing and editing, respectively.

Abstract

Aim: Healthy Living after Cancer *Online* (HLaC *Online*) is a co-designed physical activity, nutrition, and psychosocial web-delivered intervention for post-treatment cancer survivors. Previous research demonstrated low program uptake and usage, with feedback identifying a lack of accountability and information overload as factors. This study evaluated whether adding two 15-minute telephone coaching calls to the intervention improved usage and outcomes compared to the self-directed version.

Methods: Fifty-two Australian post-treatment cancer survivors were randomised to receive the program in a self-directed format (HLaC *Online; n* = 27) or with brief telephone support (HLaC *Online*+coaching; *n* = 25). Participants completed questionnaires at baseline, post-intervention (12 weeks after signing up), and one-month follow up. Feasibility was measured via intervention uptake, usage, adherence, usability, satisfaction, and attrition. Between-group effects were quantified using Cohen's *d*. Participants specified at baseline their intended module use; adherence was defined as the proportion of their nominated modules that were completed. Preliminary efficacy outcomes included quality of life, physical activity, nutrition, distress, and cancer-related symptoms. Differences between groups and the clinical significance of change over time was examined using repeated measures linear mixed model analyses and reliable change indices.

Results: Overall, 47 participants received their allocated intervention. Five (HLaC *Online*+coaching *n* = 4, and HLaC *Online* *n* = 1) dropped out due to personal reasons, cancer recurrence, or technical difficulties. HLaC *Online*+coaching participants accessed more modules (*M* = 5.1, *SD* = 3.3 vs *M* = 3.2, *SD* = 4.0, *d* =

0.50) and had higher adherence (*M* = 61.2%, *SD* = 0.4% vs *M* = 34.4%, *SD* = 0.4%, *d* = 0.64). Those allocated to HLaC *Online*+coaching rated usability (*M* =74.16, *SD*=17.7 vs *M* = 6 3.1, *SD* = 26.6, *d* = 0.49) and satisfaction (*M* = 26.5, *SD* = 3.38 vs *M* = 22.0, *SD* = 5.94, *d* = 0.94) higher than HLaC Online participants. Signals of preliminary efficacy were found in both conditions with small to moderate improvements for symptom distress, fibre intake behaviours, and sitting time. HLaC *Online* demonstrated small effects on QoL at post-intervention ($d_{within\ group}$ = 0.34), that were not maintained at the 1-month follow up ($d_{within\ group}$ = 0.13). HLaC *Online*+coaching demonstrated small to moderate effects on fear of cancer recurrence ($d_{within\ group}$ = -0.45 and -0.49).

Conclusion: The initial findings support the implementation of telephone coaching calls to improve the feasibility of HLaC *Online*, but these findings need to be balanced with the additional resources required. Signals of preliminary efficacy indicated that HLaC *Online* as a guided or self-directed program can support cancer survivors in reducing symptom distress and sitting time and improving fibre intake behaviours.

Introduction

Chapter 4 presented the initial single-arm feasibility evaluation of HLaC *Online*, whereby eleven cancer survivors accessed the program over 12-weeks, and uptake, usage, perceived usability and satisfaction of the program was assessed. Evidence to support the feasibility of this first iteration of HLaC *Online* was not obtained, due to (i) low user uptake and usage, and (ii) wide variability in perceived usability and satisfaction of the program. However, qualitative interviews with a subset of this sample identified three potential barriers to the user engagement: (1) cancer-related symptoms (e.g., fatigue and cancer-related cognitive impairment); (2) the perceived high time investment required for HLaC *Online* compounded by lack of time; and (3) website glitches, including the lack of automated sign up and improper saving of module content. To address these barriers and facilitate website engagement, one strategy recommended by both the stakeholders in **Chapter 3** and the participants of the initial feasibility study (**Chapter 4**) was the inclusion of human guidance.

Guidance in digital health interventions refers to part of the intervention being supplemented or supported by a coach (Mayer et al., 2018), facilitator, lived experience peer (O'Carroll Bantum et al., 2014), or health care professional (McNeil et al., 2019). The inclusion of guidance has been posited in the digital health literature to support user engagement with these interventions by providing a source of accountability for intervention use and behavioural change, identifying and addressing barriers to intervention use, and encouraging meaningful intervention use by connecting users personal experience to the intervention content (Jonathan et al., 2017; Mohr et al., 2011; Musiat et al., 2022). Existing digital health interventions targeting physical activity and/or diet in cancer have implemented human guidance via synchronous (e.g., face-to-face, telephone, video conferencing, or instant messaging; (Lynch et al., 2019; McNeil et al., 2019) or asynchronous (e.g., emails or moderated forums; (Mehta et al., 2022; Moskowitz et al., 2021; O'Carroll Bantum et al., 2014; Valle & Tate, 2017) modalities and with variations in timing and frequency. Most commonly, interventions have implemented synchronous human guidance at the commencement of the intervention to assist with the program orientation and establishing intervention goals (Kiss, 2019).

Although several studies have investigated digital health lifestyle interventions with human guidance (Ester et al., 2021), there is limited research investigating the impact of such guidance on user engagement, satisfaction, and adherence in the cancer survivor and other chronic health populations. To date, two studies have compared a self-directed and guided online health behaviour intervention for post-treatment cancer survivors. First, Chan et al. (2020) investigated an online physical activity and diet intervention for prostate cancer survivors with two conditions differing only by the inclusion of two optional telephone calls with a dietitian and an exercise trainer. Findings revealed that participants in the guided condition visited more pages of the website, and a greater proportion rated their satisfaction as “very high” compared to the self-directed condition. Second, van de Wiel et al. (2021) evaluated an online physical activity program embedded for breast and prostate cancer survivors with, verses without, monthly telephone calls from a physiotherapist. Unlike Chan et al. (2020), van de Wiel et al. (2021) did not find differences between the groups in program usage.

The impact of guidance on digital health intervention adherence has been more thoroughly investigated for psychological interventions. Meta-analytic evidence from the general population suggests that, on average, the completion rates of web-based interventions targeting symptoms of anxiety and depression were 12% higher when guidance was included in the intervention protocol (Musiat et al., 2022). This evidence is consistent with data from the cancer survivor population. A recent systematic review and meta-analysis investigating the usage of digital psychological interventions in cancer patients revealed that the proportion of participants who used the intervention at least once ranged from 85% to 100% for guided interventions compared to 8.3% to 81% for self-directed interventions (Akdemir et al., 2024).

While there is some evidence to suggest human guidance can improve engagement and adherence to digital health interventions, there is mixed evidence regarding whether this also translates into efficacy. Counterintuitively, a meta-analysis conducted by Ester et al. (2021) found that *self-directed* digital health interventions were associated with greater increases in physical activity in cancer patients and survivors, than interventions which included partial face-to-face supervision. However, this evidence is limited by associations, rather than direct effects, as the meta-analysis did not include studies directly comparing guided and self-directed interventions. In comparison, Phillips et al. (2022) utilised a factorial design with several supportive strategies alongside *Fit2Thrive,* a mobile application program targeting physical activity in breast cancer survivors, and found that Moderate and Vigorous Physical Activity (MVPA) increased more in participants who received supportive calls. In sum, research indicates that adding guidance to an online intervention, such as HLaC *Online*, may facilitate greater website engagement, higher program satisfaction, and improve health behaviour outcomes. However, minimal studies have directly compared guided and self-directed lifestyle interventions in the cancer survivor population.

Aim

The present study therefore aimed to co-design and evaluate the impact of adding human guidance for HLaC *Online*. More specifically, to examine whether guidance results in superior feasibility and preliminary efficacy outcomes in comparison to the self-directed version of the program.

Method

Co-design: Intervention refinement

As per the Standford's Design Thinking Process (Woods et al., 2017), a second *ideate* phase of co-design was conducted with the HLaC *Online* research team, comprising experts in digital health and lifestyle interventions in cancer survivorship, oncology health care professionals, a cancer survivor consumer representative, and the project's industry partner, Cancer Council SA, to determine how human support could be added to HLaC *Online* to increase participants usage and adherence to the program. A single stakeholder engagement meeting with the members from the Cancer Council SA support team was held to establish the service's willingness and capacity to implement human support alongside HLaC *Online*. If indicated, the meeting aimed to achieve consensus about the level of human support that could be offered with the view of subsequent, sustainable implementation. The agenda of the meeting included discussion of (a) the results from **Chapter 4**, and (b) the options for *modes* of human support (i.e., telephone, SMS messaging, and online chat or videoconferencing platforms), and the support *content* (i.e., reminders to use the program, text-based coaching, personalised feedback, or establishing peer relationships). The consensus from this meeting was: (a) weekly automated SMS messages reminding all participants to log in to HLaC

Online should be added; and (b) two 15-minute telephone calls spaced four weeks apart would be possible to implement within Cancer Council SA following this trial. For the content of the first telephone call, the stakeholders suggested adapting the existing telephone call scripts for Weeks 1 and 2 of the telephone-delivered Healthy Living after Cancer protocol. The Week 1 telephone call script covered a check in on participant well-being, motivation for participating in the program, an introduction to SMART goals, the benefits of tracking progress, and setting a physical activity goal. The stakeholders recommended editing this script to align with the online delivery by including an orientation to the website (i.e., a run through of included modules, features, and different types of activities), allowing participants to choose what area of health (i.e., physical activity, healthy eating, or mental health) they would like to set a goal for, and providing recommendations for which modules participants should review. The Week 2 telephone call script covered a well-being check in, checking in on goal attainment and discussing their achievements or barriers to achievement where applicable, and revising goals. The edits recommended by stakeholders for this call included reviewing participants' use of the website, with a particular focus on their use of recommended modules from the previous phone call. These key changes were then implemented into the web-program and trial methodology, and evaluated via a feasibility RCT.

Design

A two-group RCT was used to evaluate the feasibility and efficacy of adding two telephone coaching calls to HLaC *Online*. Participants were assessed at baseline, post-intervention (12-weeks following baseline) and one month follow up. The primary outcome was feasibility and secondary outcomes were indicators of preliminary efficacy, including QoL, fatigue, physical activity, diet quality, cancer-related symptoms, and fear of cancer recurrence. Ethics approval was obtained by the Cancer Council Victoria Human Research Ethics Committee (HREC2106) and the trial was registered with the Australian New Zealand Clinical Trials Registry (ANZCTRN12622001111763).

Participants

The eligibility criteria for the current study remained largely the same as the previous pre-post trial described in **Chapter 4,** except for broadening the time since diagnosis criterion from within 5-years of cancer diagnosis to an unlimited time since diagnosis. This eligibility criterion was broadened as it was noted in the previous trial that two people signed up who were greater than 5 years post diagnosis, indicating that people are still interested in lifestyle interventions after cancer further along in their survivorship. The eligibility criteria are briefly summarised below:

- Australian adults (≥18 years old), diagnosed with localised, non-metastatic cancer.
- Completed primary cancer treatment.
- No contraindications to engaging in unsupervised physical activity.
- No cognitive or mental health impairments that would hinder participation.
- Sufficient English comprehension to enable program participation.

Procedure

The reporting and conduct of this study followed the Consolidated Standard of Report Trials (CONSORT) guidelines (Eldridge et al., 2016). Participants were recruited between August 2022 and January 2023. Recruitment channels included:

(1) organic social media posts through Cancer Council SA and Bowel Cancer Australia; (2) paid social media advertising via Cancer Council SA and Flinders University; (3) Cancer Council SA services (i.e., support line cancer nurses, accommodation, and newsletters); (4) cancer support groups and organisations (via distribution of a plain language summary and/or flyer promoting the study to any cancer survivors in their network); and (5) Breast Cancer Network Australia's review and survey group.

Consenting participants completed a baseline questionnaire via the online survey platform, Qualtrics. Participants then received *immediate* access to the HLaC *Online* program. Following baseline completion, participants were randomly allocated to receive the intervention (HLaC *Online*+coaching) or the active control condition (HLaC *Online*). Block randomisation was conducted in Excel (Block sizes 2, 4 and 6) by the PhD candidate. Due to the nature of the telephone coaching calls, the participants and the PhD candidate were not blinded to the group allocation. Participants allocated to the intervention condition were contacted within two working days to schedule the first coaching call.

Intervention conditions

HLaC *Online*+coaching. Participants allocated to the HLaC *Online*+coaching condition received access to the 12-week HLaC *Online* program as described in **Chapter 4**. Briefly, HLaC *Online* comprised nine modules of psychoeducation and interactive activities covering: (a) setting and achieving healthy lifestyle goals, (b) life after cancer treatment, (c) physical activity, (d) nutrition, (e) mental health, (f) managing fatigue, (g) maintaining a healthy weight, (h) accessing peer support, and (i) behavioural maintenance strategies. To encourage usage of the program, participants received two automated email reminders following one and two weeks of website inactivity. Intervention participants received weekly automated SMS reminders to log in and track their progress, and two coaching telephone calls in Weeks 1 and 4 of the 12-week active intervention period. The telephone coaching calls were delivered by the PhD candidate.

Coaching Call 1. Participants were encouraged to access the *My Goals* module prior to the Week 1 telephone call and to have this available during the call. The call involved introducing the HLaC *Online* program, determining their aims in participating in the program, and establishing at least one SMART goal and action plan in the *My Goals* module. At the conclusion of the telephone call, participants were encouraged to complete two other SMART goals and action plans prior to the next telephone call.

Coaching Call 2. The Week 4 telephone call involved a check in with participants' progress with the SMART goals, a discussion about any barriers they had encountered in achieving their goals and refining their action plan as needed. Participants also had the opportunity to discuss any issues using the HLaC *Online* program. Following both telephone calls, participants were emailed a summary of what was covered.

HLaC *Online.* Those allocated to the active control group received access to HLaC *Online* as a self-directed program, with the automated email and SMS reminders for the 12-week active intervention period. They did not receive the telephone coaching calls.

Measures

Table 5.1 summarises all measures used in the present study. Given the same battery of validated psychometric measures from **Chapter 4** was adopted for the present study, only new measures not previously described in that chapter are summarised below.

Table 5.1

Battery of measures for the evaluation of adding telephone coaching calls to HLaC Online

Outcome	Score range	Internal consistency (α)
Sociodemographic information	N/A	N/A
Clinical history	N/A	N/A
Feasibility outcomes		
Uptake	N/A	N/A
Usage	N/A	N/A
Usability (System Usability Scale; Brooke, 1996)	0 - 100 (corresponding F and A+ grade; see **Table 4.2**)	.96
Indicators of preliminary efficacy outcomes		
QoL (Functional Assessment of Cancer Therapy – General; Cella et al., 1993)	Global QoL 0 – 108 Physical well-being, Functional well-being, Social/family well-being 0 – 28 Emotional well-being 0 – 24	Global QoL = .92 Physical well-being = .84 Functional well-being = .87 Social/family well-being=.86 Emotional well-being = .82
Physical Activity (Active Australia Survey; Health & Welfare, 2003)	N/A	N/A
Daily sitting time (International Physical Activity Questionnaire; Craig et al., 2003)	N/A	N/A[a]
Diet Quality (Fat and Fibre Behaviour Questionnaire; Reeves et al., 2015)	1 - 5	Fruit intake = N/A Vegetable intake = N/A Fibre index = .63 Fat index = .52

Table 5.1. *continued*

Outcome	Score range	Internal consistency (α)
Fatigue (Functional Assessment of Chronic Illness - Fatigue; Smith et al., 2010)	0 - 52	.95
Cancer related symptoms (MD Anderson Symptom Inventory; Cleeland et al., 2000)	0 - 10	Symptom severity = .86 Symptom interference = .91
Fear of cancer recurrence (4-item Concerns About Recurrence Questionnaire; Thewes et al., 2015)	0 - 40	.86
Psychological Distress (21-item version of Depression, Anxiety and Stress Scale; Lovibond & Lovibond, 1995)	0 - 63	.91

[a] As scale includes two-items, split half reliability is more appropriate, ρ = .54

Additional measures of feasibility

Three additional measures assessing user satisfaction, intervention adherence, and the intervention delivery time were added to the current trial to evaluate the feasibility of HLaC *Online* and the additional coaching telephone calls.

User satisfaction. User satisfaction of the overall program was measured in two ways: (a) overall intervention satisfaction and (b) module satisfaction. Overall intervention satisfaction was measured using the Client Satisfaction Questionnaire–8

(CSQ-8; Attkisson & Zwick, 1982). The CSQ-8 is an eight-item standardised measure to assess general satisfaction with health services. Example items include "*How would you rate the quality of the program you received?*" and "*Has the program you received helped you to deal more effectively with your problems?*". Each item asks participants to respond on a 4-point Likert scale with six possible sets of response options, including: (1) *Excellent, Good, Fair,* and *Poor*; (2) *No, definitely not; No, not really; Yes, generally;* and *Yes, Definitely*; (3) *Almost all of my needs have been met, Most of my needs have been met, Only a few of my needs have been met,* and *None of my needs have been met*; (4) *No, definitely not; No, I don't think so; Yes, I think so;* and *Yes, definitely*; (5) *Yes, they helped a great deal; Yes, they helped somewhat; No, they really didn't help;* and *No, they seemed to make things worse*; (6) *Very satisfied, Mostly satisfied, Indifferent or mildly dissatisfied,* and *Quite dissatisfied.* Items were summed, with scores ranging from 8 to 32, with higher scores indicating greater satisfaction. The CSQ-8 demonstrated acceptable internal consistency during its development (α = .93; Attkisson & Zwick, 1982) and in the current study (α = .95). The CSQ-8 has been used to evaluate other digital health services in cancer populations, including a cancer pain intervention delivered via videoconferencing (Kelleher et al., 2019) and an internet-based intervention for coping with haematological cancer (David et al., 2013).

Module satisfaction was measured using a 5-star rating and an open text-response as recommended by Perski and Short (2021).

Adherence. As stakeholders have previously highlighted that users of HLaC *Online* could self-select which modules they would like to use, participants nominated at the end of the baseline questionnaire which of the HLaC *Online* modules they were interested in using. Adherence was therefore defined as the proportion of their completed nominated modules.

Intervention delivery time. To understand the time requirements in delivering HLaC *Online*+coaching and HLaC *Online*, administration activities and their duration were recorded. For HLaC *Online*+coaching, these activities included setting up the automated SMS reminders, contact with participants to arrange the telephone coaching calls, the telephone coaching calls, note keeping, and any other assistance participants required to use the program. For HLaC *Online*, these activities included setting up the automated SMS reminders and any other assistance participants required to use the program.

Statistical analysis

All analyses were conducted using IBM Statistical Package for the Social Sciences (version 28; 2021). Descriptive statistics summarised participants baseline demographic profile, and clinical characteristics, while independent samples *t*-tests and Chi-squared tests were conducted to compare whether these differed between participants allocated to HLaC *Online*+coaching and HLaC *Online*. Differences between groups were considered significant if $p < .05$.

Missing data

Fifteen simple logistic regressions were used to determine whether demographic (age), clinical (age at diagnosis, time since diagnosis, and BMI) or baseline variables (FACT-G, MVPA, average daily sitting time, fat index, fibre index, symptom severity, symptom interference, FACIT-F, FCR, and distress), or group allocation predicted incompletion of follow-up measures. A binary variable was created to classify participants as: (1) not missing (i.e., completed at least one follow-up measure); or (2) missing (i.e., missing all follow-up data). In each analysis, this binary variable was entered as the dependent variable and one demographic, clinical, or baseline variable was entered as the independent variable. Gender, country of birth, educational achievement, relationship status, cancer type, and treatment were not entered as independent variables due to a low number of participants in one or more groups.

Feasibility outcomes

Descriptive statistics were used to summarise feasibility outcomes, including participant uptake, program usage, adherence, usability, attrition, user satisfaction, and intervention delivery time. Due the underpowered nature of the study, differences between groups were quantified using Cohen's *d* and interpreted using Cohen's benchmarks of 0.2, 0.5, and 0.8 indicating small, medium, and large effects, respectively (Cohen, 2013).

Clinical outcomes

Repeated measures Linear Mixed Model analyses using a first-order autoregressive model were performed to compare the changes over time in the HLaC *Online* and HLaC *Online*+coaching. The main analyses included the intent-to-treat sample (*n* = 52). Two sensitivity analyses were conducted by repeating linear mixed models while: (1) controlling for baseline differences; and (2) using data from participants who completed at least one follow up assessment, to ensure that data did not systematically differ from the included participants. Corresponding within group and between group (adjusted for baseline differences) Cohen's *d*s were calculated at post-intervention and 1-month follow up. The benchmarks described above were used to interpret the strength of the effect. For QoL, Fatigue, Fat and

Fibre index, and MVPA, positive between group effect sizes indicated a greater increase (i.e., improvement) over time for HLaC *Online*+coaching group. For average daily sitting time, cancer related symptom severity and interference, fear of cancer recurrence and distress, a positive effect size indicated greater decreases for the HLaC *Online* group.

Results

Primary Outcome: Feasibility

Uptake

Figure 5.1 presents a graphical representation of the flow of participants through the RCT. Overall 1,894 new users visited the website landing page. Eighty-one people signed up to the program, of whom 28 did not complete the baseline questionnaire and one person was ineligible (currently undertaking cancer treatment). Overall, 52 participants were randomised, resulting in a 64.2% uptake rate.

Demographic and clinical characteristics of participants by group allocation are presented in **Table 5.2**. Overall, the mean age of participants was 58.73 (*SD* = 10.06). The majority of participants were female (94.2%), born in Australia (63.5%), identified as Australian (80.8%), were tertiary educated (67.3%), married (67.3%), lived in an urban area (78.8%) in the highest quintile for SES (32.7%), and diagnosed with breast cancer (88.5%). The majority of participants were recruited from Facebook advertisements (*n* = 20). Other pathways included Breast Cancer Network Australia (*n* = 9), cancer support services newsletters (*n* = 8), cancer support groups (*n* = 5), Weekend notes (*n* = 2), and a Cancer Council support line nurse (*n* = 1).

Figure 5.1

Participant flow diagram for HLaC Online randomised control trial

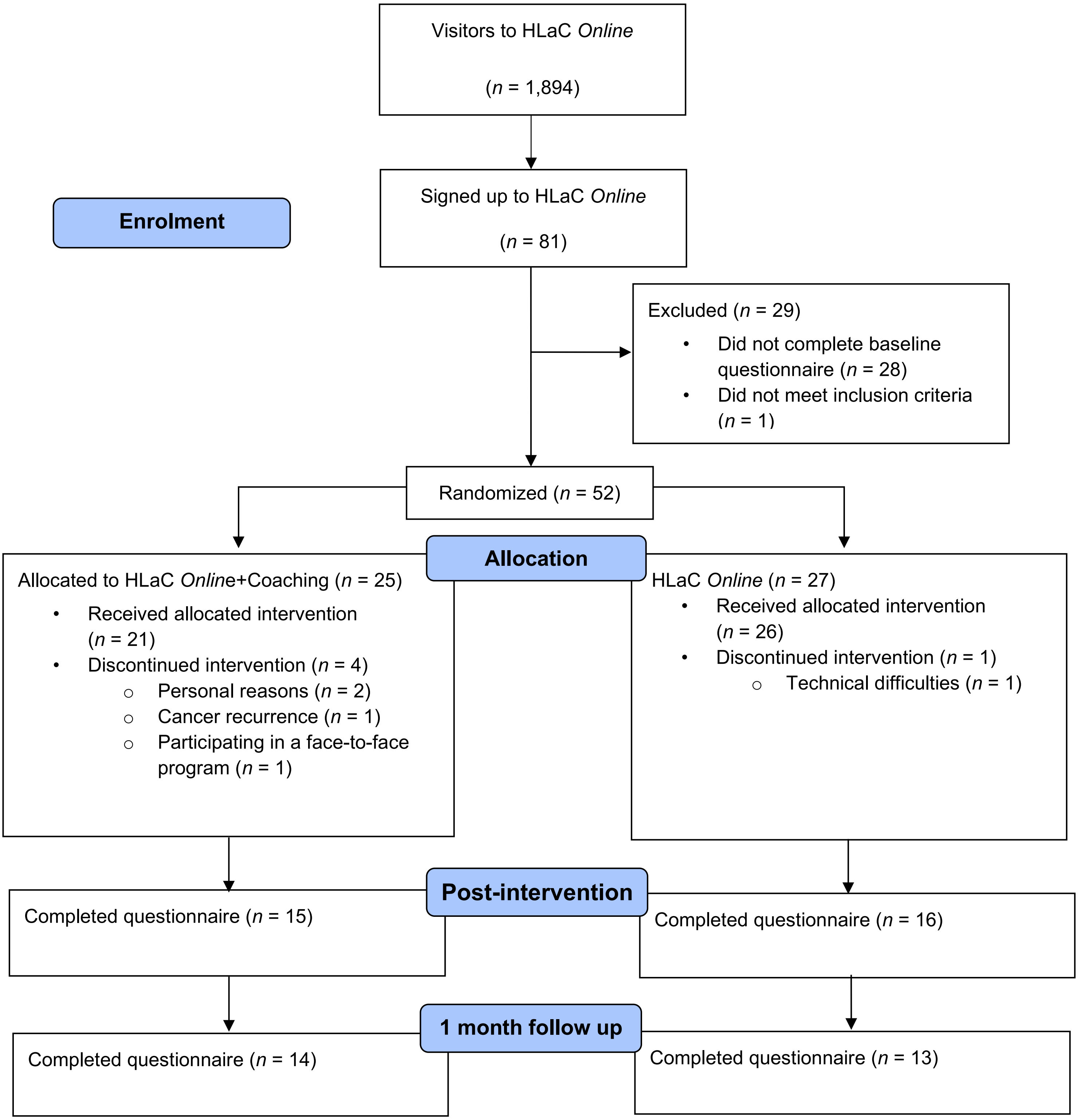


Table 5.2

Participant demographic and clinical characteristics

Characteristic	HLaC *Online* +coaching (*n* = 25)	HLaC *Online* (*n* = 27)	Group differences between intervention groups
	M (*SD*)	*M* (*SD*)	*p*
Age	58.07 (7.95)	59.34 (11.91)	.66
BMI	28.52 (5.84)	27.89 (5.89)	.99
Age at diagnosis	53.76 (8.91)	51.15 (10.92)	.38
Time since diagnosis (years)	3.49 (3.62)	6.22 (6.95)	.08
	n (%)	*n* (%)	*p*
Gender			
Female	24 (96.00)	25 (92.60)	N/A[a]
Male	1 (3.70)	1 (4.00)	
Other (not specified)	-	1 (3.70)	
Relationship status			
Married	17 (81.00)	18 (72.00)	N/A[a]
Other	4 (19.00)	7 (28.00)	
Educational achievement			
Secondary school	1 (4.00)	2 (8.00)	N/A[a]
TAFE	7 (28.00)	7 (28.00)	
Tertiary	17 (68.00)	16 (64.00)	
Country of Birth			
Australia	18 (72.00)	15 (55.60)	.22
Other[b]	7 (28.00)	12 (44.40)	
Geographical remoteness			
Urban	19 (76.00)	22 (81.50)	.63
Rural	6 (24.00)	5 (18.50)	
SES			
1st Quintile	4 (16.00)	5 (18.50)	N/A[a]
2nd Quintile	3 (12.00)	1 (3.70)	
3rd Quintile	5 (20.00)	4 (14.80)	
4th Quintile	5 (20.00)	8 (29.60)	
5th Quintile	8 (32.00)	9 (33.30)	

Table 5.2. *continued*

Characteristic	HLaC *Online* +coaching (*n* = 25)	HLaC *Online* (*n* = 27)	Group differences between intervention groups
	n (%)	*n* (%)	*p*
Country of Birth			
Australia	18 (72.00)	15 (55.60)	.22
Other[b]	7 (28.00)	12 (44.40)	
Cultural Background[c]			N/A[a]
Australian	20 (80.00)	22 (81.50)	
English	4 (16.00)	7 (25.90)	
Irish	3 (12.00)	-	
Scottish	2 (8.00)	-	
Indian	2 (8.00)	1 (3.70)	
Other[d]	-	6 (22.20)	
Cancer type			
Breast	21 (84.00)	25 (92.60)	N/A[a]
Other[e]	4 (16.00)	2 (7.40)	
Completed Treatment			
Yes	21 (84.00)	25 (92.60)	N/A[a]
No/Unsure[f]	4 (16.00)	2 (7.40)	
Treatment received[c]			
Surgery	24 (96.00)	25 (92.60)	.60
Chemotherapy	16 (64.00)	21 (77.80)	.27
Radiotherapy	18 (72.00)	20 (74.10)	.87
Immunotherapy	1 (4.00)	6 (22.20)	N/A[a]
Hormonal	14 (56.00)	10 (37.00)	.17

[a] indicates assumptions were violated to conduct a chi-square analysis (i.e., 25% of cell counts <5).

- indicates no participants in this group.

[b] United Kingdom (n = 11), India (n = 2), Canada (n = 2), New Zealand (n = 1), South Korea (n = 1), Peru (n = 1), and Pakistan (n = 1).

[c] Multiple responses allowed.

[d] Chinese (n = 1), Korean (n = 1), Spanish (n = 1), South American (n = 1), Canadian (n = 1), and Ukrainian (n = 1)

[e] Colorectal (n = 1), head and neck (n = 1), lymphoma (n = 1), thyroid (n = 1), kidney (n = 1), and multiple (n = 1).

[f] All participants which selected ‘No’ or ‘Unsure’ for currently undertaking treatment indicated they were currently on hormonal treatment.

Attrition

Of the 52 participants, 39 (75.0%) participants completed at least one follow up questionnaire. Group allocation did not predict missing follow up data (*Wald*(1) = 0.23, *p* = .63). **Table 5.3** summarises the odds ratio of each of the demographic, clinical, and baseline variables analyses. There were no significant baseline predictors of missing follow up data and data were missing at random.

Table 5.3

Baseline values and logistic regression analysis predicting missing follow up data.

Predictor	Missing	Not missing	
	M (*SD*)	*M* (*SD*)	*OR* [95% *CI*]
Age	57.33 (10.31)	58.78 (10.63)	0.98 [0.92, 1.05]
Age at diagnosis	52.77 (9.63)	53.06 (10.72)	1.00 [0.94, 1.07]
Time since diagnosis	4.20 (5.14)	5.26 (6.05)	0.97 [0.86, 1.09]
BMI	28.66 (3.49)	28.00 (6.50)	1.01 [0.91, 1.12]
FACT-G	75.46 (9.90)	73.06 (18.01)	1.01 [0.97, 1.05]
MVPA	311.15 (254.49)	309.74 (341.67)	1.00 [0.99, 1.00]
Average daily sit time^{c}	338.24 (362.33)	388.60 (237.47)	1.00 [0.99, 1.00]
Fat index	3.50 (0.26)	3.40 (0.48)	2.04 [0.43, 9.65]
Fibre index	3.01 (0.71)	2.92 (0.65)	1.12 [0.43, 2.92]
Symptom Severity^{c}	4.43 (1.50)	3.51 (2.05)	1.27 [0.89, 1.80]
Symptom interference	3.98 (2.20)	3.39 (2.36)	1.13 [0.86, 1.48]
FACIT-F	108.77 (16.76)	106.37 (28.61)	1.00 [0.98, 1.03]
FCR	18.08 (8.78)	16.94 (10.44)	1.01 [0.95, 1.08]
Distress	18.00 (10.03)	22.34 (17.84)	0.98 [0.94, 1.02]
	N (%)	*N* (%)	*OR* [95% *CI*]
Group allocation			
HLaC *Online*	6 (22.2)	21 (77.8)	0.74 [0.21, 2.59]
HLaC *Online*+coaching	7 (28.0)	18 (72.0)	-

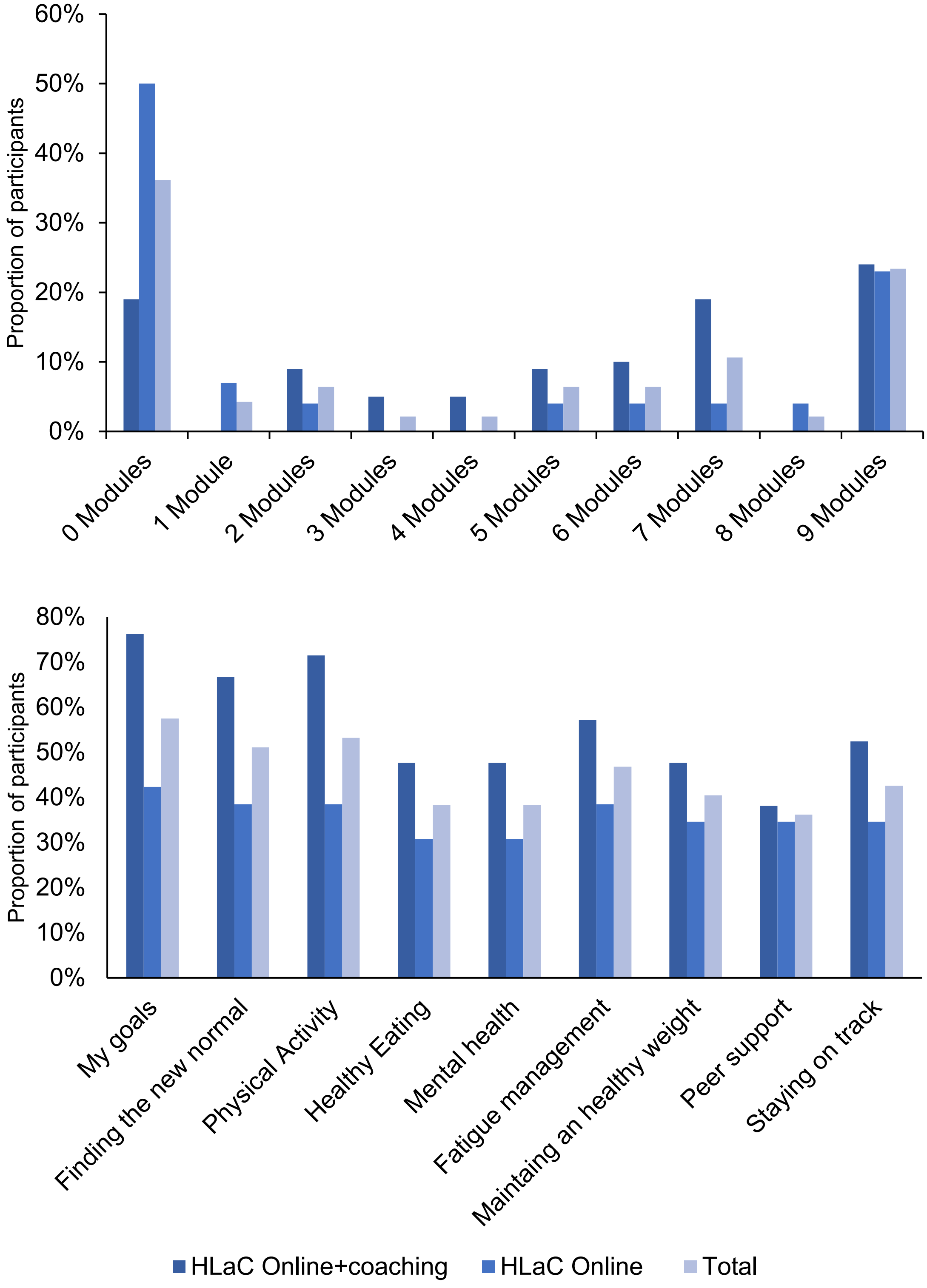
- Indicates reference group

Usage

Figure 5.2 presents the module usage of participants by group and the overall sample. Although not statistically significant, participants in the HLaC *Online*+coaching condition (*M* = 5.05, *SD* = 3.32) accessed close to two modules more than those in the HLaC *Online* condition (*M* = 3.23, *SD* = 3.97), *d* = 0.49 (95% CI = -0.10, 1.07). Fifty percent (*n* = 13) of participants allocated to HLaC *Online* did not complete any modules. In comparison, only 24% (*n* = 4) of participants allocated to HLaC *Online*+coaching did not complete any modules. There were similar rates in both groups of participants completing all nine modules (HLaC *Online*+coaching = 24%; HLaC *Online* = 23%). The most frequently completed modules included *My Goals*, *Finding the New Norma*l, and *Physical Activity*.

Figure 5.2

Percentage of participants completing each module, and the number of modules completed (n = 47).



Adherence

Participants allocated to the HLaC *Online*+coaching condition (*M* = 61%, *SD* = 39) had greater adherence than those allocated to the HLaC *Online* condition (*M* = 34%, *SD* = 44), *t*(45) = 2.17, *p* =.04, *d* = 0.63 [95% CI = 0.04, 1.22].

Website Usability

On average, all participants rated the usability of the HLaC *Online* at 69.26 (*SD* = 22.37), corresponding to a C grade (see **Table 4.2**). Participants allocated to the HLaC *Online*+coaching condition rated the programs usability significantly higher than those in the HLaC *Online* condition, *t*(45) = 2.17, *p* =.04, *d* = 0.63 [95% CI = 0.04, 1.22]. Specifically, participants allocated to HLaC *Online*+coaching rated the usability with a B grade (*M* = 74.16, *SD* = 17.70), whereas participants allocated to the HLaC *Online* condition rated usability as a C grade (*M* = 63.10, *SD* = 26.60).

Website satisfaction: Overall program satisfaction

All participants on average were mildly satisfied with the program (*M* = 24.52, *SD* = 5.13). Participants allocated to the HLaC *Online*+coaching condition on average were significantly more satisfied with the program (*M* = 26.53, *SD* = 3.38) than participants allocated to the HLaC *Online* condition who were only 'mildly satisfied' (*M* = 22.00, *SD* = 5.94), *t*(25) = 2.50, *p* =.02, *d* = 0.97 [95% CI = 0.16, 1.77].

Website satisfaction: Individual module satisfaction

Twenty-six participants responded to at least one module satisfaction rating. More participants in the HLaC *Online*+coaching group responded to the module satisfaction ratings (*n* = 15) than HLaC *Online* (n = 11). **Table 5.4** summarises the average satisfaction rating of each module with corresponding qualitative feedback.

Most of the modules achieved a rating of four or more stars. The *Maintaining a healthy weight* module had the highest rating, of 4.67 stars. However, this rating was paired with mixed qualitative feedback, with some participants reporting that the module was informative, while others reported not seeing the associated worksheets or trackers. The *Staying on track* module received the lowest rating, of 3.67 stars. Only four participants provided qualitative feedback. Two participants commented that they needed to apply these strategies to their lives and one participant commented that they did not see the worksheets. The last participant provided feedback on the program as a whole and requested instructions on how to submit worksheets.

Table 5.4

Module satisfaction ratings and key points of feedback

Module	*n*	Star rating	*n*	Key feedback	Example of feedback
My goals	8	★★★⯨	11	• Helpful process to analyse current lifestyle and set clear goals • Module too long • Unable to remember SMART goals when setting action plans • More steps needed in action plan	*"It is great to set clear goals which helps to guide me achieving more specific goals. Because it is being very specific the whole process was taking too long for me."*
Finding the new normal	10	★★★★	10	• Highly relevant and normalising information • Cancer survivor videos helpful	*"Great to have a range of people speaking about their respective experiences however maybe a wider range of types of cancers would be a good option."*
Physical activity	10	★★★★⯨	13	• Mixed feedback about exercise videos – some found them helpful, and others found them too basic • Options to increase accessibility to exercises	*"I tried these exercises, and they were quite manageable to do."* *"I am extremely active and always have been, so I found this module on exercise too basic for my current exercise context."*
Healthy eating	6	★★★★⯨	8	• Food swaps and label explanations were helpful • Information provided in the module confirmed what they already knew	*"I loved the food label explanation, the swapping guide and the eating out guide - these are all areas where I can make improvements in choices"*

Table 5.4. *continued*

Module	*n*	Star rating	*n*	Key feedback	Example of feedback
Mental Health	4	★★★★⯨	4	• Prompted booking an appointment with a psychologist • Liked the downloadable content	*"The ability to download a few meditations so they can be accessed remotely"*
Fatigue Management	8	★★★⯨		• Information was too general. • Recommended examples of implementing different strategies • Requested more information for helping support network to understand fatigue	*"I would have liked a bit more explanation/detail/example on pacing"*
Maintaining a Healthy Weight	6	★★★★⯨	10	• Informative • Participants reported not seeing videos, worksheets, or the meal tracker	*"It would be good to have a worksheet that tracked food intake and maybe a calorie counter. I will find these elsewhere."*
Peer Support	8	★★★★⯨	7	• Some found it helpful to know which peer support options are available, while others had already accessed these options and provided mixed feedback.	*"The modules were helpful especially indicating that even after treatment, you can seek help"*
Staying on Track	6	★★★⯨	4	• Limited feedback provided	*"This track is very good, and I can think of nothing to change. It is up to me now to put into practice what I have learned."*

Intervention delivery

Of the 21 participants who received the coaching calls, 85.7% received two coaching calls. On average, the duration of the first telephone call was 29.91 minutes (*range* = 21 – 61) and the second telephone call was 19.67 minutes (*range* = 8 – 45). Two participants required telephone calls that were over 40 minutes in duration. Both participants cited significant life stressors, unrelated to cancer, as barriers for achieving healthy living goals. Overall, the average time spent delivering HLaC *Online*+coaching, including scheduling of the automated SMS reminders, organising the telephone calls, completing the telephone calls, and sending the telephone call summary, was 92.07 minutes (*SD* = 36.59). In comparison, the average time spent delivering the self-directed version, including scheduling the automated SMS reminders was 6 minutes (SD = 3.41).

Secondary Outcomes: Signals of preliminary efficacy

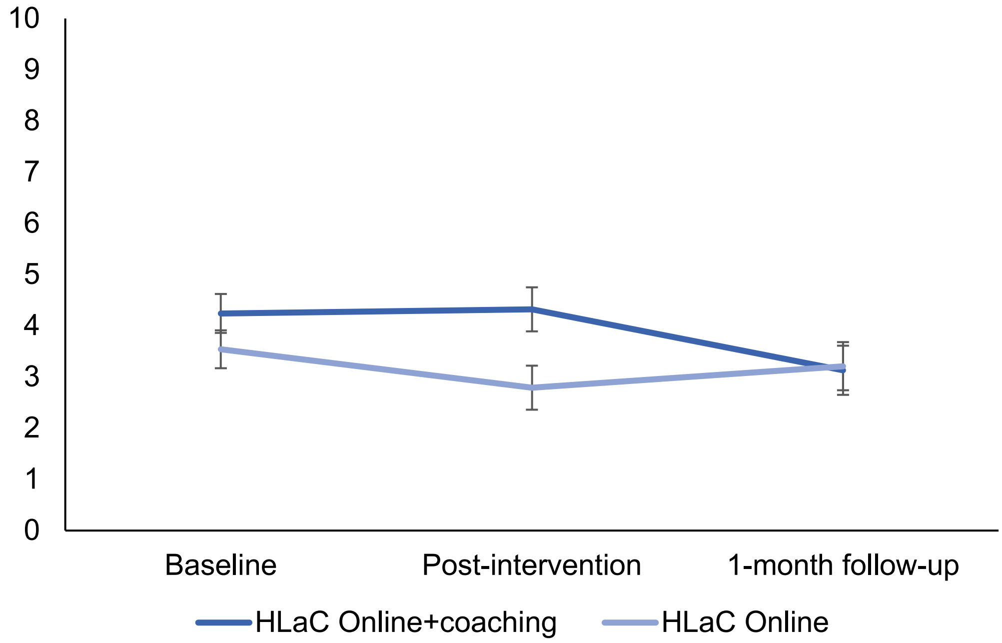
Differences between groups over time

Table 5.5 summarises the estimated means and standard errors, the main effects of time, and the group x time interactions with corresponding effect sizes for all preliminary efficacy outcomes. **Table 5.6** presents the reliable changes indices of all preliminary efficacy outcomes.

Symptom severity. One significant group x time interaction was obtained for *symptom severity*. As presented in **Figure 5.3**, compared to HLaC *Online*+coaching, the HLaC *Online* group demonstrated a greater decrease in symptom severity from baseline to post-intervention, as indicated by a moderate positive significant effect (*d* = 0.49). However, from baseline to 1-month follow-up, a negative effect of a similar magnitude indicated that HLaC *Online*+coaching had a greater decrease in symptom severity in comparison to HLaC *Online* (*d* = -0.41). Reliable improvement was only detected for 7.7% of participants allocated to HLaC *Online*+coaching from baseline to 1-month follow-up.

Figure 5.3

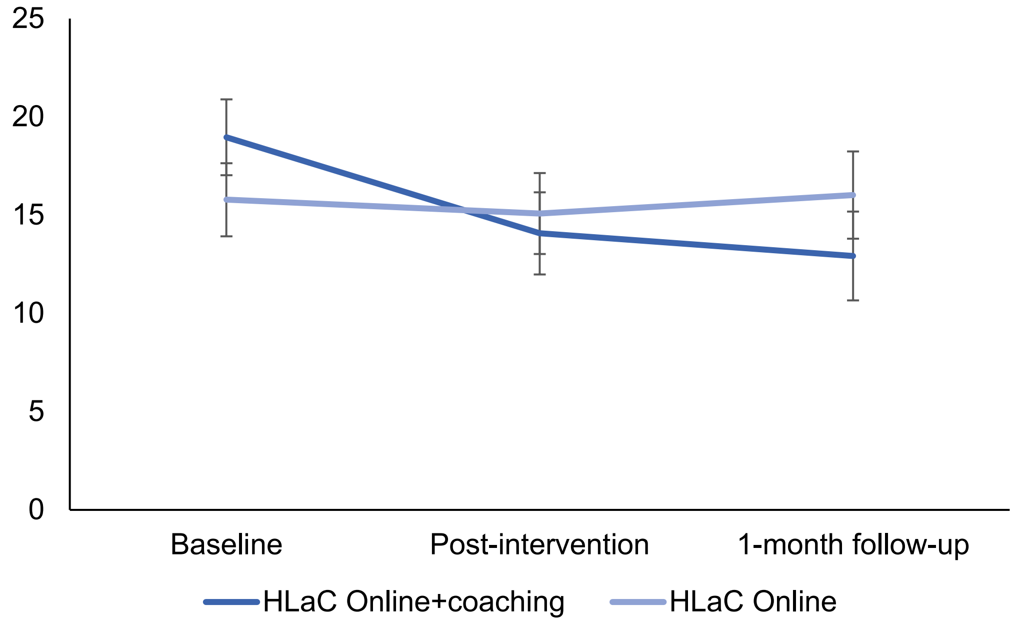
Group x time interaction for cancer related symptom severity



Fear of Recurrence. While not reaching statistical significance, participants in the HLaC *Online*+coaching group reported a decrease in fear of cancer recurrence from baseline to post-intervention with a small to medium effect (*d* = -0.45), which was sustained at the 1-month follow up (*d* = -0.49). In contrast, no change was observed in the HLaC *Online* group (see **Figure 5.4**). After controlling for baseline, this difference between groups had a small to medium effect at post-intervention (*d* = -0.43) and a medium to large effect at 1-month follow up (*d* = -0.65). Reliable improvement was only detected in 17.4% of participants allocated to HLaC *Online*+coaching from baseline to 1-month follow-up.

Figure 5.4

Change in fear of cancer recurrence over time for HLaC Online and HLaC Online+coaching



Fat index. Similarly, HLaC *Online*+coaching demonstrated a small within group effect on the Fat index at post treatment, which was sustained at follow up. This effect was not detected in the HLaC *Online* group at post-treatment or follow up. While there was a small between group effect at post-intervention and 1-month follow up, after controlling for baseline, the 95% confidence interval crossed zero, indicating large variability in responses.

Other outcomes*.* On all remaining outcomes, no statistically or clinically significant differences between groups emerged over time.

Table 5.5

Estimated means, standard errors, and within group effect sizes, and main effects of time for preliminary efficacy outcomes

Outcomes		Baseline	Post-intervention			1-month follow up			Main effect of time	Group x time interaction
		M (SE)	*M (SE)*	Within group over time *d* [95% CI][g]	Between group over time *d* [95% CI][g]	*M (SE)*	Within group over time *d* [95% CI][h]	Between group over time *d* [95% CI][h]	*F (p)*	*F (p)*
Quality of life										
Global	HLaC *Online* +coaching	70.81 (3.56)	75.33 (3.89)	0.22 [-0.04, 0.48]	-0.14 [-0.51, 0.23]	73.72 (4.23)	0.14 [-0.05, 0.33]	0.01 [-0.27, 0.28]	4.78 (.01)*	0.30 (.74)
	HLaC *Online*	76.17 (3.42)	83.14 (3.78)	**0.34 [0.09, 0.59]**		78.95 (4.06)	0.13 [-0.05, 0.32]			
Physical Well-being	HLaC *Online* +coaching	19.08 (1.10)	19.45 (1.23)	0.06 [-0.25, 0.35]	-0.30 [-0.74, 0.13]	19.57 (1.35)	0.07 [-0.13, 0.28]	-0.19 [-0.49, 0.11]	1.74 (.19)	0.87 (.43)
	HLaC *Online*	20.20 (1.06)	22.24 (1.20)	**0.30 [0.01, 0.60]**		21.74 (1.30)	0.07 [-0.13, 0.28]			
Social/family Well-being	HLaC *Online* +coaching	17.21 (1.30)	18.75 (1.40)	0.21 [-0.03, 0.45]	0.03 [-0.31, 0.37]	17.70 (1.51)	0.06 [-0.11, 0.24]	-0.01 [-0.26, 0.24]	2.80 (.07)	0.02 (.98)
	HLaC *Online*	19.71 (1.25)	21.07 (1.36)	0.18 [-0.05, 0.41]		20.28 (1.46)	0.07 [-0.09, 0.25]			
Emotional Well-being	HLaC *Online* +coaching	17.12 (0.89)	18.45 (1.05)	0.21 [-0.18, 0.63]	0.20 [-0.38, 0.78]	18.12 (1.16)	0.18 [-0.01, 0.37]	0.10 [-0.17, 0.37]	0.85 (.43)	0.21 (.81)
	HLaC *Online*	17.78 (0.86)	18.21 (1.04)	0.06 [-0.32, 0.46]		18.34 (1.15)	0.09 [-0.08, 0.28]			
Functional Well-being	HLaC *Online* +coaching	17.40 (1.15)	18.55 (1.24)	0.18 [-0.05, 0.41]	-0.23 [-0.57, 0.10]	18.03 (1.34)	0.09 [-0.11, 0.29]	-0.05 [-0.34, 0.23]	6.27 (.003)*	1.06 (.35)
	HLaC *Online*	18.48 (1.11)	21.17 (1.21)	**0.41 [0.18, 0.64]**		19.61 (1.29)	0.17 [-0.02, 0.36]			

Table 5.5. *continued*

Outcomes		Baseline	Post-intervention			1-month follow up			Main effect of time	Group x time interaction
		M (SE)	*M (SE)*	Within group over time *d* [95% CI][g]	Between group over time *d* [95% CI][g]	*M (SE)*	Within group over time *d* [95% CI][h]	Between group over time *d* [95% CI][h]	*F (p)*	*F (p)*
Fatigue	HLaC *Online* +coaching	31.80 (2.26)	31.50 (2.55)	-0.02 [-0.34, 0.30]	-0.34 [-0.79, 0.12]	34.63 (2.80)	**0.21 [0.04, 0.38]**	-0.10 [-0.33, 0.14]	1.62 (.20)	1.04 (.36)
	HLaC *Online*	34.51 (2.18)	38.08 (2.49)	0.25 [-0.05, 0.56]		38.42 (2.70)	**0.29 [0.13, 0.45]**			
MVPA	HLaC *Online* +coaching	286.16 (68.43)	346.14 (84.46)	0.10 [-0.38, 0.57]	-0.13 [-0.80, 0.54]	357.06 (89.51)	0.12 [-0.34, 0.57]	-0.32 [-0.96, 0.33]	0.18 (.84)	0.18 (.84)
	HLaC *Online*	341.52 (65.85)	435.95 (81.47)	0.19 [-0.27, 0.64]		510.50 (88.95)	0.32 [-0.12, 0.76]			
Average daily sitting time	HLaC *Online* +coaching	383.19 (45.46)	302.50 (53.08)	-0.27 [-0.64, 0.10]	-0.09 [-0.61, 0.44]	225.52 (57.18)	-0.46 [-0.95, 0.04]	-0.66 [-1.37, 0.05]	3.13 (.054)	1.94 (.16)
	HLaC *Online*	369.37 (43.74)	308.25 (50.89)	-0.21 [-0.56, 0.15]		360.75 (55.18)	-0.02 [-0.50, 0.45]			
Diet Quality										
Fruit servings	HLaC *Online* +coaching	1.44 (0.18)	1.42 (0.21)	-0.02 [-0.51, 0.48]	-0.29 [-0.91, 0.33]	1.50 (0.24)	0.04 [-0.40, 0.48]	-0.33 [-0.95, 0.28]	0.58 (.56)	0.41 (.67)
	HLaC *Online*	1.82 (0.18)	2.04 (0.22)	0.17 [-0.32, 0.67]		2.15 (1.50)	0.25 [-0.18, 0.67]			
Vegetable servings	HLaC *Online* +coaching	2.92 (0.30)	3.14 (0.36)	0.11 [-0.41, 0.62]	-0.05 [-0.68, 0.58]	3.96 (0.40)	0.44 [-0.15, 1.02]	0.54 [-0.10, 1.18]	1.94 (.15)	1.06 (0.35)
	HLaC *Online*	3.04 (0.29)	3.34 (0.37)	0.13 [-0.37, 0.63]		3.28 (0.39)	0.09 [-0.47, 0.67]			
Fat index	HLaC *Online* +coaching	3.41 (0.10)	3.59 (0.11)	**0.32 [0.08, 0.54]**	0.26 [-0.08, 0.59]	3.61 (0.12)	**0.33 [0.09, 0.57]**	0.24 [-0.11, 0.58]	3.03 (.06)	0.76 (.48)
	HLaC *Online*	3.40 (0.09)	3.45 (0.10)	0.09 [-0.13,0.32]		3.48 (0.11)	0.14 [-0.09, 0.37]			

Table 5.5. *continued*

Outcomes		Baseline	Post-intervention			1-month follow up			Main effect of time	Group x time interaction
		M (SE)	*M (SE)*	Within group over time *d* [95% CI][g]	Between group over time *d* [95% CI][g]	*M (SE)*	Within group over time *d* [95% CI][h]	Between group over time *d* [95% CI][h]	*F (p)*	*F (p)*
Fibre index	HLaC *Online* +coaching	2.91 (0.13)	3.04 (0.14)	0.17 [-0.06, 0.42]	-0.23 [-0.63, 0.18]	3.24 (0.15)	**0.42 [0.14, 0.70]**	-0.03 [-0.28, 0.22]	4.08 (.02)*	1.68 (.20)
	HLaC *Online*	3.03 (0.13)	3.25 (0.14)	**0.28 [0.05, 0.51]**		3.15 (0.15)	0.14 [-0.13, 0.41]			
Symptom severity	HLaC *Online* +coaching	4.24 (0.38)	4.32 (0.43)	0.03 [-0.28, 0.35]	0.43 [-0.02, 0.89]	3.13 (0.48)	**-0.45 [-0.75, -0.15]**	-0.41 [-0.84, 0.02]	1.99 (.15)	3.44 (.04)*
	HLaC *Online*	3.54 (0.37)	2.79 (0.43)	**-0.31 [-0.61, -0.01]**		3.21 (0.47)	-0.13 [-0.42, 0.16]			
Symptom interference	HLaC *Online* +coaching	4.05 (0.45)	3.84 (0.51)	-0.08 [-0.39, 0.24]	**0.49 [0.03, 0.95]**	3.03 (0.56)	**-0.37 [-0.60, -0.14]**	0.08 [-0.24, 0.41]	4.85 (.01)*	2.01 (.15)
	HLaC *Online*	3.26 (0.45)	1.93 (0.52)	**-0.46 [-0.77, -0.15]**		2.05 (0.55)	**-0.43 [-0.65, -0.21]**			
Fear of cancer recurrence	HLaC *Online* +coaching	18.96 (1.93)	14.07 (2.09)	**-0.45 [-0.69, -0.20]**	**-0.43 [-0.79, -0.08]**	12.92 (2.26)	**-0.49 [-0.84, -0.13]**	**-0.65 [-1.16, -0.14]**	5.96 (.06)	2.91 (.06)
	HLaC *Online*	15.78 (1.86)	12.08 (2.06)	-0.06 [-0.30, 0.17]		16.02 (2.22)	0.02 [-0.32, 0.36]			
Distress	HLaC *Online* +coaching	24.32 (3.82)	21.46 (4.26)	-0.17 [-0.41, 0.15]	0.09 [-0.31, 0.50]	22.17 (4.68)	-0.09 [-0.34, 0.15]	-0.07 [-0.43, 0.28]	1.38 (.26)	0.19 (.83)
	HLaC *Online*	20.00 (3.68)	15.34 (4.24)	-0.20 [-0.47, 0.07]		19.29 (4.63)	-0.03 [-0.27, 0.21]			

[g] Describing the effect from baseline to post-intervention

[h] Describing the effect from baseline to 1-month follow-up

Bolded values indicate 95% confidence values that do not cross zero

Table 5.6

Reliable change index of preliminary efficacy outcomes from baseline to post-intervention

	Baseline – post-intervention (*n* = 30)				Baseline – 1-month follow-up (*n* = 27)			
	HLaC *Online*		HLaC *Online*+coaching		HLaC *Online*		HLaC *Online*+coaching	
Outcome	Improvement (%)	Deterioration (%)	Improvement (%)	Deterioration (%)	Improvement (%)	Deterioration (%)	Improvement (%)	Deterioration (%)
Quality of life[a]								
Global	6.7	0.0	0.0	0.0	7.1	0.0	0.0	0.0
Physical Well-being	13.3	0.0	0.0	0.0	7.1	0.0	0.0	0.0
Social/Family Well-being	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Emotional Well-being	13.3	13.3	0.0	0.0	0.0	0.0	0.0	0.0
Functional Well-being	6.7	0.0	0.0	0.0	7.1	0.0	0.0	0.0
Fatigue[a]	13.3	0.0	0.0	6.7	7.1	0.0	0.0	0.0
MVPA[a]	12.5	0.0	6.7	6.7				
Daily Sitting Time[b]	0.0	0.0	7.1	0.0	7.1	14.3	7.1	7.1
Diet Quality[a]								
Fruit Servings	0.0	0.0	0.0	0.0	0.0	7.1	0.0	0.0
Vegetable Servings	0.0	0.0	6.7	0.0	7.1	0.0	0.0	0.0

Table 5.6. *continued*

Fat Index	0.0	0.0	0.0	0.0	0.0	0.0	7.1	0.0
Fibre Index	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Symptom Severity[b]	0.0	0.0	6.7	0.0	0.0	0.0	7.7	0.0
Symptom Interference[b]	0.0	0.0	0.0	0.0	27.3	0.0	7.7	0.0
Fear of Cancer Recurrence[b]	0.0	0.0	0.0	0.0	0.0	0.0	15.4	0.0
Distress[b]	7.1	0.0	0.0	6.7	0.0	0.0	7.7	15.4

[a] Improvement improvement indicates a Reliable change index score of 1.96 or higher and deterioration indicates a Reliable change index score of -1.96 or lower

[b] Improvement improvement indicates a Reliable change index score of -1.96 or lower and deterioration indicates a Reliable change index score of 1.96 or higher

Main effect of time

There were four significant main effects of time for Global QoL, Functional Well-being, fibre intake, and symptom interference.

QoL. First, while both groups demonstrated improvements in *Global QoL* from baseline to post-intervention with a small effect, participants allocated to the HLaC *Online* demonstrated a slightly stronger effect than HLaC *Online*+coaching (d = 0.34 vs. d = 0.22). However, this effect was not maintained at the 1-month follow up. This trend in the HLaC *Online* group was driven by changes observed in *Functional Well-being* and *Physical Well-being*, both of which demonstrated a small, significant within group effect from baseline to post-intervention. In the HLaC *Online* group, 6.7% and 7.1% demonstrated reliable change from baseline to post-treatment and from baseline to 1-month follow-up, respectively, in both Global QoL and Functional Well-being. On the Physical Well-being subscale, 13.3% of these participants demonstrated reliable improvement from baseline to post-intervention and 7.1% from baseline to 1-month follow up. While there were no statistically significant effects on Emotional Well-being, 13.3% demonstrated reliable improvement and reliable deterioration from baseline to post-intervention. However reliable change was not detected from baseline to 1-month follow up. No reliable change was detected in the HLaC *Online*+coaching group for any QoL outcomes.

Fibre Intake. Both groups reported increased fibre intake. HLaC *Online* demonstrated improvements from baseline to post-intervention with a small significant effect, which was not maintained at the 1-month follow-up. In comparison, participants allocated to HLaC *Online*+coaching demonstrated a delayed response, with an increase in fibre intake at 1-month follow up with a small to medium effect (d

= 0.42). Despite the small to medium effects, no reliable change was detected in both groups at either follow up assessment. While not a significant main effect of time, participants allocated to HLaC *Online*+coaching demonstrated improvements in fat intake from baseline to both post-intervention (*d* = 0.32) and 1-month follow up with a small effect (*d* = 0.33). Reliable change indices indicated that 7.1% of participants allocated to the HLaC *Online*+coaching group reported reliable improvement from baseline to 1-month follow up, but not at post-intervention. No reliable change was detected in the HLaC *Online* group.

Cancer related symptom interference. Finally, both groups demonstrated a significant decrease in cancer related symptom interference. HLaC *Online* demonstrated a decrease in cancer related symptom interference from baseline to post-intervention with a small to medium effect (*d* = -0.42). These improvements were maintained at the 1-month follow up (*d* = -0.43). In contrast, HLaC *Online*+coaching did not have a significant effect from baseline to post-intervention (*d* = -0.08) but did demonstrate a small significant effect from baseline to 1-month follow up (*d* = -0.37). Reliable change indices indicated that 27.3% in the HLaC *Online* group and 7.7% in the HLaC *Online*+coaching group reported reliable improvements in cancer related symptom interference from baseline to 1-month follow-up.

Other outcomes. No other time effects occurred on the other preliminary efficacy outcomes.

Main effect of condition

Fruit intake. There was a significant main effect of condition for fruit servings, *F*(1, 49.93) = 5.81, *p* = .02, *d* = 0.67 (95% CI [0.11, 1.23]). On average, participants in the HLaC *Online* condition reported half a serve greater fruit intake than participants in the HLaC *Online*+coaching condition (*Mdifference* = 0.55, *SE* = 0.23).

Symptom interference. There was a significant main effect of condition for symptom interference *F*(1,54.67) = 4.31, *p* = .04, *d* = 0.58 (95% CI [0.02, 1.13]). On average, participants allocated to HLaC *Online*+coaching reported higher cancer related symptom interference in comparison to participants allocated to HLaC *Online* (*Mdifference* = 1.22, *SE* = 0.59).

Other outcomes. No other differences between conditions occurred on the other preliminary efficacy outcomes.

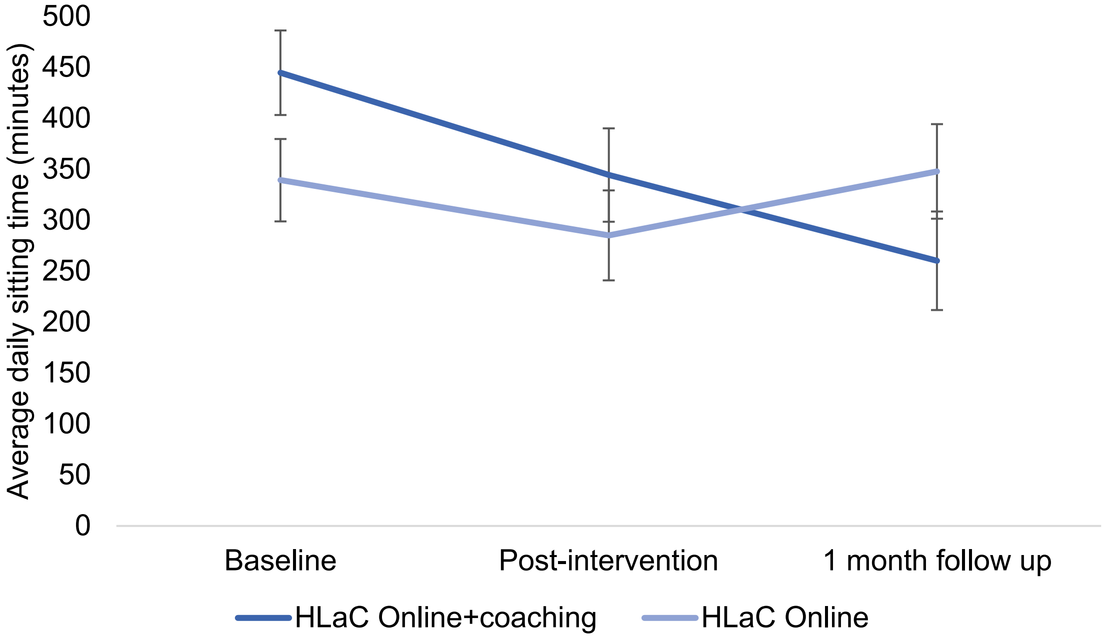
Sensitivity analysis

Although there were no significant differences between the two groups at baseline, participants allocated to HLaC *Online*+coaching had a greater time since diagnosis than those allocated to HLaC *Online*. On average, those allocated to HLaC *Online*+coaching on average were 6.22 years post-diagnosis, over the 5-year benchmark used to determine an individual’s chance of survival and risk of cancer recurrence. In contrast, participants allocated to HLaC *Online* were below this benchmark and were, on average, 3.49 years post-diagnosis. To determine the impact of time since diagnosis, the repeated measures linear mixed models were repeated while controlling for time since diagnosis. To retain all participants data in the analysis, time since diagnosis was imputed for four participants (HLaC *Online*+coaching *n* = 3, HLaC *Online* *n* = 1) using their corresponding group mean. Three differences emerged from this analysis. The group x time interaction, *F*(2, 52.87) = 3.28, *p* = .05, and the main effect of time, *F*(2, 52.90) = 5.85, *p* = .01, became significant for *fear of cancer recurrence*, and the main effect of time for *fat* *intake* became significant, *F*(2, 56.25) = 3.67, *p* = .03. The effect sizes for these outcomes remained similar to those found in the primary analyses (See **Appendix I**).

In addition, the repeated measures linear mixed models were repeated with the removal of participants who dropped out or did not complete any follow-up assessments. These analyses revealed a significant group x time interaction, *F*(2, 50.92) = 3.30, *p* = .05 and main effect of time, *F*(2, 50.92) = 3.83, *p* = .03, for average *daily sitting time*. As presented in **Figure 5.5**, participants in both groups experienced reductions in average daily sitting time from baseline to post treatment. However, at 1-month follow up, participants allocated to the HLaC *Online* group regressed back to baseline average daily sitting time, whereas those in the HLaC *Online*+coaching group continued to decrease their average daily sitting time. No other differences were observed, and effect sizes remained similar to those found in the primary analyses.

Figure 5.5

Group x time interaction for average daily sitting time (completers)



Discussion

The present study directly compared the feasibility and preliminary efficacy of a guided versus self-directed digital health intervention in post treatment cancer survivors. Overall, HLaC *Online*+coaching demonstrated superior feasibility, as indicated by higher usage and adherence of the intervention, and higher ratings of satisfaction and perceived usability. Furthermore, there was high adherence to the telephone coaching calls, with 85.7% of participants in this group completing both telephone calls. These improvements in feasibility did, however, require an hour and a half of staff time for the intervention delivery, in comparison to the few minutes needed for HLaC *Online*. Interestingly, both versions of the program demonstrated evidence of preliminary efficacy with small to medium effects across health behaviours and psychosocial outcomes. Specifically, both versions resulted in improved fibre intake behaviour, cancer-related symptom distress and sitting time. Furthermore, only participants allocated to HLaC *Online* also reported improvements in QoL, while only HLaC *Online*+coaching participants reported improvements in fear of cancer recurrence.

One key impact of the coaching calls appears to be reducing non-engagement with the program. Despite the addition of the SMS reminders, the proportion of participants who used zero modules in the HLaC *Online* consistent remained comparable to the proportion observed in **Chapter 4** (50% and 45%). In comparison, the proportion of participants allocated to HLaC *Online*+coaching who completed zero modules was significantly lower, at only 19%. While HLaC *Online*+coaching may have reduced non-engagement, it is important to note that comparable proportions of participants completed all nine modules in both groups. This finding directly contrasts the association between the inclusion of human guidance and an increase in program completion demonstrated in a meta-analysis by Musiat et al. (2022). Instead, this pattern of website engagement aligns with the Model of Supportive Engagement for ehealth interventions proposed by Mohr et al. (2011). This model suggests that coaching increases adherence to ehealth interventions through providing accountability, which is enhanced by the therapeutic bond and the legitimacy of the individual providing the guidance (i.e., having the necessary expertise and trustworthiness). However, the association between human support and adherence to an ehealth intervention is moderated by their level of intrinsic verses extrinsic motivation. Participants with higher levels of intrinsic motivation (i.e., motivated by internal factors, such as personal interest or sense of fulfillment) may not require additional coaching to adhere to the program. In comparison, participants with higher levels of extrinsic motivation (i.e., motivated by external factors, such as rewards or praise) may benefit from the coaching calls, as they can assist with connecting the program to the individuals' goals by signposting relevant modules, promote self-reflection and problem solving, and offer verbal praise for achievements. These findings indicate that the telephone coaching may not be required for all participants of HLaC *Online* and could be reserved for the most likely to not engage or to disengage. Clearly then, identifying those at risk of non-engagement and disengagement is an important avenue for future research.

Both groups showed promising signals of preliminary efficacy in improving health behaviours and psychosocial outcomes. It is important to interpret these results with caution, as this study utilised a small sample to evaluate the feasibility of delivering HLaC *Online* and HLaC *Online*+coaching and was not intended to be adequately powered to evaluate the program's efficacy and differences between groups. That said, both groups demonstrated improvements in fibre intake, cancer-related symptom distress, and sitting time. Furthermore, the direction of effect demonstrated trends towards improved fatigue. These findings compare favourably to the original telephone-delivered Healthy Living after Cancer (Eakin et al., 2020), with similar changes to healthy fibre behaviours and sitting time observed (+0.24 units and -71.4 minutes, respectively). The reductions to sitting time is of particular interest as, in the general population, limiting daily sitting time has been found to reduce the risk of deconditioning and all-cause mortality (Stamatakis et al., 2019). The association between daily sitting time and the risk for all-cause mortality can be mitigated by achieving over 300 minutes of MVPA per week. Although we did not see any significant changes over time in MVPA in the current study, on average, both groups were engaging in more than 300 minutes of MVPA per week. Notably, there were differences between the HLaC *Online* conditions on the QoL, fat intake, and fear of cancer recurrence outcomes. HLaC *Online* participants reported improvements in physical and functional well-being at post-intervention. These changes to physical well-being in particular were greater than the effect observed in **Chapter 4**, but slightly smaller than observed in face-to-face (Rogers et al., 2015b; Wang et al., 2021) and other online health behaviour interventions (Galiano-Castillo et al., 2016; Holtdirk et al., 2021). In comparison, HLaC *Online*+coaching participants reported improvements in fear of cancer recurrence, greater than the changes observed in the telephone-delivered Healthy Living after Cancer (-3.36 units; Eakin et al., 2020).

A pattern emerged in the fibre intake, cancer-related symptom interference, and sitting time outcomes, whereby HLaC *Online* participants demonstrated immediate but not sustained improvements, whereas HLaC *Online*+coaching participants demonstrated delayed improvements at 1-month follow up. The telephone coaching calls may have influenced this pattern in two ways. First, previous research has demonstrated that most promising physical activity interventions include action planning and problem solving (Grimmett et al., 2019), the primary focus of the telephone coaching calls. While this content is addressed in the *My Goals* module, only 42.3% of HLaC *Online* participants completed this module and may have missed this crucial content. Second, HLaC *Online* participants may have completed their content straight away, whereas the HLaC *Online*+coaching participants may have waited for the coaching calls and took longer to progress through the program. Consequently, smaller, more paced changes may be more beneficial as they are easier to maintain long term (Grimmett et al., 2019).

While HLaC *Online*+coaching had superior feasibility to HLaC *Online,* these findings need to be balanced with the additional resources required to administer the human guidance. On average, the administration time for HLaC *Online*+coaching was an hour and a half. In contrast, the HLaC *Online* group only required six minutes. The average telephone call duration in HLaC *Online*+coaching was similar to the duration reported by Evans et al. (2021a), who delivered two telephone coaching calls alongside an online physical activity intervention to patients with metastatic prostate cancer. Allowing for 25 to 30 minutes per telephone call was required for delivering human support for online, rather than the planned 15 minutes. Although these telephone calls demand more staff time than a self-directed version of HLaC *Online,* the time requirements remain significantly less than that observed in the telephone-delivered Healthy Living after Cancer (Eakin et al., 2020). Although the total administration time per participant was not reported as an outcome for the telephone delivered Healthy Living after Cancer, on average, each telephone call had a thirty-minute duration, and participants could be offered up to twelve phone calls. Therefore, HLaC *Online*+coaching might represent a nice balance-point between the resource intensive original version, and the self-directed version that may not be appropriate for those less likely to engage.

A stratified care approach may be an option for economically implementing HLaC *Online* (Delgadillo et al., 2022)*.* This would involve appropriately assessing triaging participants who are likely to be low- or non-engagers to the guided version of the program, while referring others to the self-directed platform as a starting point. Further research is required to identify factors that predict low- and non-engagement with HLaC *Online.* In an online physical activity intervention for older adults (≥ 65 years old), low engagers were younger, had lower education attainment, had poor cognitive and physical functioning, and had higher self-reported depression scores. Engagement was also associated with higher prior computer usage and having short term-plans for lifestyle change (Coley et al., 2022). While these factors offer a starting point, it provides limited understanding of how cancer-specific factors, such as treatment-related side effects, may play a role in their engagement with an online healthy living intervention (Kemp et al., 2023).

Limitations

Four additional limitations need to be considered in the interpretation of these results. First, our sample comprised of primarily female, highly educated, breast cancer survivors, many of whom were already meeting the recommendations of 150 minutes of moderate to vigorous physical active per week (thus creating a ceiling effect). Consequently, although the program was offered to survivors of all cancer types, it is unclear whether this program would meet the needs of the wider cancer survivor population and those who are currently inactive. Second, only a small number of participants provided a star rating on each of the modules. Interestingly, slightly more participants responded to the open text-response to provide module feedback. Furthermore, as the satisfaction ratings were measured at the completion of the module, participants who disengaged from the module early due to low levels of satisfaction may not have been captured. Other studies considered satisfaction measures during the intervention might consider including the satisfaction ratings in a more accessible location (i.e., on the home page or beginning of the module). Third, the Fat index subscale demonstrated inadequate levels of internal consistency, and therefore, this subscale did not reliably assess fat intake behaviours. Future research should consider other dietary behaviour or specific food intake assessments, such as the Food Frequency Questionnaire (Flagg et al., 2000) or a 24-hour dietary recall (Subar et al., 2012). Finally, the adherence measure developed for this study assessed the proportion of modules that participants indicated interest in (at baseline) that were subsequently accessed. Focusing on participants *interest* may not accurately reflect the modules that would be most *helpful* to participants in meeting their goals. Subsequent studies might consider utilising baseline assessments to determine which modules might be most useful to participants and evaluate the proportion of those modules accessed.

Overall, adding two telephone coaching calls to HLaC *Online* improved the feasibility of the program, as indicated by greater usage and adherence to the program, and higher usability and satisfaction ratings. Trends in the preliminary efficacy signals suggest that both guided and self-directed programs may improve cancer-symptom distress, fibre intake behaviours, and sitting time, similar to changes observed in participants of the telephone-delivered Healthy Living after Cancer. HLaC *Online*+coaching may provide superior maintenance effects on these outcomes and on fear of cancer recurrence, however, longer-term follow up is required. These findings need to be balanced with the additional resources required to implement HLaC *Online*+coaching. Appropriate triaging could be developed and used to determine which participants are most likely to disengage and would benefit from the telephone coaching calls.

Chapter 6.

General Discussion

Overview

This chapter aims to synthesise the findings of the studies presented in this thesis and contextualise their collective contributions to the broader fields of post-treatment cancer survivorship and digital health interventions. Initially, the key findings from each chapter are summarised and compared with the existing literature. Subsequent sections address the clinical implications and future research directions using online interventions to promote healthy lifestyle behaviours in post-treatment cancer survivors, and the methodological limitations of this collection of studies. The important role of co-design in intervention development and promoting engagement with online interventions are central themes explored in this chapter.

Summary and implications of findings

The overarching aims for this thesis were to (1) evaluate the evidence supporting the addition of a mental health component to digital health interventions; and (2) co-design and evaluate Healthy Living after Cancer *Online* (HLaC *Online*), an online physical activity, nutrition, and psychosocial intervention for post treatment cancer survivors. As explored in **Chapter 1**, psychosocial variables are often employed as *outcome measures* of healthy living programs, but few include them as intervention *targets*. However, cancer survivors and oncology healthcare professionals define ‘healthy living’ as more than just physical health, also including mental health and adjustment to the ‘new normal’ after treatment (Grant et al., 2021). Therefore, it was important to first understand the current body of evidence of the combined effect of addressing both physical and mental health within a healthy living intervention to inform HLaC *Online*. Online-platforms is a delivery modality suitable for targeting multiple health behaviours in the same intervention, as they enable participants to self-tailor what information they access and when. However, few interventions have targeted mental health within the intervention (Holtdirk et al., 2021; Kanera et al., 2016). Further, utilising co-design for the development of HLaC *Online* ensures that the resulting program is sensitive to the specific needs of the post-treatment cancer survivor population. In addition, this approach follows best-practice principles for consumer-led development of interventions (Skivington et al., 2021).

Current evidence for healthy living interventions in cancer survivorship: does the data support including a mental health component?

To inform the design of HLaC *Online,* **Chapter 2** utilised systematic review and meta-analysis to update previous evidence of the efficacy of healthy living interventions in improving Quality of Life (QoL) in post-treatment cancer survivors and investigate whether the addition of a mental health component was associated with greater effects. Other key intervention characteristics relevant to informing HLaC *Online's* design, such as mode of delivery (i.e., individual, group, telephone, online, and print) and duration (≤12 weeks and ≥12 weeks) were also investigated, to determine whether they moderated the association between engaging in a healthy living intervention and QoL. This review included 88 articles involving 110 interventions, with 66 off these studies included in the meta-analysis. The results demonstrated a small positive effect of healthy living interventions on cancer survivors' QoL. While there was no evidence that the inclusion of a mental health component in the healthy living intervention was associated with a greater effect on QoL, **only 16%** of the included interventions addressed both physical and mental health behaviours. Therefore, there were insufficient data to draw conclusions, and provided an imperative for future research in this area.

In contrast, face-to-face delivery modalities and interventions delivered over 12 weeks or less were associated with greater effects on QoL. While these differences may be partially explained by most studies utilising the face-to-face modality, another potential explanation explored in **Chapter 2** was the role of intervention adherence and whether participants were receiving the recommended 'dose' of the healthy living interventions (Nagpal et al., 2021). Specifically, shorter interventions may promote greater adherence to the intervention by reducing the time commitment required from participants, which can lower potential scheduling barriers to participation and make the intervention more appealing. Face-to-face interventions may promote greater adherence by providing accountability and individual tailoring of the intervention. In comparison, interventions delivered via online platforms have consistently displayed low levels of user engagement, characterised by few logins, low completion rates, and limited use of program features (Short et al., 2015b). Consequently, participants are likely not using the program as intended and missing out on potential benefits. Therefore, strategies that promote usage of online platforms need to be considered during intervention development to potentially increase intervention adherence and were factored into the co-design of HLaC *Online*.

Co-designing Healthy Living after Cancer *Online*

The second aim of this thesis utilised the Stanford University's Design Thinking Process (Woods et al., 2017) in finalising the co-design of HLaC *Online*. First, **Chapter 3** described the *Ideate* and *Prototype* phases, whereby a wireframe was developed, informed by the content of the telephone-delivered Healthy Living after Cancer and the findings from the *empathise* and *define* phases conducted by Grant et al. (2021). The wireframe proposed a self-directed, 12-week intervention which addressed multiple areas of health, including physical activity, nutrition, maintaining a healthy weight, mental health, finding the ‘new normal’ after cancer treatment, fatigue management, and peer support. To support health behaviour change, the proposed intervention also included information and activities to encourage engagement in goal setting and behaviour change maintenance. The wireframe was then presented in a series of focus groups and interviews to the end-user stakeholder group for their feedback on the design and content. Additionally, this round of stakeholder engagement explored how end-users might utilise the program to improve their lifestyle behaviours.

Consistent with the findings from **Chapter 2**, the stakeholders highlighted that maintaining engagement would pose a significant challenge to HLaC *Online*, with the majority describing a typical user as someone who is initially highly engaged in the intervention, before their interest and use of the online platform tapers off gradually. Consequently, participants of HLaC *Online* may not access all the content that is relevant to their needs. As a result, the stakeholders’ feedback focused primarily on how the design, content, and features of HLaC *Online* could support participant uptake and engagement with the online platform and the health behaviours. Specifically, the stakeholders’ feedback fell into five themes: (a) specific website design considerations to increase accessibility, usability and the ability to self-tailor the content; (b) strategies for promoting and maintaining long term user engagement, including interactive elements, reminders, program support, and activities that build skills; (c) enhancing relatability and relevance by including cancer specific information, represent a diverse population, and peer stories; (d) incorporating professional support through links to reputable websites and information about accessing relevant healthcare professionals; and (e) addressing the need for family and peer support. These findings align with previous systematic and scoping reviews that investigated engagement in digital health interventions, which identified that engagement is facilitated by intervention related constructs (i.e., content credibility, relevance, readability, customisation, and personalisation) and technology- and environmental- constructs. These latter constructs include the website's usability, instructions on how to use the website, and social support, facilitate engagement in digital health interventions (Beatty & Binnion, 2016; Borghouts et al., 2021; Leslie et al., 2022; Sharpe et al., 2017). Furthermore, these findings highlight that HLaC *Online* should not only implement supportive strategies for engagement with the website, but also engagement in the recommended health behaviours through skill building and the recommendation for manageable activities. An example of the latter is recommending and supporting increased walking as physical activity, as this is likely the easiest, most accessible form of exercise for participants. **Chapter 3** recommendations for supporting engagement in both the website and the health behaviours aligns with the subclasses of engagement in digital health behaviour change proposed by Cole-Lewis et al. (2019). In their model, the authors differentiated between engagement in the digital health intervention ("Little e") and engagement in the health behaviour itself ("Big E"). Cole-Lewis et al. (2019) further divided *Little e* into two types: (1) engagement with the interventions features and (2) engagement in the behaviour change components. Stakeholder feedback of HLaC *Online* highlighted that each of these types of engagement needed to be accessible for the end-user, such that the website is easy to navigate, the behaviour change components (i.e., worksheets and trackers) are easy to use, and the behaviour recommendations are achievable.

Stakeholder feedback was then integrated into the website design of HLaC *Online*. Key changes to the intervention design included a responsive design, guidance videos at the beginning of the intervention and each module to assist users navigation and completion of activities, a simple mood rating as an alternative to the thought record, additional information on potential physical and emotional sequalae following cancer treatment, guidance on how to access relevant healthcare professionals, links to reputable website for additional information, email reminders to prompt usage of HLaC *Online*, and multiple options for peer support.

Following the Stanford University's Design Thinking Process (Woods et al., 2017) to the *Test* phase, **Chapter 4** utilised a mixed methods study to evaluate HLaC *Online*'s feasibility and usability. Eleven Australian post-treatment cancer survivors were granted access to for 12 weeks asked to complete questionnaires and a semi-structured interview to evaluate the programs uptake, usage, usability, attrition, satisfaction, and signals of preliminary efficacy. Consistent with the findings from **Chapter 2** and **Chapter 3**, engagement emerged as a key barrier to the intervention's feasibility. Almost half of participants did not log into the program after access was granted. This engagement rate was much lower than that observed in other online healthy living interventions for cancer survivors, where between 82% and 100% of participants log in at least once (Forbes et al., 2015; Rees-Punia et al., 2022; Williams et al., 2022). However, those who did login to HLaC *Online* had comparable module completion and number of logins to that observed in similar interventions. On average, participants of HLaC *Online* completed three modules and logged into the program four times. In comparison, participants of the eight-module program, *Kanker Nazorg Wijzer* completed two modules on average (Kanera et al., 2016). With regard to number of logins, previous research has varied anywhere between four times over the intervention period (Rees-Punia et al., 2022) to 53 over a 12-week period (Frensham et al., 2018). Furthermore, while there was substantial variability in responses, the signals of preliminary efficacy showed trends toward improvement in Moderate and Vigorous Physical Activity (MVPA), vegetable intake, and psychological distress.

While those who did not engage with the website did not participate in the follow-up interviews, qualitative feedback provided by participants who did access the website provided some insight into the potential barriers for engagement. Technology and program barriers, including the lack of automated access, website glitches, and perceived time burden, increased the effort requirements of participation. Disengagement will likely occur if the higher effort is not compensated by sufficient reward, in this case supporting participants to achieve healthy living goals (Kelders et al., 2012; Short et al., 2015a; Siegrist, 1996). Participants also identified that cancer-related symptoms, particularly fatigue and cancer-related cognitive impairment, were a significant barrier to engagement, because experiencing these symptoms (1) reduced their intrinsic motivation to participate in the program and health behaviours and (2) limited their ability to absorb the intervention content and complete activities. This finding aligns with previous research investigating digital *mental health* interventions, which identified that severity of distress symptoms at baseline can impact user engagement (Borghouts et al., 2021). Therefore, it is likely that fatigue and cancer-related cognitive impairment have a similar impact on engagement in digital health interventions. To address these barriers, one recommendation from participants and previous research was to implement SMS reminders and human guidance (Mohr et al., 2011; Musiat et al., 2022).

Guided verses self-directed online interventions

The final study presented in **Chapter 5** of this thesis, described the incorporation of these recommendations in the development of the next and final iteration of HLaC *Online,* in collaboration with Cancer Council SA stakeholders. **Chapter 5** then presented the subsequent feasibility comparison of a guided verses self-directed version of HLaC *Online,* using a randomised trial with 52 post-treatment cancer survivors. Following stakeholder advice on what could be implemented within suite of services at Cancer Council SA, SMS reminders were added to the HLaC *Online* website. Further, a guided version, HLaC *Online*+coaching, included access to the HLaC *Online* website and two 15-minute coaching telephone calls spaced four weeks apart. Overall, the guidance calls improved the feasibility of the program, as demonstrated by higher usage and adherence to the program, along with more favourable satisfaction and usability ratings. Perhaps most importantly, the addition of the telephone coaching calls appeared to reduce non-engagement with HLaC *Online*, as only 19% of participants allocated to HLaC *Online*+coaching did not access any modules, in comparison to 50% of participants allocated to HLaC *Online.* However, a similar proportion of participants in both conditions completed all nine modules, indicating that coaching is not a universal requirement. As explored in **Chapter 5**, this pattern of user engagement is consistent with Mohr, et al.'s (2011) Model of Supportive Engagement for ehealth interventions. This model suggests that the relationship between human support and increased adherence to ehealth interventions is moderated by participants' level of intrinsic versus extrinsic motivation. Specifically, participants with higher levels of intrinsic motivation may find engaging with the modules personally rewarding, satisfying, and aligning with their values. Therefore, for these individuals, the absence of the telephone coaching calls would not diminish engagement in HLaC *Online,* as the individuals' primary source of motivation remains intact. In comparison, participants who are more extrinsically motivated are likely to require more assistance relating the program to their personal goals, identifying relevant modules, and may need positive reinforcement. That is, the support offered by the telephone coaching calls. Thus, participants with more extrinsic motivation are more vulnerable to not engaging or quickly disengaging from the program when they do not receive telephone coaching calls. The qualitative feedback provided by the HLaC *Online* participants in **Chapter 4** also provides a cancer survivorship lens over this finding, as participants linked the experience of cancer-related fatigue and cancer-related cognitive impairment to reduced intrinsic motivation. Qualitative research has previously identified and started to explore the relationship between cancer-related symptoms, motivation, and engagement in digital health (Kemp et al., 2023). The findings from this thesis provides justification for future quantitative research to further investigate the relationship between cancer-related symptoms and motivation, and their cumulative impact on engagement with digital health interventions.

Another moderator in the relationship between human support and adherence proposed by the Model of Supportive Adherence to eHealth Interventions is the bandwidth of the communications medium (e.g., face-to-face, telephone, instant messaging, and email; Mohr et al., 2011). Previously, face-to-face and telephone were considered to provide a superior social presence due to the higher number of communications cues (i.e., non-verbal and/or verbal cues). However, as people gain more experience using text media combined with the introduction of emojis to communicate feelings, Mohr et al. (2011) argued that emails and SMS can also provide the positive social presence necessary for supportive accountability. Mohr et al. (2011) suggested that the positive effect of these interactions increases when there is an expectation of future contact. Indeed, evidence from a scoping review on online psychological interventions suggest that scheduled human support was superior to unscheduled support, with no differences found in how that human support was delivered (Shim et al., 2017). Therefore, online interventions should consider which communications medium or combination of media, is appropriate for the target population and what is feasible for long-term delivery. In the case of HLaC *Online*, Cancer Council SA (see **Chapter 5**) recommended telephone calls as the most effective method of delivering human support.

While the findings from **Chapter 5** add to the emerging body of literature of supporting the use brief human guidance to support engagement with digital health interventions for post-treatment cancer survivors (Chan et al., 2020; van de Wiel et al., 2021), there remains mixed evidence of whether this translates to improved efficacy. In **Chapter 5**, the signals of preliminary efficacy – improvements in fibre intake behaviour, cancer-related symptom distress and sitting time – occurred in both the guided and the self-directed versions of HLaC *Online.* Moreover, while HLaC *Online*+coaching demonstrated superior improvements in sitting time and fear of cancer recurrence, HLaC *Online* demonstrated superior improvements in QoL, driven by changes in functional and physical well-being. However, a pattern emerged whereby HLaC *Online* demonstrated immediate benefits, which were not sustained at the 1 month follow up. In comparison, HLaC *Online*+coaching appeared to report a delay in intervention effects. In **Chapter 5**, it was posited that this patten may be reflective of participants of HLaC *Online*+coaching enacting smaller, more evenly paced changes, which translated to more sustainable change as a result of more thorough action planning during the telephone coaching calls (Grimmett et al., 2019).

In comparison, over half of the participants in the HLaC *Online* condition did not complete the *My Goals* module, thereby not completing the action plan. An alternative explanation may have been differences in when the module content was accessed. Participants receiving the telephone calls in HLaC *Online*+coaching may have taken longer to progress through the modules, coinciding with when they received the telephone coaching calls, whereas participants of HLaC *Online* may have completed modules immediately. However, these findings are limited by the small sample size and the single follow up time-point. Additional follow up is needed to confirm the maintenance of the delayed effects of HLaC *Online*+coaching found in **Chapter 5**. In addition, a larger trial with adequate statistical power and an inactive control group is required to verify the efficacy of HLaC *Online* and HLaC Online+coaching in improving QoL and health behaviours in post-treatment cancer survivors. A larger trial will also allow subgroup analyses to further investigate whether the amount or the timing (i.e., accessing content all at the beginning or over the intervention period) of engagement in the online healthy lifestyle program leads to greater efficacy.

In sum, providing supportive accountability to HLaC *Online* via two telephone coaching calls improved the program’s feasibility, as indicated by greater usage and adherence to the program and higher usability and satisfaction ratings. However, both the guided and self-directed versions of HLaC *Online* demonstrated trends for improving cancer-symptom distress, fibre intake behaviours, and sitting time. Despite the equivalency in preliminary efficacy outcomes, the superior engagement rates of HLaC *Online*+coaching group is an important finding. It indicates that the telephone coaching calls increased the number of participants who viewed the module content and improved the reach of the intervention to participants who would have otherwise not engaged. A larger randomised trial with an inactive or attention control group is required to evaluate the program's efficacy and investigate what pattern of engagement leads to more meaningful behaviour change. Other online programs should consider the implementation of brief and scheduled human support to promote engagement, using a communication medium that is appropriate for their target population and that is feasible for long-term delivery (Mohr et al., 2011).

The critical role of co-design with multiple stakeholder groups

One strength of this thesis is the repeated and sustained involvement of different stakeholder groups, such as post-treatment cancer survivors, oncology healthcare professionals, cancer support representatives, digital health experts, and website developers, at each stage of the co-design process. Engaging multiple groups over time enabled diverse feedback based on the stakeholders' relevant expertise and built upon feedback generated from previous phases for intervention refinement (Skivington et al., 2021). During each phase, post-treatment cancer survivors shared their own lived experiences with the aftereffects of cancer treatment and provided feedback to enhance the program's relevance and accessibility to the cancer population. The oncology healthcare professionals drew upon their clinical expertise on how to best support long term health behaviour change, including program adherence strategies and linking in with professional supports. Representatives from cancer support organisations, particularly those from Cancer Council SA, provided advice on how HLaC *Online* could be designed for long term implementation and sustainability. The digital health experts and the website developers provided recommendations on the potential features of the program to support engagement, such as the program aesthetic, interactive activities, and reminders. The benefits of integrating the feedback from stakeholders were observed in the participants usage and feedback in **Chapter 4** and **Chapter 5**. First, the *Finding the New Normal* module, introduced as a direct result of the first round of stakeholder engagement (Grant et al., 2021) and further refined in the second round of stakeholder engagement (**Chapter 3**) was one of the most frequently used and highly praised modules in **Chapter 4** and **Chapter 5**. Furthermore, the email reminders implemented on the recommendation of all stakeholders were also highly praised for assisting with adherence to the program in **Chapter 4**. These findings indicate that co-design improved the relevance and usability of HLaC *Online* and are consistent with previous research reporting that co-designed information resources have higher usability and were preferred over expert-created information (Bashir et al., 2019). In addition to intervention refinement, stakeholder engagement informed the research question and methodology utilised in **Chapter 5**. As introduced in **Chapter 1**, the value of engaging with stakeholders in the research design is highlighted by the United Kingdom's Medical Research Council (MRC) to aid with prioritising the most relevant research questions (Skivington et al., 2021). Further, these partnership may also increase the likelihood of future adoption of the co-designed program, however, there is limited literature investigating this (Harrison et al., 2022). It is important to note that qualitative feedback will be gathered from participants of the study presented in **Chapter 5** and integrated into the potential next iteration of HLaC *Online*. To reduce the risk of biasing participant responses and data interpretation (McGrath et al., 2019; Nastasi & Schensul, 2005), another researcher, not involved in the delivery of HLaC *Online*+coaching, will lead the collection and analysis of participant feedback. Overall, these findings highlight the importance of utilising multiple stakeholder groups during co-design to ensure that the resulting intervention is relevant and meets the needs of the target population and the organisations who may be involved in the future implementation.

Clinical Implications and directions for future research

Online interventions can be an accessible, flexible, and convenient option for promoting health behaviour change in post-treatment cancer survivors, however, low engagement continues to be a barrier limiting the feasibility of such interventions and may diminish potential benefits. As discussed in this chapter, the feasibility of online interventions can be improved by the inclusion of human support, as it enhances supportive accountability and encourages participants to engage in the behaviour change techniques included in the intervention, such as action planning. Human support does not have to be extensive, and can include a small number of check-ins. Preliminary efficacy signals presented in **Chapter 5** suggest that the HLaC *Online* program with two telephone coaching calls can achieve similar or superior improvements in healthy fibre behaviours, sitting time, cancer-related symptom severity, and fear of cancer recurrence as the telephone-delivered Healthy Living after Cancer intervention (Eakin et al., 2020), which delivered up to twelve phone calls. Current and future online interventions experiencing low engagement and future online interventions should consider including human support in their protocol and tailoring the timing, frequency, and communications media to the suit the target population preferences, while assessing can feasibly be implemented long term. In addition, there are several considerations for the intervention design that may be able to further improve feasibility and economical implementation, including administration requirements of human support, utilising needs-based assessments

(Delgadillo et al., 2022), and offering shorter or tunnelled interventions (Wildeboer et al., 2016).

The administration requirements of implementing human support with online interventions

While HLaC *Online*+coaching demonstrated superior feasibility to the self-directed HLaC *Online* and demonstrated promising indicators of preliminary efficacy, delivering the human support required considerably more staff resources in administration. As **Chapter 5** outlined**,** the average administrative time for HLaC *Online*+coaching was 1.5 hours, consisting of scheduling the automated SMS reminders, organising telephone calls, conducting the telephone calls, clinical note taking, and emailing the participant with a summary of the key points discussed. In comparison, as HLaC *Online* only required scheduling the SMS reminders, the average time administration time was only six minutes. The administration time for the telephone calls themselves took longer than expected. While we initially planned for 15-minute telephone coaching calls, the first phone call required 30 minutes to orientate the participant to the website and set up healthy living goals. Furthermore, the second phone call required on average 20 minutes to identify and address barriers to meeting healthy living goals. Coaching telephone call durations of 25 to 30 minutes have been reported by other online healthy living interventions for participants with metastatic prostate cancer (Evans et al., 2021a), and was the duration for each telephone call in the telephone-delivered Healthy Living after Cancer (Eakin et al., 2020). Organisations looking to implement human support via telephone calls will need to consider if 30-minute calls fit within their long-term service capacity.

Organisations will also need to consider *who* delivers the human support. It was noted that some participants of the study presented in **Chapter 5** required up to an hour for their telephone coaching calls. This extended duration coincided with participant reports of significant life stressors. As the coach was a Provisional Psychologist, even with redirection, participants may have used the telephone calls as emotional support, rather than the intended health coaching purposes. Therefore, it is important to ensure that participants understand the purpose of the telephone call at the outset and that the coach is adequately trained to manage distressed participants and deviations from the telephone script. Organisations will need to also consider the resources required to integrate appropriate training for the coach where required. Furthermore, the expertise of the coach may also impact on participants' behaviour change. In a review of multiple behaviour change interventions, Amireault et al. (2016) identified that an exercise specialist-led and dietitian-led interventions resulted in greater improvements in physical activity and diet quality, respectively, and smaller improvements in other health behaviours. Research investigating the training of the support person for mental health interventions are less clear. In a meta-review of digital mental health interventions (Werntz et al., 2023), half of the meta-analyses synthesising interventions utilising clinically trained human support found significantly greater effects on mental health outcomes than no human support. Additionally, only one of four included meta-analyses found significant differences between therapist and administrative support (Richards & Richardson, 2012). Therefore, for optimal outcomes and return on investment, organisations should consider the specialty or combination of specialties most needed among intervention participants.

Overall, organisations seeking to implement human support via the telephone alongside online interventions will need to consider whether their staff have the appropriate professional background for the intervention target, are appropriately trained, and have the capacity to deliver such support.

Stratified Care: Using a needs-based assessment and allocation process for economical implementation of online interventions

Stratified care, where a needs-based assessment is conducted to identify and allocate participants who may benefit most from the telephone coaching calls (Delgadillo et al., 2022), could be an effective tool for the economical implementation of HLaC *Online* and HLaC *Online*+coaching. In **Chapter 4** and **Chapter 5**, a small group of participants were observed to be high engagers in the program, regardless of whether they received telephone coaching calls. Therefore, by identifying the individual characteristics that correlate with high verses low engagement with HLaC *Online*, a triage system utilising standardised assessment of such correlates could be implemented upon enrolment to distinguish potential low- or non-engagers. This group of potential low- or non-engagers could then be allocated HLaC *Online*+coaching to improve their engagement with the intervention.

To date, there is a dearth of research investigating the correlates of engagement in online healthy living interventions in the cancer population. Only one study investigating the usability of an online physical activity program for cancer survivors (*SurvivorSHINE*; Williams et al., 2022) over two weeks found that male gender and Caucasian participants spent more time on the website. In the general population, socio-demographic factors (i.e., age, gender, ethnicity, rurality, education), clinical factors (i.e., self-reported health and mental health, healthcare utilization, and QoL), and currently lifestyle behaviours have been investigated as potential correlates of engagement with an online healthy lifestyle intervention (Mench et al., 2018; Moffit et al., 2023). However, the evidence is inconsistent. In contrast Williams et al. (2022), Moffit et al. (2023) and Brouwer et al. (2010) found that female participants were more likely to complete intervention modules and had high utilisation of the provided trackers. Further, Moffit et al. (2023) found that self-reported depression was associated with lower lesson completion, while seeing a GP within the last year was associated with higher utilisation of the provided trackers of an online physical activity intervention. In comparison, Bouwer (2010) those who had completed secondary or tertiary education, those aged 40 to 50 years, and or those with a Body Mass Index (BMI) of under 25, were more likely to initiate and complete the intervention modules. One online physical activity intervention for older adults (≥ 65 years old) found that low engagers were younger, had lower educational attainment, poorer physical and cognitive functioning, and higher self-reported depression scores. In this study, high engagers had higher prior computer usage and short term-plans for lifestyle change (Coley et al., 2022). In the diabetes population, a range of investigated factors (including ethnicity, education, income, health literacy, self-efficacy, problem solving skills, and previous computer experience) were *not* associated with engagement in an online diet and physical activity program.

Factors associated with engagement in online psychological interventions have been more thoroughly investigated. For these interventions, female gender, treatment expectancy, and conscientiousness demonstrated a positive relationship with adherence (Beatty & Binnion, 2016; Forbes et al., 2018). One mindfulness intervention for distressed cancer survivors demonstrated that non-engagers had higher fear of cancer recurrence (Cillessen et al., 2020).

In sum, potential individual characteristics that may be associated with low- or non-engagement with online healthy lifestyle interventions in the general population include socio-demographic factors (e.g., gender, age, education), clinical factors (e.g., BMI, physical and cognitive functioning, distress), conscientiousness, and previous technology experience. However, further research is required to explore the direction of the effect of such factors and the potential relationship cancer-specific factors (e.g., fear of cancer recurrence, treatment-related side effects), and other psychological factors (e.g., motivation, self-efficacy, health literacy) on engagement with online healthy lifestyle interventions. Researchers and clinicians could then use these findings to develop an appropriate stratified-care system to allocate the telephone coaching calls to participants likely to be low- or non-engagers.

Impact of intervention architecture on engagement

One barrier to program usage identified by the participants of HLaC *Online* in **Chapter 4** was the perceived time investment of engaging in the program, due to the amount of information and modules available. As explored in **Chapter 1** and **Chapter 2**, one benefit of digital health interventions is the ability to implement complex programs addressing multiple health behaviours whereby participants can self-tailor the modules they access (Kuijpers et al., 2013). However, the participants of HLaC *Online* in **Chapter 3** reflected that they intended to visit all the modules, but their capacity to engage in the program was limited by the amount of content, combined with the experience of cancer-related side effects and lack of time due to other commitments. Two ways to address the perceived time burden of HLaC *Online* and reduce the potential overwhelm of offering nine modules are (1) reducing the number of modules and/or (2) offer tunnelled delivery of the modules (i.e., in a set order delivered over time; Oinas-Kukkonen & Harjumaa, 2009; Wildeboer et al., 2016). Three online interventions involving a small number of modules than HLaC *Online* have been trialled in the past. *SurvivorSHINE* included five modules*,* although, module completion was not reported (Williams et al., 2022). *iMove More for Life* was trialled as a one- or three-module format, with the three-module format comprising two delivery schedules: weekly or monthly. Short et al. (2017) found that 100% of participants allocated to receive a single module completed the module. Of those who were offered three modules, the weekly group had a greater proportion of participants complete 2 or more modules (60% vs 46%). However, participants in the monthly group completed more action plans, the behaviour change technique discussed earlier. All delivery schedules lead to clinical benefit, as all participants reported comparable change in self-reported MVPA. However, differences emerged in self-reported resistance-based activity, whereby participants allocated to the monthly modules reported greater change than the single module. Finally, *Prostate Cancer Health and Fitness* trialled a four module intervention and compared tunnelled or free choice delivery (i.e., immediate access to all modules) using a randomised control trial (Finlay et al., 2020). In terms of engagement, the tunnelled version participants completed more physical activity logs, while participants in the free choice were more likely to complete the four available modules. These difference in engagement did not influence health behaviour outcomes. Both groups showed a similar increase in the proportion participants meeting physical activity guidelines and this increase was not significantly different to the control condition. In contrast, a meta-analysis found that employing these persuasive design strategies improved the effectiveness of online mental health interventions in the general population (Wildeboer et al., 2016). However, careful consideration of implementing both strategies for HLaC *Online* is required, as this same meta-analysis demonstrated diminished effects when both strategies were implemented at the same time.

Alternatively, the needs-based assessment within the stratified care approach, described above, could be used to allocate the most relevant modules to participants. A similar process was investigated by Reinwand et al. (2015) in the general population with an online intervention addressing 5 healthy lifestyle behaviours: increasing fruit and vegetable consumption, increasing physical activity, reducing alcohol intake, and promoting smoking cessation. Participants were recommended modules relating to areas where they did not meet current national guidelines. Interestingly, participants who were recommended fewer modules were more likely to adhere to those modules. Furthermore, in the general population, such tailoring of eHealth interventions has demonstrated efficacy in promoting weight loss than generic information or usual care controls (Ryan et al., 2019). In sum, developing a needs-based assessment to be administered at baseline could improve the implementation of HLaC *Online* and HLaC *Online*+coaching by (1) identifying participants at high risk of low or non-engagement and (2) providing signposting of relevant modules based on participants self-reported behavioural change potential.

The implementation of HLaC *Online* into community practice

In practice, employing a stepped or stratified care approach and shorter interventions are emerging as a priority. The findings from this thesis have been presented the project's industry partner, Cancer Council SA. This presentation was followed by a meeting with the HLaC *Online* research team and members of the Cancer Council SA support team to determine whether HLaC *Online* and/or HLaC *Online*+coaching could be integrated into their suite of services and, if so, how it could be implemented. Stakeholders were interested in, and committed to, implementing both the guided and self-directed versions HLaC *Online,* alongside a four-session face-to-face group version of Healthy Living after Cancer, which is currently being offered within the organisation. To ensure that the delivery modalities align, the content and format of HLaC *Online* require updating and collapsed to four modules: Physical Activity, Healthy Eating, Emotional Well-being, and Finding the 'new normal' after treatment. First, further research will be required to first update the content of HLaC *Online* with collaboration of relevant healthcare professionals. Next, there needs to be consideration of how the intervention can be implemented within the service, whereby post-treatment cancer survivors are offered either HLaC *Online*, HLaC *Online*+coaching, or the Healthy Living after Cancer group based on their needs and preferences, in conjunction with intervention evaluation.

Methodological considerations

The current thesis demonstrates several methodological strengths that align with the MRC's recommendations for the development and evaluation of complex interventions (Skivington et al., 2021). These strengths include the involvement of a diverse group of stakeholders in the co-design of the intervention, multiple rounds of intervention testing, providing an estimation of required resources to deliver the program, and using mixed methods to evaluate the intervention's feasibility. Nevertheless, there are several additional methodological limitations not yet covered in this chapter relating to the study samples, measures, and conditions, that need to be considered when interpreting the findings from this thesis.

Sample limitations

A major limiting factor across the studies in this thesis was the representativeness of the sample to the cancer survivor population, due to an overrepresentation of female breast cancer survivors, many of whom were highly educated, lived in an urban area, and had a high socio-economic status, and an underrepresentation of cultural diversity. An overrepresentation of women is a well-recognised limitation in psycho-oncology and cancer survivorship research (Hoyt & Rubin, 2012; Hulbert-Williams et al., 2019). However, people with a history of breast cancer also form a large proportion of the cancer survivorship population, as breast cancer is estimated to be the most commonly diagnosed cancer in Australia and has a 5-year survival rate of 92% (AIHW, 2023). Thus, participation rates are reflective of the proportionate prevalence of the cancer survivorship population. Regardless, although this program is offered to post-treatment survivors of curative cancer types, the findings from this thesis may have limited generalisability to cancer types beyond breast cancer. In addition, as first identified in **Chapter 3**, there was inadequate representation of people from different cultures, such as Aboriginal and Torres Strait Islander Australians or Culturally and Linguistically Diverse Australians. Future iterations of HLaC *Online* should engage with stakeholders from Aboriginal and Torres Strait Islander and other cultural group communities, to ensure the program is culturally safe and meets the unique needs of these communities.

In addition to the limited demographic, cultural, and clinical representativeness of the samples in **Chapter 4** and **Chapter 5**, participants were, on average, already meeting the physical activity recommendations of 150 minutes of MVPA per week. This limitation influences the findings from these two chapters in three ways. First, participants may already be experiencing the maximum benefit of physical activity. Therefore, there may not have been much potential for change in physical activity through additional interventions. Second, this program may not have been appropriately designed for individuals who were already active. Indeed, the qualitative feedback in **Chapter 4** suggested this, with one participant reporting that HLaC *Online* confirmed what they already knew. Third, it is unclear what HLaC *Online*'s potential is to improve engagement in physical activity in *inactive* people, who may be more likely to benefit from such intervention. Therefore, moderator analyses based on participants baseline physical activity should be conducted in a larger study with adequate statistical power to determine whether those who are sedentary or less active benefit more from HLaC *Online* than participants who are more active or currently meeting the lifestyle guidelines. Similar moderator analyses could be conducted for baseline nutrition.

The last limitation related to the studies samples pertains to the 'post-treatment' phase of survivorship. As oncology care has shifted dramatically in the last 10 years, with the advent of immunotherapy, and personalised and precision targets for treatments, the profile of cancer survivors is changing (Mollica et al., 2022). There are many variations of what treatment can look like and cancer survivors may be receiving maintenance treatments following the more active anti-cancer treatment (DiSilvestro & Alvarez Secord, 2018). Furthermore, cancer survivors with metastatic disease can live well for many years with treatment and could also benefit from healthy living interventions (Lai-Kwon et al., 2023). One study found that women with metastatic breast cancer were less active, had lower aerobic fitness, and had higher levels of fatigue and dyspnoea, compared to healthy controls (Yee et al., 2014). Furthermore, interventions targeting physical activity in women with metastatic breast cancer have demonstrated no adverse events, with improvements in strength (Delrieu et al., 2020), aerobic fitness, and fatigue (Yee et al., 2019). In the same population, an intervention promoting a plant-based diet demonstrated improvements in fat and fibre intake, cognitive functioning, and emotional well-being (Campbell et al., 2024). An online intervention targeting physical activity has also been trialled with men diagnosed with metastatic prostate cancer (Evans et al., 2021a). No adverse events were reported, and trends indicated improvements in MVPA and step count. Therefore, there is potential for HLaC *Online* to be offered to cancer survivors yet to complete active treatment. However, there may be content in HLaC *Online* that is not appropriate in its current format for this population, in particular, the *Finding the new normal* module. Further consultation with relevant stakeholders (i.e., cancer survivors diagnosed with metastatic disease and healthcare professionals) would be required to adjust the content to suit this population.

Measures

Self-reported outcome measures

There are inherent limitations with the use of self-reported outcome measures in **Chapter 4** and **Chapter 5**, particularly for physical activity and diet quality. While these measures are a cost-effective, have low participant burden and allow direct comparison with the telephone-delivered Healthy Living after Cancer program, this comes at a trade-off for objective accuracy. Objective measures using accelerometer data are available, although, researchers will need to consider the cost and participant burden when utilising such measures (Kirkpatrick et al., 2019; O’Brien et al., 2017). In the current thesis, this measurement limitation was further compounded by an error coding the fat and fibre behaviour questionnaire in **Chapter 4** and inadequate internal consistency on the fat index on the same questionnaire in **Chapter 5**. Consequently, we did not reliably assess fat intake behaviours in either feasibility evaluation of HLaC *Online*. Alternative measures of diet quality that might be considered in future evaluations of HLaC *Online* and other online interventions include the Food Frequency Questionnaire (Flagg et al., 2000) or a 24-hour dietary recall (Subar et al., 2012).

Measuring engagement and adherence to digital health interventions

There has been a lack of consistency in how engagement and adherence to digital health interventions is conceptualised and subsequently measured in previous research. As discussed earlier in this chapter, engagement can be differentiated into engagement with the platform itself, in the behaviour change techniques, or in the health behaviour (Cole-Lewis et al., 2019). Each of these levels of engagement has been measured within previous online interventions for post-treatment cancer survivors. Regarding engagement with the platform, three studies utilised website metrics, such as number of logins, login duration, or number of modules completed (Frensham et al., 2018; Holtdirk et al., 2021; Kuijpers et al., 2016). In comparison, Valle and Tate (2017) focused on engagement in behaviour change techniques by assessing the number of activities completed. Six studies have investigated a combination of engagement with the platform and in the behaviour change techniques, including setting goals, completing action plans, or engaging with posts (Forbes et al., 2015; Kanera et al., 2016; Kenfield et al., 2019; O'Carroll Bantum et al., 2014; Rabin et al., 2011; Short et al., 2017). Additionally, adherence measurements can also focus on website usage. For example, van de Wiel et al. (2021) measured adherence as at least five logins over the intervention period and

Trinh et al. (2018) measured adherence as three logins per week over twelve weeks. In comparison, Lee et al. (2014) focused on adherence to health behaviours and measured adherence to the healthy lifestyle recommendations at the completion of treatment. Similarly, two studies measured adherence to health behaviours via self-reported check ins, however, these check ins were at varying timepoints. Lynch et al. (2017) administered daily check-ins over the intervention period, whereas, Berg et al. (2014) administered three check ins over a 12-week period. Five studies did not provide a conceptualisation and did not report a measure of engagement or adherence (Demark-Wahnefried et al., 2023; Golsteijn et al., 2018; Paxton et al., 2017; Rees-Punia et al., 2022; Williams et al., 2022). This variation in measures impacts the ability to compare engagement and adherence across online interventions and measuring adherence becomes particularly challenging when online interventions become more complex and address multiple behaviours. It is important to note that there have also been attempts to develop a scale for digital health engagement, however, these have not been validated (Perski et al., 2020). In addition to varied definitions of engagement and adherence to online interventions, the broader literature have not determined the optimal effective ‘dose’ of online interventions to generate meaningful behaviour change. It is assumed that there is a need to increase engagement, but it remains uncertain about whether this need exists and if so, to what extent (Short et al., 2015a; Short et al., 2018). Furthermore, inconsistent reporting of engagement in healthy living interventions in the cancer survivor population had made it impossible to explore this relationship (Furness et al., 2020).

Chapter 5, attempted to address this issue by first understanding which topics participants were interested in and measuring whether they then completed those relevant modules. Although this aligns with **Chapter 3** stakeholder perception of how HLaC *Online* should be used, and that it could be used for other online intervention trials, focusing on participant interests at baseline comes with its own limitations. Interests can be impacted by the participants pre-existing knowledge, values, and motivation (Coumans et al., 2020; Schraw & Lehman, 2001; Short et al., 2018). Furthermore, participants' interests may not align with the behaviours that require changing. For example, a participant who is interested in physical activity may already be active. The needs-based assessment described above may address these limitations by providing recommendations of relevant modules for participants based on their baseline measures and assessing the proportion of those modules accessed (Coumans et al., 2020). In a larger trial, future research might also investigate whether those changes are observed in the outcomes relevant to the recommended modules, such as assessing change in physical activity in participants who were recommended the physical activity module.

Measuring satisfaction using quantitative and qualitative means

One limitation identified in **Chapter 4** was only the collection of qualitative satisfaction feedback only during the post-intervention interview. As many cancer survivors described disengaging from the intervention weeks prior to the interview, they were unable to recall and therefore, provide feedback on individual modules. **Chapter 5** attempted to address this limitation by including a satisfaction measure at the end of each module using a quantitative star rating and an open response for qualitative feedback (Perski & Short, 2021), combined with an overall satisfaction, rating at the post-intervention assessment. While these measures were simple to implement and provided additional information about participant satisfaction compared to the qualitative feedback gathered in **Chapter 4**, only a small number of participants completed the module satisfaction ratings. Thus, there may have been a response bias towards positive responses, due to the measure being administered at the end of the module and therefore, not capturing the satisfaction of participants who disengaged prior to the last page of the module. Overall, these two chapters highlight the importance of implementing both qualitative and quantitative measures for assessing user satisfaction. However, researchers will need to determine the optimal positioning of module satisfaction ratings, to ensure it is capturing participants who disengage from module.

Conditions

Lack of control condition

Another limitation of **Chapter 4** and **Chapter 5** was the absence of an inactive or attention control condition. Consequently, nonspecific effects or other confounds cannot be ruled out when interpreting the changes observed in the preliminary efficacy outcomes. Employing an inactive control condition, such as usual care (i.e., no intervention) or a waitlist group (i.e., delayed intervention), can control threats to internal validity, such as regression to the mean and spontaneous improvement in symptoms (Locher et al., 2018). Further, these conditions can control some threats to external validity, such as the Hawthorne effect (i.e., participants' change in behaviour due to their awareness of being studied; Locher et al., 2018). Usual care conditions are the most frequently adopted control in randomised control trials evaluating health behaviours in cancer survivors. However, there is inconsistency in the definitions ‘usual care,’ with variations in the amount of resources and attention provided to the participants (Tock et al., 2022). In comparison, while waitlist controls use more resources, they can improve participant recruitment and retention.

Attention controls, involving a substitute activity with similar attention and contact, control for the non-specific effects of the intervention. For example, one telephone-delivered physical activity intervention for women with ovarian cancer provided the attention control participants weekly telephone calls and a book on ovarian cancer survivorship (Zhou et al., 2017). Careful consideration is required to determine an appropriate attention control, such that it contains common factors with the intervention without the potential of it becoming an intervention itself. Trials of online interventions might consider online resources and offered by national cancer support organisations, such as the *Living well after cancer* online booklet published by Cancer Council Australia (2021). Researchers evaluating the efficacy of online healthy living interventions, including HLaC *Online*, should consider which control condition is appropriate to answer their research question and comparable for their intervention condition (Tock et al., 2022).

Offering peer support within HLaC Online

The final limitation of this thesis was the inability to address the peer support needs within the HLaC *Online* program, as requested by the post-treatment cancer survivors in **Chapter 3**. Having the ability to communicate with other participants of the online healthy living program has was also requested in the qualitative feedback for the *SurvivorSHINE* intervention (Williams et al., 2022). Communication via online forums and social media pages have been utilised in previous interventions (Hong et al., 2015; Wootten et al., 2014). However, the HLaC *Online* research team did not have the capacity to moderate such forums. Although outside of the scope for the current intervention, future online interventions could consider the use of online forums or integrating peer-to-peer support (e.g., peer coaching) within the program to address peer supports of post-treatment cancer survivors.

Conclusion

Over the last 15 years, there has been a growing body of evidence to support the feasibility and efficacy of delivering healthy living interventions to post-treatment cancer survivors. Although cancer survivors define healthy living as an overall QoL, including physical health, mental health, and finding the ‘new normal’ after treatment (Grant et al., 2021), few have targeted psychosocial variables *within* the healthy living intervention (Holtdirk et al., 2021; Kanera et al., 2016). Furthermore, previous research has shown that cancer survivors’ highest unmet needs are in the psychological domain (Lisy et al., 2019). To address this gap, this thesis evaluated the current evidence for multicomponent healthy living interventions addressing physical and mental health in post-treatment cancer survivors. Our findings demonstrated that, while including a mental health component did not enhance the efficacy of the intervention in improving QoL, there was a limited pool of evidence from which to draw firm conclusions, warranting future research in this area. In adding to this literature, the current thesis utilised co-design to develop and evaluate the feasibility of HLaC *Online*, an online physical activity, healthy eating, and psychosocial intervention for post treatment cancer survivors. Overall, findings demonstrated that a self-directed version of HLaC *Online* is feasible, but it may depend on the participants’ level of intrinsic motivation. To reduce non-engagement in HLaC *Online*, telephone coaching calls are a feasible option that can also lead to greater reductions in sitting time and cancer-related distress.

Online interventions offer a promising solution to support health behaviour change in cancer survivors who do not have access to traditional face-to-face interventions. Furthermore, online interventions have the potential for addressing organisation level barriers of providing can be a cost-effective and scalable delivery modality for organisations to expand their available services. However, there is a clear need to differentiate users who engage well and benefit from a self-directed online intervention from those who require additional human support. The next steps for the implementation of HLaC *Online* include (a) refining the program to align with industry partner's formatting requirements, to be delivered over four modules, consistent with Cancer Council SA's other healthy living services, and (b) develop and test a stratified-care model with needs-based assessment, to identify potential low or non-engagers. Finally, the next iteration of HLaC *Online* will require a larger hybrid implementation-efficacy trial to evaluate the program's efficacy compared to an inactive control and its cost-effectiveness within Cancer Council SA's suite of services.

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Appendix A

Chapter 2 published study

Material from: LESKE, M., GALANIS, C., KOCZWARA, B., BEATTY, L. A META-ANALYSIS OF HEALTHY LIFESTYLE INTERVENTIONS ADDRESSING QUALITY OF LIFE OF CANCER SURVIVORS IN THE POST TREATMENT PHASE. JOURNAL OF CANCER SURVIVORSHIP, published 2024, Springer Nature

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REVIEW

A meta-analysis of healthy lifestyle interventions addressing quality of life of cancer survivors in the post treatment phase

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Abstract

Purpose This study's primary aim was to investigate whether including a mental health component to healthy lifestyle interventions are associated with greater effects on quality of life (QoL) for post-treatment cancer survivors than addressing physical activity and/or nutrition alone.

Methods PsycINFO, Scopus, Medline, CINAHL, and Google Scholar were searched to identify randomised control trials of healthy lifestyle interventions for post-treatment cancer survivors, with a usual care or waitlist control, and measured QoL. Meta-analyses quantified the effects of interventions vs controls at post-treatment on total QoL, physical, emotional, and social well-being. Subgroup analyses compared interventions with vs without a mental health component, modes of delivery, and duration. The quality of the included studies was assessed using the Cochrane Risk of Bias 2.

Results Eighty-eight papers evaluating 110 interventions were included: 66 effect sizes were extracted for meta-analysis, and 22 papers were narratively synthesised. The pooled effect size demonstrated a small, significant effect of healthy lifestyle interventions in comparison to control for all QoL outcomes (total $g = 0.32$, $p > .001$; physical $g = 0.19$, $p = 0.05$; emotional $g = 0.20$, $p > .001$; social $g = 0.18$, $p = 0.01$). There was no significant difference between interventions with vs without a mental health component. Face-to-face delivered interventions were associated with greater total QoL and physical well-being compared to other modalities. Interventions delivered ≤12 weeks were associated with greater physical well-being than those delivered ≥13 weeks. Overall, studies had substantial levels of heterogeneity and 55.9% demonstrated high risk of bias.

Conclusions Participating in a healthy lifestyle intervention following cancer treatment improves QoL. Few trials addressed mental health or evaluated online or telephone modalities; future research should develop and evaluate interventions that utilise these features.

Implications for Cancer Survivors Brief healthy lifestyle interventions can be recommended for cancer survivors, particularly those interested in improving physical well-being.

Keywords Cancer survivors · Lifestyle intervention · Quality of life · Complex interventions

Introduction

Advances in earlier detection and diagnosis, improved treatment options, and better supportive care are contributing to the growing cancer survivor population [1]. However, the physical (e.g. fatigue, pain, nausea, and changes in appearance) and psychosocial (e.g. psychological distress, challenges in relationships, financial stress, and changes in cognitive and sexual functioning) side effects of a cancer diagnosis and its associated treatments can significantly impact an individual's quality of life (QoL) long after they have completed treatment [2–4]. QoL for cancer survivors is a subjective multi-dimensional concept that encompasses and measures various aspects of a person's physical, emotional, social, and spiritual well-being, and functional status. QoL refers to how a person perceives their life in the context of their health and personal values, and how well they can function and participate in activities that are important to them [5–7].

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Healthy lifestyle interventions addressing physical activity, nutrition, and/or weight management have been posited as one strategy to improve QoL and support cancer survivors following the completion of treatment. Such interventions have demonstrated efficacy in (a) reducing treatment-related side effects, cancer recurrence and mortality [8], and (b) improving emotional well-being [9]. Several meta-analyses have evaluated the efficacy of healthy lifestyle interventions in enhancing QoL in cancer survivors, but their results have been inconsistent. Small to moderate positive effects on QoL have been demonstrated across meta-analyses involving physical activity interventions involving all cancer types [7] and breast cancer survivors [9–11]. Similarly, healthy lifestyle education programs have demonstrated a moderate positive effect on lung cancer survivors QoL [12]. In contrast, meta-analyses which have investigated healthy lifestyle interventions for gynaecological cancers [13] or have only involved nutritional therapy [14] have not demonstrated significant differences to usual care control groups. Two meta-analyses investigating telehealth interventions [15, 16], such as those delivered via telephone, or videoconferencing and online platforms, have produced contrasting findings. Larson and colleagues [15] conducted a meta-analysis involving eleven studies and initially obtained a large positive effect; however, the magnitude of the effect was decreased to non-significant when two large studies contributing to heterogeneity were removed. In comparison, the second, and larger, meta-analysis by Li and colleagues [16] involving 28 studies found a small positive effect for telehealth interventions on cancer survivors' QoL.

Although these meta-analyses support the implementation of healthy lifestyle interventions following cancer treatment, they have primarily focused on interventions which target physical health behaviours, such as physical activity and diet quality. However, a qualitative study conducted by Grant and colleagues [17] with cancer survivors, oncology healthcare professionals, and representatives from cancer support organisations identified that a healthy lifestyle after cancer treatment includes both physical health and mental health. The participants of this study recommended that a mental health component be included in healthy lifestyle interventions. Addressing mental health within healthy lifestyle interventions is also promoted by research investigating barriers to physical activity and healthy eating, which have identified stress as a prevalent barrier to engaging in these health behaviours [18, 19].

Thus, interventions targeting a healthy lifestyle after cancer treatment should go beyond physical activity and nutrition and address mental health as well. To date, meta-analyses have not examined whether interventions that include a mental health component increase the impact of healthy lifestyle interventions on cancer survivors' QoL. The current meta-analysis aims to update the previous evidence for the efficacy of healthy lifestyle interventions on QoL post-intervention and to investigate whether interventions which include a mental health component in their intervention protocol are associated with greater effects on QoL in comparison to interventions which only address physical activity or nutrition. The secondary aim of this meta-analysis is to investigate whether other aspects of the intervention, such as mode of delivery (individual, group, telephone, online, or print) or duration (shorter vs longer), affect the association between the interventions and QoL.

Method

This meta-analysis followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [20] and was prospectively registered on PROSPERO (CRD42021273722).

Study selection

To identify relevant studies, a review of electronic databases relevant to psychology and health, including PsycINFO, Scopus, Medline, and CINAHL, was conducted. In addition, the first 200 references identified in Google scholar were included in the review. The search strategy was based on the PICO approach, as follows: *population*—terms related to (1) cancer, and (2) survivor; *intervention*—terms related to (1) healthy lifestyle, (2) physical activity, (3) nutrition, and (4) weight control; *outcome*—terms related to QoL (see Multimedia A for details). The final database search was conducted on the 9th of June 2022.

Articles were included in the analysis if they meet the following criteria: (1) involved adult cancer survivors (i.e. ≥18 years and have completed active treatment); (2) offered an intervention targeting health behaviour change (i.e. physical activity, sedentary time, or diet, or weight management); (3) reported an outcome measure for total QoL, and/or Physical, Emotional, or Social Well-being on a reliable and valid measure of QoL (e.g. European Organization for the Research and Treatment of Cancer Quality of Life Questionnaire (EORTC QLQ-C30; [6]), Functional Assessment of Cancer Therapy-General (FACT-G; [5]), or 36- or 12-Item Short Form Health Survey (SF-36; [21], SF-12; [22]); (4) involved a randomised control trial or pilot randomised control trial using a waitlist or usual care control (i.e. access to publicly available materials); (5) written in English and published in a peer-reviewed journal. Included articles investigated interventions utilising any mode of delivery. Articles were excluded if they involved a population other than adult cancer survivors, did not offer an intervention targeting health behaviour change, offered an intervention which only targeted mental health, did not measure QoL, or utilised any of the following designs: crossover design, single group pre-post, qualitative, cross-sectional design, protocol paper, systematic review, or meta-analysis. Articles were also excluded if they were grey literature (e.g. dissertations or conference papers).

Authors ML and CG conducted preliminary screening of titles and abstracts. Abstracts meeting inclusion criteria were subject to full-text evaluation. Disagreement between the two reviewers were resolved through discussion. If consensus was not achieved, a third author (LB) was consulted.

Data extraction

Data extracted from articles that met inclusion criteria included study characteristics (e.g. author, year of publication, country intervention was delivered), participant characteristics (e.g. gender, age, cancer type, and time since diagnosis), intervention characteristics (i.e. duration, mode of delivery, and behaviours targeted), and outcome measures. Interventions were categorised as addressing physical activity if they targeted bodily movement and included increasing exercise (i.e. planned, structured, and repetitive movements to increase physical fitness), leisure time activity, and reducing sedentary time. Interventions were categorised as addressing nutrition if they targeted the increase and/or decrease of certain foods or nutrients. Interventions were categorised as including a mental health component if they provided a manualised psychological treatment, psycho-education material on mental health and well-being, or counselling with the intention of addressing emotional distress. To calculate effect sizes between the intervention and control groups, the post-intervention sample size, means, and standard deviations for total QoL were extracted. As several QoL measures do not quantify a total score, the means and standard deviations of subscales relevant for physical, emotional, and social well-being in both the intervention and control groups were also extracted. These subscales were selected as they were present in all valid QoL scales. For inter-rater reliability, two authors (ML and CG) undertook data extraction on a subset of articles ($n = 58$).

Quality assessment

The risk of bias of each study was evaluated by one author (ML) using the Cochrane Risk of Bias tool 2.0 (RoB 2; [23]). This tool evaluates the risk of bias in five domains: (1) the randomisation process, (2) deviations from intended interventions, (3) missing outcome data, (4) measurement of outcome, and (5) selection of the reported result. As the current meta-analysis was summarising self-reported QoL, domain 4: measurement of outcome, was not considered in the evaluation of risk. Using this tool, the articles were evaluated and judged on the domains as being either low risk of bias, some concerns, or high risk of bias. For overall bias, articles were considered to have low risk of bias if they were rated as low risk of bias on each of the domains and high risk of bias if they were rated as having high risk of bias on at least one of the domains or as having some concerns on at least two of the domains.

Data analysis

The Comprehensive Meta-Analysis computer package [24] was used for all analyses. Standardised mean differences (Hedge's g) between the intervention and control groups with 95% confidence intervals were calculated for the total QoL and each of the QoL subscales. Effect sizes were pooled using a random effects model to derive the overall effect size of healthy lifestyle interventions on QoL for cancer survivors. Following this, three pre-specified subgroup analyses were conducted to investigate whether the efficacy of healthy lifestyle interventions on QoL was influenced by selected intervention components. The first subgroup analysis interventions were categorised based on the inclusion of a mental health component. The second sub-group analysis separated interventions based on their dominant mode of delivery, such as individual face-to-face, groups, telehealth, digital health, or print. As there were interventions where one delivery was not dominant, a multiple category was included. The final pre-specified sub-group analysis investigated interventions which had a shorter duration (i.e. 12 weeks or less) or a longer duration (i.e. 13 weeks or more). Narrative synthesis was used to summarise findings in studies which could not be included in the meta-analysis. The narrative synthesis focused on the efficacy of the healthy lifestyle intervention in comparison to the usual care control and the potential impact the intervention characteristics of the inclusion of a mental health component, the mode of intervention delivery, and intervention duration.

Heterogeneity and publication bias

The heterogeneity of the data was assessed using Q (presence of heterogeneity) and I^2 (proportion of total variation between studies that results from heterogeneity) statistics [25]. The I^2 scale ranges from 0% (no heterogeneity) to 100% (high heterogeneity). Cochrane's guide to interpretation of the I^2 statistic specifies that 0–40% = heterogeneity that might not be important, 30–60% = moderate heterogeneity, 50–90% = substantial heterogeneity, and 75–100% = considerable heterogeneity. To interpret the I^2 statistic, the number of studies included magnitude and direction of the effect, and Q statistic was taken into consideration. Sources of heterogeneity were explored by conducting post hoc sub-group analyses [26], by dividing studies into two or more subgroups and calculating the Q and I^2 statistics for each subgroup. Three subgroups were explored: (1) multi-component (i.e. targeting more than one health behaviour) vs single component (i.e. targeting a single health behaviour); (2) measure of QoL; (3) QoL measured as the primary vs secondary outcome. For the second subgroup analysis, the measures of QoL were grouped under their measurement system, rather than individual measures, to ensure relatively equal groups. For example, those who included the FACT-Breast, FACT-Colorectal, and FACT-General were grouped under FACT and the SF12 and SF-36 were grouped under SF.

Publication bias was evaluated by Egger's regression intercept, which examines the correlation between effect sizes and standard errors of effect sizes. If there is a significant association between study effect size and study precision, this indicates the possibility of publication bias. Each QoL outcome was considered separately.

Results

Study selection

Figure 1 presents the PRISMA flow diagram of the study selection process. Following screening, 88 articles involving 110 interventions met inclusion criteria for the systematic review, and 66 articles met criteria for meta-analysis. Articles were most commonly excluded due to the use of an active control (e.g. workbook or telephone calls). The predominant reason for excluding articles from the meta-analysis was reporting change over time instead of post treatment means and standard deviations. The agreement rate between reviewers was 91.5% for title and abstract screening, 77.4% for full text review, and 66% for data extraction. Exacting different total scores for QoL when multiple scales were reported (e.g. SF-36 and FACT-G) accounted for 73% of the differences in the data extraction. In all instances of disagreement, consensus was reached through discussion.

Study characteristics

Multimedia B summarises the 88 included studies. The total number of participants included in this review was 9556, with sample sizes ranging from 14 to 641 and a median of 71. There was an over-representation of females in included studies with 51 interventions offered only to breast cancer survivors. The average age of included participants was 57.93 (*SD* = 11.32) years. Forty-eight studies reported time since diagnosis, of which the median was 23.53 months (range = 6.40–87.6 months). The majority of included studies were conducted in the USA (*n* = 27), Canada (*n* = 11), Australia (*n* = 9), Spain (*n* = 6), Netherlands (*n* = 6), and the UK (*n* = 5). In terms of study design, 30.7% studies measured QoL as their primary outcome. The most common QoL measures were the FACT (*n* = 33), EORTC QLQC30 (*n* = 25), and the SF questionnaire (*n* = 23).

Intervention characteristics

Mode of delivery

A diverse range of delivery modalities were investigated in the included interventions. Most utilised *face-to-face delivery* (*n* = 84), of which approximately half (*n* = 43) were provided individually [27–52] while the remainder were delivered via groups [43, 53–83]. Twenty-five (22.7%) of these face-to-face interventions were supported by additional modalities, such as printed or emailed materials [55–57, 84–86], telephone [41, 66, 87, 88], videos [89, 90], or a combination of these [71, 73, 91].

Sixteen studies utilised a *digital health modality* (such as an online platform, or a mobile application) [82, 92–97]. Within this group, wearable devices were also utilised as either the primary delivery modality [98] or accompanying another delivery modality [57, 87, 88, 98]. Nine utilised *telehealth*, of which 8 delivered content over phone calls and 1 investigated SMS delivery [99], whereby participants were sent education material over text messages. Delivery modalities less frequently used included DVDs [100] and print [98, 101–103].

Intervention duration

The duration of the interventions ranged from 2 to 104 weeks (*M* = 20, *Mdn* = 12). 50.9% of the interventions were delivered over 12 weeks or less, with the most common intervention durations being 12 weeks (31.8%), 26 weeks (15.5%), and 52 weeks (17.3%).

Health behaviours targeted

Physical activity Most included interventions addressed physical activity (*n* = 107, 93.9%). Twenty-two interventions targeted *aerobic activity* (e.g. walking, cycling) [28–30, 34, 43, 45, 50, 51, 57, 58, 61, 63, 75, 80, 81, 91, 104, 105]. Seven interventions focused on *resistance exercises* (e.g. lifting weights) [35, 40, 48, 67, 78]. Thirty-four interventions promoted a *combination* of aerobic and resistance exercises [27, 31–33, 36–39, 41, 42, 52, 53, 55, 59, 68, 76, 77, 79, 83, 85, 89, 90, 93, 101, 103, 106–108]. Four interventions practiced yoga [60, 62, 72] and one intervention [70] involved a combination of aerobic, resistance, and yoga exercises. Twenty-five interventions did not specify a particular exercise, instead focusing on increasing minutes of physical activity per week [46, 47, 54, 71, 74, 82, 86, 87, 94–100,

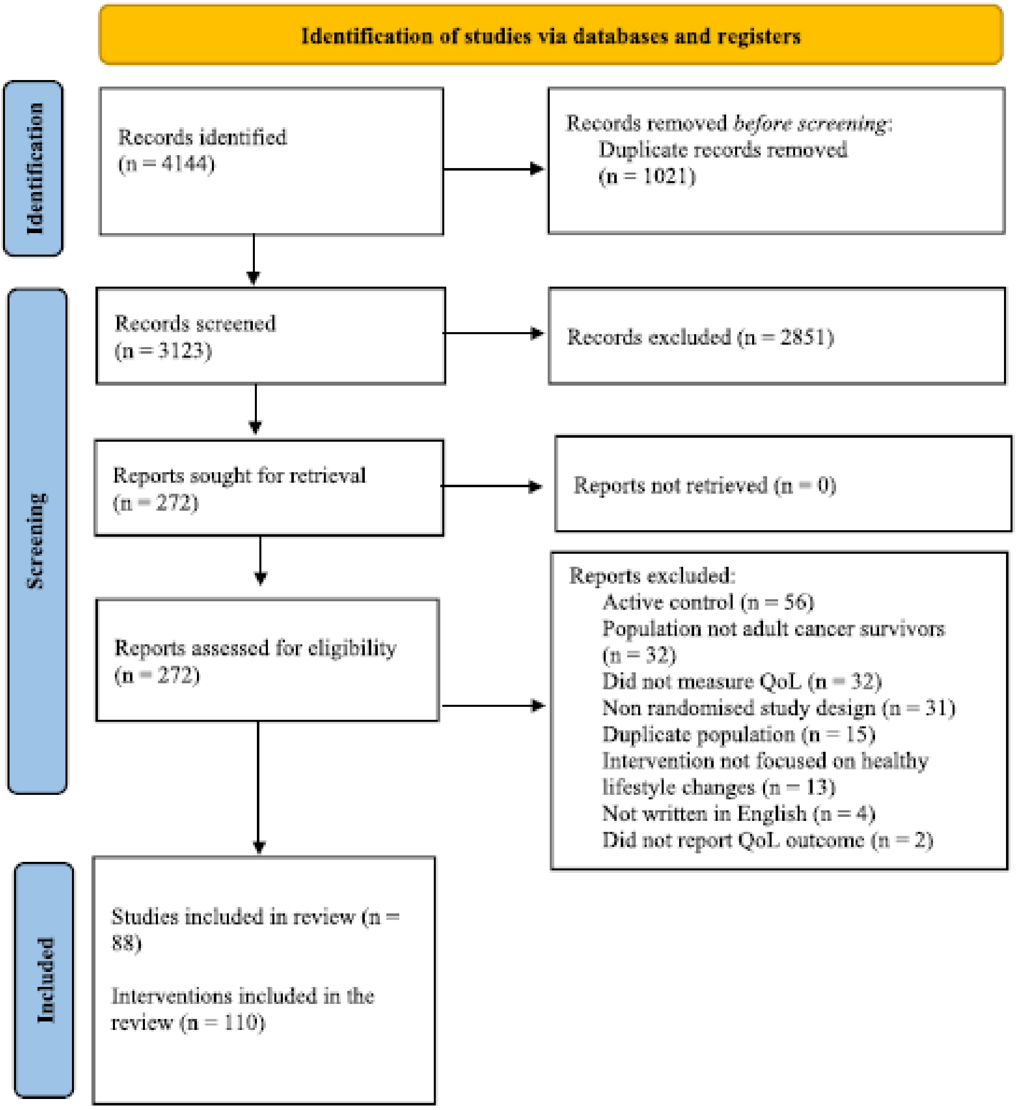

Fig. 1 PRISMA flow diagram of included studies

102, 109], reducing sedentary time [92], or a combination of these [69, 88, 110].

Nutrition Thirty-five (30.7%) of the included interventions contained a nutritional component. Of these interventions, 12 focused on *diet restriction* through decreasing certain food groups consumed [56], or reducing total daily calorie intake [50]. Common recommendations for daily calorie intake in the included interventions were between 1200 and 2000 kcal/day [38, 58, 83] or reducing the participants current calorie intake by 600 kcal [85]. Comparatively, six interventions focused on *dietary change* and promoted increasing certain food groups [65, 84, 97], such as 5 servings of vegetables and 2 servings of fruit per day, and increasing intake of nuts, grains, and fish. Thirteen interventions utilised a *combination* of dietary restriction and dietary change strategies [34, 55, 59, 69, 79, 87, 105–108]. Two inventions cited a *particular diet plan*, such as an anti-inflammatory diet [73] or the Mediterranean diet [56]. Six interventions included *non-specified* dietary guidance or counselling [70, 74, 77, 95, 99, 111]. Three interventions included recommendations to *decrease alcohol consumption* [55, 85, 108].

Mental health Overall, 19 of the 110 (17.3%) interventions featured a mental health component in their protocol. Six provided *mental health treatment* based on evidence based psychological therapies, such as cognitive behavioural therapy [45, 66, 95, 97, 105] or Mindfulness-Based Stress Reduction [79]. Seven interventions included *psycho-educational material* on social and emotional well-being [99], stress management [46, 56, 112], mindfulness [77], or psychological adjustment following a cancer diagnosis [111]. One intervention utilised meditation following a yoga session [60]. Three interventions described the use of 'psychological support' or counselling but did not provide further details [38, 42, 76].

Meta-analysis of overall intervention effects

Post-treatment data was available for meta-analysis from 48 articles for total QoL (Fig. 2), 50 for physical well-being (Fig. 3), 50 for emotional well-being (Fig. 4), and 48 for social well-being (Fig. 5).

The overall pooled effect size of the interventions demonstrated a small significant, positive effect of healthy lifestyle interventions on cancer survivors' total QoL ($g = 0.32$, 95% CI [0.17, 0.48], $p > .001$), physical well-being ($g = 0.19$, 95% CI [0.01, 0.36], $p = 0.05$), emotional well-being ($g = 0.20$, 95% CI [0.10, 0.31], $p > .001$), and social well-being ($g = 0.18$, 95% CI [0.05, 0.31], $p = 0.01$) in comparison to waitlist or usual care controls. For total QoL, 1 intervention demonstrated a negative effect, and favoured the control group over the intervention group [113]. Similar results were found for each of the subscale outcomes, whereby 3 interventions demonstrated negative effects (favouring the control condition) for physical well-being [73, 78, 113], 3 for emotional well-being [67, 95, 113, 114], and 2 for social well-being [103]. Consequently, these results should be interpreted with caution. According to Cohen's criteria, substantial heterogeneity was observed for emotional well-being ($Q = 142.99$, $p < .001$; $I^2 = 65.73$) and considerable heterogeneity was observed for total QoL ($Q = 236.19$, $p < .001$; $I^2 = 80.10$), physical well-being ($Q = 384.89$, $p < .001$; $I^2 = 87.27$), and social well-being ($Q = 248.98$, $p < .001$; $I^2 = 81.12$); visual inspection of each forest plot demonstrates dispersion across 0.

Subgroup analyses

Table 1 summarises the results of the pre-specified subgroup analyses conducted to examine differences arising from the

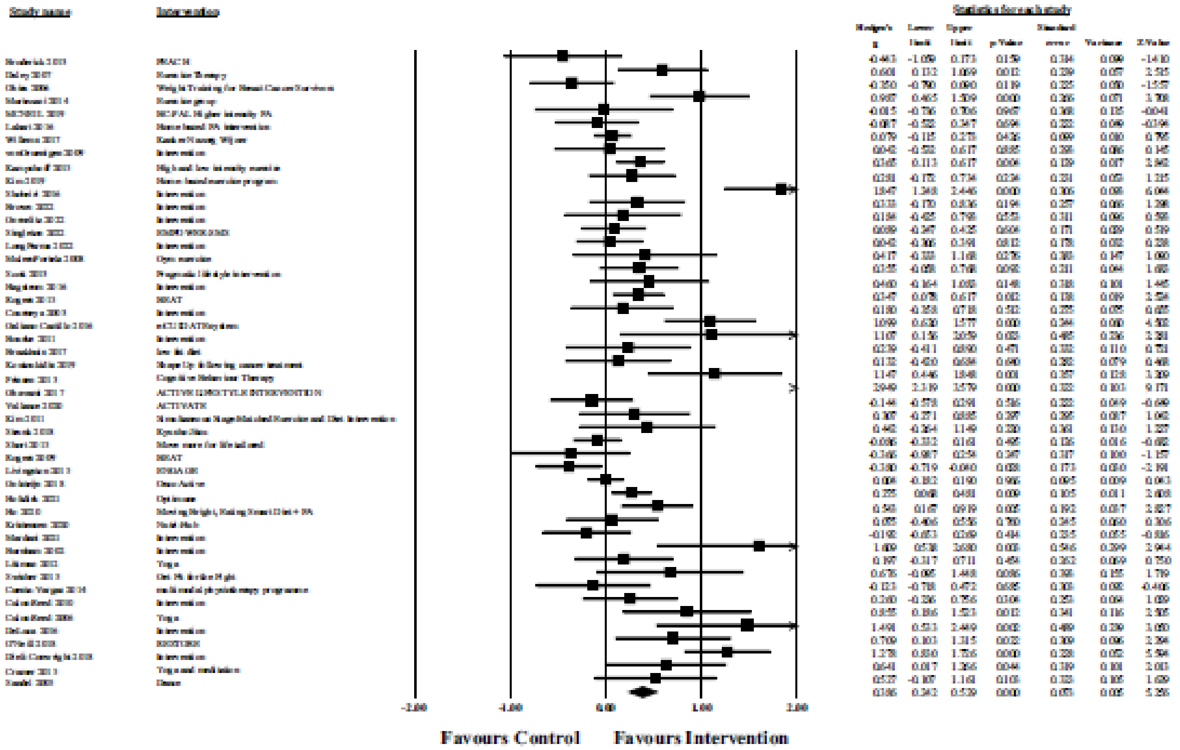

Fig. 2 Forest plot of meta-analysis of effect sizes identified for each health behaviour intervention on post intervention Total QoL

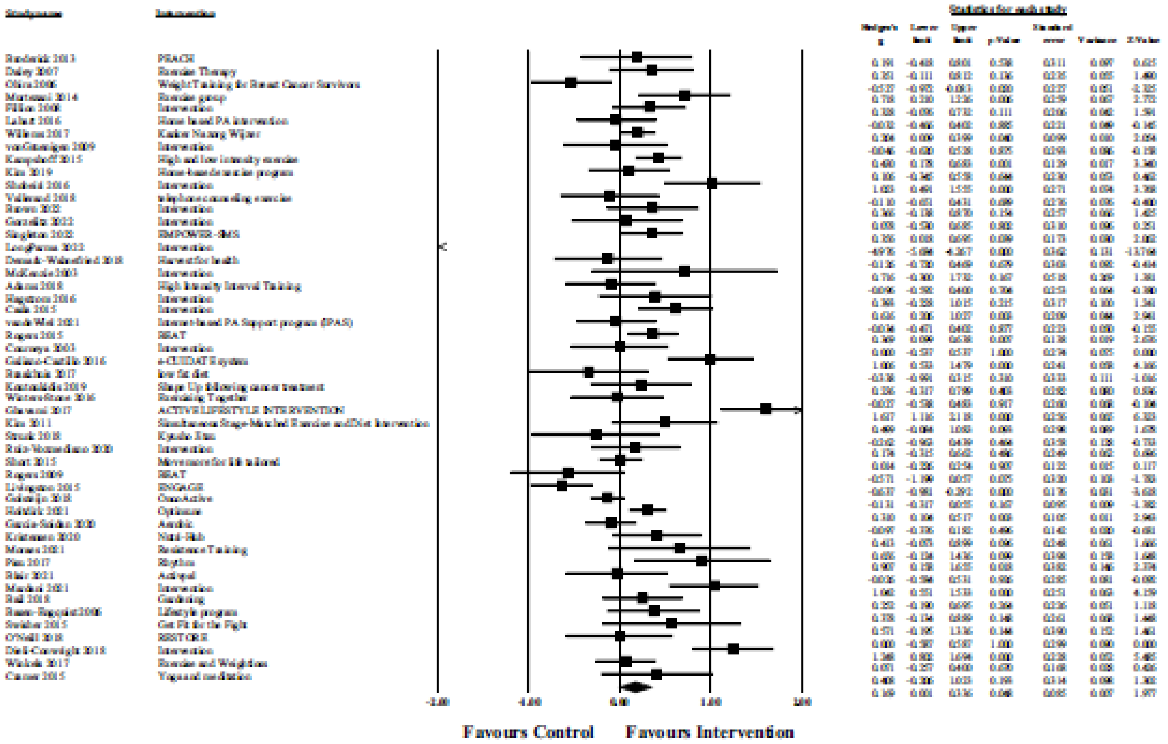

Fig. 3 Forest plot of meta-analysis of effect sizes identified for each health behaviour intervention on post intervention physical well-being

inclusion of a mental health component, mode of delivery, and the duration of the intervention on each of the QoL outcomes.

Mental health component There were no significant differences in effect between interventions with or without a mental health component. Heterogeneity varied across these analyses: Heterogeneity was considerable on total QoL and emotional well-being subscales, whereas physical well-being and social well-being had no significant heterogeneity.

Modality The mode of delivery subgroup analyses demonstrated a significant subgroup effect on total QoL and physical well-being. For total QoL, the individual ($g = 0.65$, 95% CI [0.27, 1.03]) and group modalities ($g = 0.35$, 95% CI [0.14, 0.57]) were associated with significant positive effects (favouring the intervention group). No other delivery modality was significant. Conversely, on the physical well-being outcome, only the individual modality ($g = 0.36$, 95% CI [0.03, 0.68]) was associated with a significant positive effect (favouring the intervention). However, these results should be interpreted with caution due to covariation distribution. Only two or three trials were included in the analysis for the print, telehealth, and multiple subgroups. Therefore, we cannot confidentially conclude that this is a true subgroup effect. Heterogeneity notably reduced in the group modality subgroup with the social well-being outcome and reduced in the smaller groups across the analyses, specifically the telephone and print subgroups.

Duration There was a significant subgroup effect of duration on the physical well-being outcome. Shorter interventions ($g = 0.33$, 95% CI [0.18, 0.49]) were associated with a small positive effect and favoured the intervention group, whereas longer interventions ($g = -0.04$, 95% CI [−0.35, 0.26]) did not demonstrate a significant effect. However, substantial unexplained heterogeneity remained within each of the subgroups.

Sources of heterogeneity The post hoc subgroup analyses exploring additional sources of heterogeneity are also presented in Table 1. None of the post hoc subgroup analyses identified significant associations across all outcomes. Heterogeneity remained considerable across these subgroup analyses, with the exception of studies which measured QoL as their primary outcome on the social well-being subscale ($I^2 = 15.20$), and studies which used the SF to measure

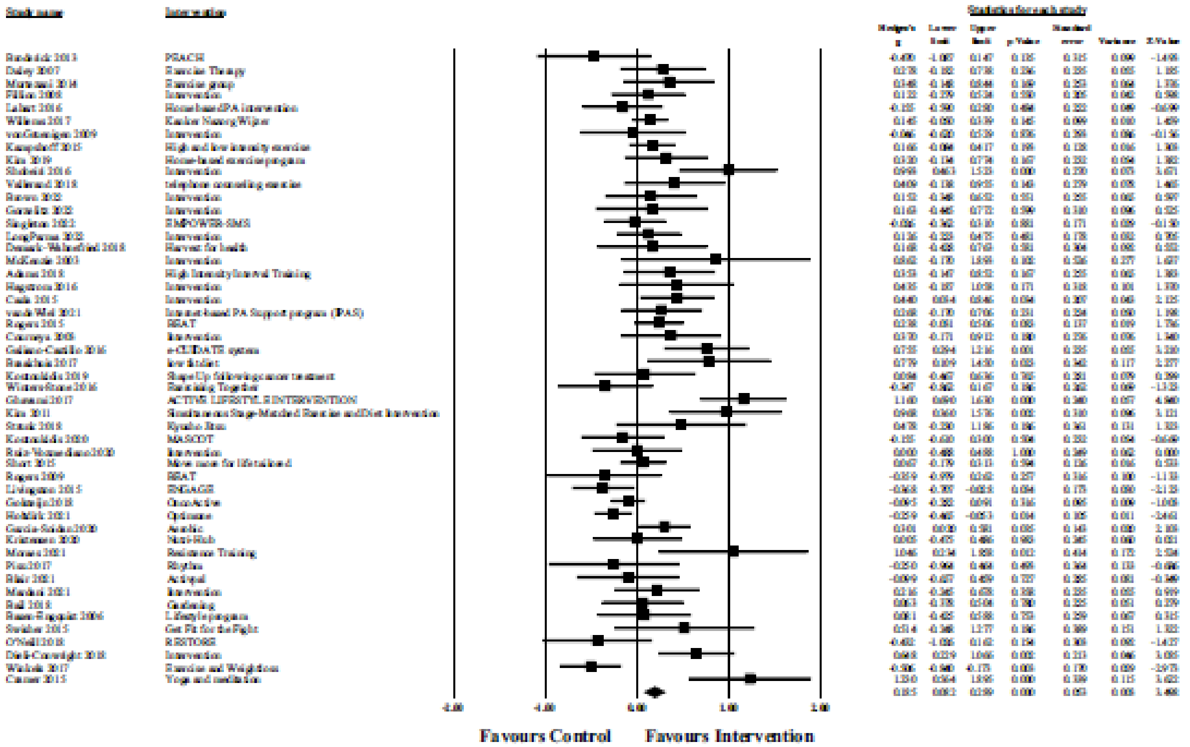

Fig. 4 Forest plot of meta-analysis of effect sizes identified for each health behaviour intervention on post intervention emotional well-being

physical well-being ($I^2 = 32.64$) and social well-being subscales ($I^2 = 22.69$).

Narrative synthesis of interventions on QoL

Twenty-two studies investigating 31 interventions were excluded from the meta-analysis as they did not provide post-treatment means and standard deviations [36, 38, 43, 48, 51, 53, 59, 74, 76, 80, 86, 89–91, 98, 107–109, 111, 115, 116]. Total QoL was reported in 14 studies evaluating 19 interventions. Of these, 5 (26.3%) interventions demonstrated significant improvements compared to control [36, 38, 51, 76, 91]. For physical well-being, 10 of the 25 interventions (40%) reporting this outcome showed significant improvements compared to control [36, 51, 74, 91, 111, 115]. In terms of emotional well-being, 6 of the 24 interventions (25%) reported greater improvements in the intervention group [51, 76, 91, 115], though in one study [43] this benefit was only found in a subgroup of participants (those not currently taking endocrine therapy). Lastly, for social well-being, only 1 out of 25 interventions reported significant improvements compared to a waitlist intervention [111]. Moreover, Saarto and colleagues [80] found that an aerobic exercise intervention demonstrated significantly *less* change over time in social well-being compared to the usual care control group.

Three studies investigated 5 interventions with a mental health component, all of which showed significant improvements in at least one area of QoL. Three of the interventions utilised individual counselling and demonstrated significant improvements in total QoL [38, 76], physical well-being [42, 76], and emotional well-being [76] compared to the control groups. Naumann and colleagues [76] also investigated group counselling, which demonstrated significant improvements in physical well-being compared to the control group. Lastly, one intervention investigated by Chang and colleagues [111] involved an e-health booklet on psychological adjustment after cancer and this intervention demonstrated significant improvements in physical well-being and social well-being compared to the control group.

In terms of mode of delivery, all interventions that demonstrated significant improvements in all QoL measures utilised face-to-face delivery [individual $n = 6$, group $n = 3$; 36, 38, 51, 76, 91, 111], with the exception of one telehealth intervention implemented by Baruth and colleagues [115], which demonstrated significant improvements in physical well-being and emotional well-being in comparison to the control group.

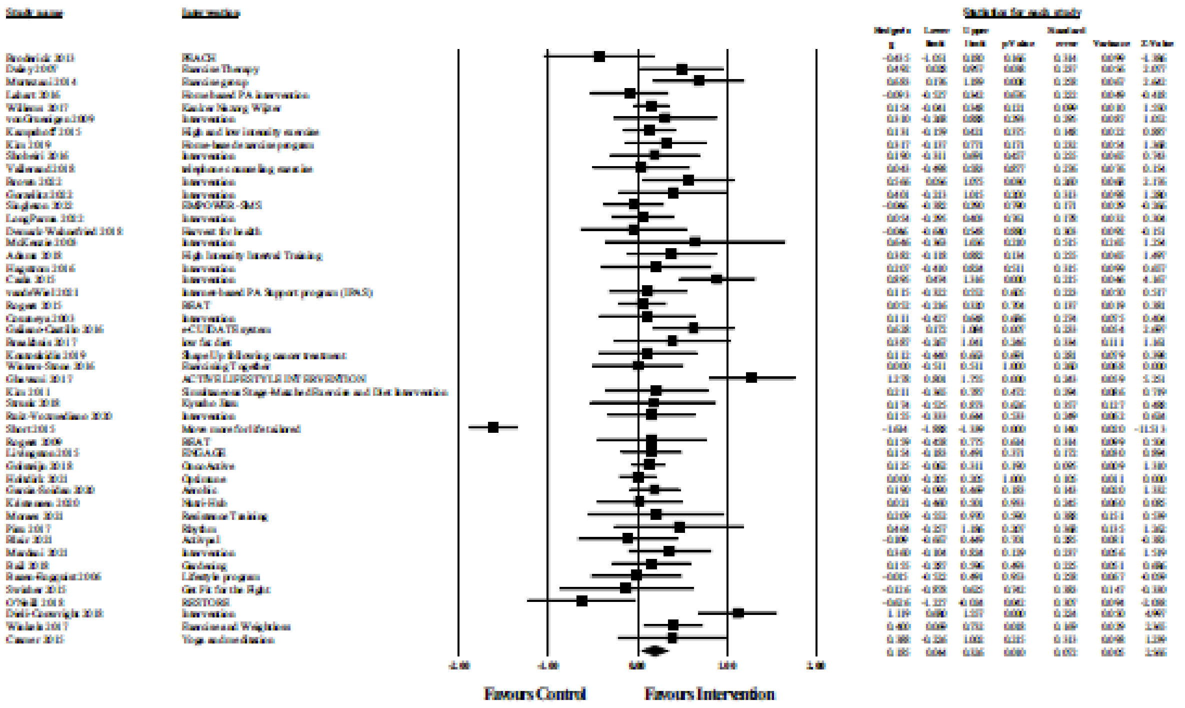

Fig. 5 Forest plot of meta-analysis of effect sizes identified for each health behaviour intervention on post intervention social well-being

Finally, with regard to duration, 17 interventions were offered over 12 weeks or less. Of these interventions, 4 (23.5%) demonstrated improvements in total Qol [36, 38, 51, 76], 7 (41.2%) demonstrated significant improvements in physical well-being [36, 42, 51, 76, 111, 115], 4 (23.5%) demonstrated significant improvements in emotional well-being [51, 76, 115], and 1 (5.8%) demonstrated significant improvements in social well-being [111] compared to the control group. Fourteen interventions were delivered over 13 weeks or more. Only 1 (7.1%) intervention demonstrated improvements in total QoL [91], 3 (21.4%) demonstrated improvements in physical well-being [59, 74, 91], and 1 (7.1%) demonstrated improvements in emotional well-being in comparison to the control group [91].

Risk of bias

The results from the risk of bias assessment are presented in Table 3 (Multimedia C) and a visual representation is provided in Fig. 6. Overall, the risk of bias was high for 55.9% of articles included in the meta-analysis. Domain 5, selection of the reported result, was the biggest contributor for risk of bias concerns, as most of the studies did not publish prespecified measurements or a data analysis plan. Consequently, only 5 studies were rated as having low risk of bias.

Publication bias

Publication bias was indicated by the Egger's regression intercept for the Total QoL outcome, 1.90, 95% CI [0.40, 3.40], $p = .01$, and the emotional well-being subscale, 1.92, 95% CI [0.09, 3.75], $p = .04$.

Discussion

This systematic review and meta-analysis updates and extends the current evidence for the use of healthy lifestyle interventions to improve the QoL in post-treatment cancer survivors. Overall, results from the meta-analysis indicate a small but significant effect in favour of healthy lifestyle interventions' positive impact on total QoL and on the dimensions of physical well-being, emotional well-being, and social well-being compared to a usual care or waitlist control. However, there was notable heterogeneity among the included studies and the majority did not find a significant effect of the intervention on all QoL outcomes. This finding was corroborated by studies included in the narrative synthesis, where out of 22 healthy lifestyle interventions examined, 17 did not differ from the usual care or waitlist control groups in each of the QoL domains. The observed

Table 1 Prespecified and post hoc subgroup analyses

Meta-analysis	*N* interventions	Sub-group (*N* interventions)	*Hedge's g* [95% CI]	Difference between sub-groups: *Q*	Heterogeneity	
					I^2	*Q*
Total QoL						
Mental health	48	Yes (12)	0.26 [0.10, 0.42]	2.05, df = 1, $p = 0.15$	43.08	19.33, df = 11, $p = .06$
		No (36)	0.41 [0.22, 0.60]		83.87	216.98, df = 35, $p < .001$
Mode of delivery	47	Individual (16)	0.65 [0.27, 1.03]	15.48, df = 5, $p = .01$*	87.42	119.27, df = 15, $p < .001$
		Group (20)	0.35 [0.14, 0.57]		71.28	66.15, df = 16, $p < .001$
		Digital (5)	0.26 [−0.02, 0.53]		79.58	19.59, df = 4, $p < .001$
		Telehealth (2)	0.14 [−0.15, 0.44]		0	0.41, df = 5, $p = 0.52^{\dagger}$
		Print (2)	−0.11 [−0.33, 0.11]		0	0.16, df = 1, $p = 0.69^{\dagger}$
		Multiple (2)	0.21 [−0.46, 0.88]		81.75	5.48, df = 1, $p = 0.02$
Duration	48	≤12 (29)	0.35 [0.18, 0.51]	0.44, df = 1, $p = 0.50$	73.88	107.18, df = 28, $p < .001$
		≥13 (19)	0.45 [0.19, 0.71]		86.01	128.68, df = 17, $p < .001$
Multicomponent	48	Yes (18)	0.50 [0.26, 0.74]	1.36, df = 1, $p = 0.24$	80.85	88.77, df = 17, $p < .001$
		No (30)	0.32 [0.14, 0.50]		79.84	143.88, df = 29, $p < .001$
Measure	43	FACT (26)	0.33 [0.16, 0.49]	0.93, df = 1, $p = 0.33$	64.44	70.30, df = 25, $p < .001$
		EORTC QLQ-C30 (17)	0.48 [0.20, 0.77]		88.92	144.39, df = 16, $p < .001$
Level of measure	48	Primary (18)	0.42 [0.21, 0.63]	0.16, df = 1, $p = 0.69$	76.63	72.73, df = 17, $p < .001$
		Secondary (30)	0.37 [0.17, 0.56]		82.00	161.07, df = 29, $p < .001$
Physical well-being						
Mental health	50	Yes (14)	0.22 [0.11, 0.34]	0.10, df = 1, $p = 0.76$	18.93	16.04, df = 13, $p = 0.25^{\dagger}$
		No (36)	0.18 [−0.06, 0.42]		90.45	366.49, df = 34, $p < .001$
Mode of delivery	49	Individual (16)	0.36 [0.03, 0.68]	15.95, df = 4, $p = 0.003$*	83.93	93.31, df = 15, $p < .001$
		Group (22)	−0.03 [−0.36, 0.31]		91.30	241.28, df = 21, $p < .001$
		Digital (6)	0.20 [−0.06, 0.46]		80.01	25.01, df = 5, $p < .001$
		Telehealth (3)	0.27 [−0.05, 0.58]		26.95	2.74, df = 2, $p = 0.26^{\dagger}$
		Print (2)	0.51 [−0.50, 1.51]		92.64	13.58, df = 1, $p < .001$
Duration	50	≤12 (27)	0.33 [0.18, 0.49]	46.73, df = 1, $p = 0.03$*	69.07	84.06, df = 26, $p < .001$
		≥13 (23)	−0.04 [−0.35, 0.26]		92.48	279.11, df = 22, $p < .001$
Multicomponent	50	Yes (23)	0.29 [0.16, 0.42]	1.87, df = 1, $p = 0.17$	52.59	46.40, df = 22 $p = .002$
		No (27)	0.07 [−0.22, 0.35]		91.96	323.57, df = 26, $p < .001$
Measure	55	FACT (17)	−0.07 [−0.52, 0.38]	3.72, df = 2, $p = 0.16$	93.44	243.93, df = 16, $p < .001$
		EORTC QLQ-C30 (16)	0.39 [0.13, 0.64]		85.67	104.71, df = 15, $p < .001$
		SF (15)	0.16 [0.01, 0.31]		32.64	20.78, df = 14, $p = 0.11^{\dagger}$
Level of measure	48	Primary (15)	0.31 [0.11, 0.52]	1.87, df = 1, $p = 0.17$	73.75	53.33, df = 14, $p < .001$
		Secondary (35)	0.10 [−0.13,0 0.33]		89.57	326.11, df = 34, $p < .001$
Emotional well-being						
Mental health	50	Yes (14)	0.10 [−0.08, 0.36]	0.93, df = 1, $p = 0.36$	60.90	34.17, df = 13, $p = .001$
		No (36)	0.23 [0.10, 0.36]		67.68	106.06, df = 5, $p < .001$
Mode of delivery	49	Individual (17)	0.30 [0.08, 0.51]	3.27, df = 4, $p = 0.51$	66.27	47.44, df = 16, $p < .001$
		Group (21)	0.12 [−0.05, 0.28]		62.71	53.63, df = 20, $p < .001$
		Digital (6)	0.08 [−0.16, 0.32]		76.24	21.05, df = 5, $p = .001$
		Telehealth (3)	0.41 [−0.17, 0.98]		75.82	8.27, df = 2, $p = .02$
		Print (2)	0.10 [−0.12, 0.32]		53.74	2.16, df = 1, $p = .14^{\dagger}$
Duration	50	≤12 (27)	0.23 [0.08, 0.39]	0.84, df = 1, $p = 0.36$	68.45	82.42, df = 26, $p < .001$
		≥13 (23)	0.14 [−0.01, 0.28]		63.25	59.87, df = 22, $p < .001$
Multicomponent	50	Yes (23)	0.21 [0.04, 0.38]	0.13, df = 1, $p = 0.72$	71.92	78.36, df = 22, $p < .001$
		No (27)	0.17 [0.04, 0.30]		59.73	64.56, df = 26, $p < .001$

Table 1 (continued)

Meta-analysis	N interventions	Sub-group (N interventions)	*Hedge's g* [95% CI]	Difference between sub-groups: Q	Heterogeneity	
					I^2	Q
Measure	49	FACT (18)	0.22 [0.06, 0.37]	0.50, df = 2, $p = 0.78$	49.11	33.40, df = 17, $p = .01$
		EORTC QLQ-C30 (16)	0.23 [0.04, 0.43]		75.61	61.51, df = 15, $p < .001$
		SF (15)	0.14 [−0.05,0.33]		55.88	31.73, df = 14, $p = .004$
Level of measure	50	Primary (14)	0.33 [0.13, 0.53]	2.89, df = 1, $p = 0.09$	71.43	45.50, df = 13, $p < .001$
		Secondary (36)	0.13 [0.004, 0.25]		63.02	94.65, df = 35, $p < .001$
Social well-being						
Mental Health	48	Yes (13)	0.07 [−0.03, 0.17]	2.01, df = 1, $p = 0.16$	0	9.80, df = 12, $p = 0.64^{\dagger}$
		No (35)	0.23 [0.03, 0.43]		85.71	237.02, df = 34, $p < .001$
Mode of delivery	48	Individual (16)	0.40 [0.18, 0.62]	7.30, df = 4, $p = 0.12$	65.20	43.11, df = 15, $p < .001$
		Group (21)	0.16 [0.04, 0.28]		26.88	6.84, df = 20, $p = .15^{\dagger}$
		Digital (6)	0.13 [−0.01, 0.26]		56.97	11.62, df = 5, $p = 0.02$
		Telehealth (3)	0.03 [−0.23, 0.28]		0	0.58, df = 2, $p = 0.75^{\dagger}$
		Print (2)	−0.63 [−2.57, 1.30]		98.06	51.46, df = 1, $p = 0.99^{\dagger}$
Duration	48	≤12 (26)	0.15 [−0.10, 0.39]	0.35, df = 1, $p = 0.56$	86.89	190.68, df = 25, $p < .001$
		≥13 (22)	0.23 [0.09, 0.36]		57.19	49.05, df = 21, $p < .001$
Multicomponent	48	Yes (22)	0.21 [0.06, 0.35]	0.13, df = 1, $p = 0.72$	59.14	51.39, df = 21, $p < .001$
		No (26)	0.16 [−0.05, 0.37]		87.98	153.14, df = 25, $p < .001$
Measure	47	FACT (17)	0.14 [−0.24, 0.51]	0.25, df = 2, $p = 0.88$	91.05	178.68, df = 16, $p < .001$
		EORTC QLQ-C30 (16)	0.22 [0.07, 0.37]		67.31	45.89, df = 15, $p < .001$
		SF (14)	0.24 [0.09, 0.39]		22.69	16.82, df = 13, $p = .21^{\dagger}$
Level of measure	48	Primary (14)	0.24 [0.13, 0.36]	0.85, df = 1, $p = 0.36$	15.20	15.33, df = 13, $p = 0.29^{\dagger}$
		Secondary (34)	0.14 [−0.06, 0.33]		85.48	227.33, df = 33, $p < .001$

*The difference between groups is $p < 0.05$

†Heterogeneity in this group is not significant

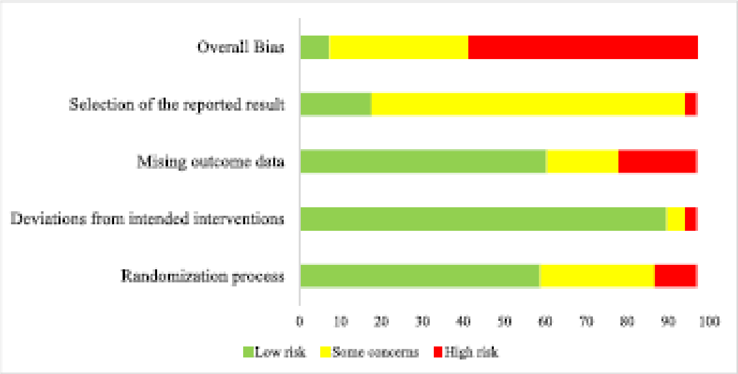

Fig. 6 Risk of bias assessment for included domains as percentages across all studies included in the meta-analysis

heterogeneity in the results aligns with the inconsistencies found in previous research on this topic.

A unique contribution of this paper was to investigate whether the association between the intervention and QoL is moderated by key intervention characteristics, primarily the inclusion of a mental health component. There was no evidence that the inclusion of a mental health component impacted the association between participation in a healthy lifestyle intervention and QoL. Consequently, there is a discrepancy between what cancer survivors request to be part of a healthy lifestyle program and support from current research on these interventions impact on QoL. A potential explanation is that improving physical well-being through physical activity and diet also addresses emotional well-being and overall QoL [117]. However, it is premature to discount the usefulness of including a mental health component, given the small number of studies which continued to display high levels of heterogeneity. Consequently, more evidence is required to appropriately answer this question. Alternatively, including a mental health component may have benefits in other areas, such as addressing barriers experienced by cancer survivors in participating in physical activity and a nutritious diet [18, 19]. Furthermore, psychosocial issues are one of the most prominent unmet needs described by cancer survivors [118] and including a component addressing these has the potential to make cancer survivors feel more supported following treatment. Therefore, future reviews might consider investigating whether including a mental health component in a healthy lifestyle intervention is associated with increased physical activity and diet outcomes or promotes more positive qualitative feedback compared to interventions which do not.

In contrast, mode of delivery and intervention duration emerged as predictors of intervention efficacy: Face-to-face delivery, either individually or in a group format, was associated with significantly higher total QoL. Individual face-to-face delivery was also associated with significantly higher physical well-being. Similarly, shorter interventions were associated with greater improvements in physical well-being. This finding aligns to some extent with the findings from a meta-analysis completed by Ferrer and colleagues [7], which investigated exercise interventions for cancer survivors and also found that intervention duration was inversely associated with QoL outcomes. However, Ferrer and colleagues found one exception to this relationship where the *intensity* of the intervention moderated outcomes, such that longer interventions (i.e. 26 weeks) with *higher* intensity exercise were associated with greater changes in QoL than shorter interventions (i.e. 8 weeks) and/or interventions with lower intensity exercise. Thus, while select longer interventions may be beneficial, collectively the weight of evidence from both prior and current meta-analyses support the implementation of short-term and face-to-face delivered healthy lifestyle interventions at the completion of cancer treatment, particularly for those looking to improve their physical well-being.

Nagpal and colleagues [119] have previously recommended that adherence is an important consideration when evaluating the efficacy of exercise interventions, due to the implications on whether participants receive the recommended 'dose.' Shorter durations and face-to-face modalities may promote greater engagement and adherence by minimising time commitments and enhancing accountability [120]. Further, interventions involving intense exercise may necessitate supervision to ensure participant safety and offer the advantage of increased accountability and tailoring. However, adherence data was not extracted in either the current study, nor the meta-analysis conducted by Ferrer and colleagues. To date, no research has directly compared the degree of adherence to shorter verses longer healthy lifestyle interventions in the cancer survivor or other relevant populations, such as older individuals or individuals with other chronic health conditions. Consequently, future primary research should consider comparing the same healthy lifestyle interventions with differing durations or delivery modalities to investigate adherence and its relationship to QoL outcomes. Future reviews should consider extracting adherence data to investigate its relationship with other intervention characteristics and outcomes. This meta-analysis provides preliminary evidence to suggest that interventions delivered via telephone or online can lead to comparable outcomes to face-to-face interventions; however, more studies are required to compare the different delivery modalities on QoL in cancer survivors.

Limitations

Although the overall meta-analysis and subgroup analyses yielded significant findings, these results should be interpreted with caution due to high levels of heterogeneity, limited power, high risk of bias, and lack of follow-up data. High levels of heterogeneity are commonly reported in meta-analyses on this topic. Notable heterogeneity continued across the pre-defined subgroup analyses, with only a reduction observed in individual subgroups, typically characterised by a low number of included studies (i.e. fewer than 10 studies). Additionally, the current meta-analysis may have limited power to detect an effect of the healthy lifestyle interventions on QoL, as less than one third of the included studies were designed to measure QoL. Consequently, the majority of the included studies may not be adequately powered to detect an effect on QoL. We attempted to address these limitations through post hoc subgroup analyses investigating multi-verse single-component interventions, whether QoL was measured as a primary or secondary outcome, and the type of outcome used, however, nil differences or reductions in heterogeneity were observed. Additionally, the validity of the results may be impacted by the quality of the studies, as the majority of them presented with a high risk of bias. Finally, as this current meta-analysis did not extract follow-up data, we are unable to evaluate whether the effects on QoL are maintained after the intervention period.

Additionally, there may be clinical factors that may moderate the efficacy of healthy lifestyle interventions on QoL in cancer survivors that were not explored in this study. A recent follow-up analysis conducted by Schleicher and colleagues [121] identified that breast cancer survivors participating the BEAT intervention who had a longer time since diagnosis (<24 months) and those who did not have a history of chemotherapy demonstrated greater increases in

QoL. Schleicher and colleagues suggested that this may be due to perceived physical functioning, as cancer survivors with a more recent diagnosis may be experiencing acute side effects from treatment, such as fatigue and nausea. This finding was particularly relevant for time since diagnosis, as those who were more than 24 months post treatment were also more likely to engage in more moderate and vigorous physical activity post treatment. Future systematic reviews and meta-analyses should consider extracting data on time since diagnosis and treatment type to explore these as potential moderating factors.

Conclusion

Overall, the current meta-analysis suggests that participating in any healthy lifestyle intervention following cancer treatment is likely to have positive benefits on QoL. Interventions which are delivered face-to-face or over a shorter duration may have a greater impact on the efficacy of such interventions; however, only a few randomised control trials have investigated alternative delivery modalities, such as digital or telehealth. Furthermore, few randomised control trials have specifically investigated the inclusion of a mental health component to healthy lifestyle interventions. Consequently, there is a need for future research to develop and rigorously evaluate healthy lifestyle interventions which also address mental health and utilise alternative delivery modalities.

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Declarations

Conflict of interest The authors declare no competing interests.

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Appendix B

Chapter 2 search terms

Scopus

(TITLE-ABS ((cancer* OR tumor* OR tumour* OR neoplas* OR malignan* OR carcinoma* OR adenocarcinoma* OR choriocarcinoma* OR leukemia* OR leukaemia* OR metastat* OR sarcoma* OR teratoma*) AND (survivor* OR survival)) AND TITLE-ABS (("healthy lifestyle" OR "healthy living" OR lifestyle OR behavio?r OR "lifestyle changes" OR "health behavio?r" OR sedentary*) OR ("Physical activity" OR pa OR exercise OR "active living" OR "activity level" OR "physical fitness" OR "physical endurance") OR (nutrition* OR diet* OR food* OR "food intake") OR (weight* OR "weight control" OR "body weight" OR "weight loss" OR "weight management" OR "body mass index" OR bmi)) AND TITLE-ABS (random* OR rct OR "clinical trial*" OR trial* OR intervention OR program OR therapy) AND ALL ("quality of life*" OR qol OR "health related quality of life" OR "health-related quality of life" OR hrqol) AND NOT INDEX (medline))

Medline

1. exp neoplasms/

2. (cancer* or tumor* or tumour* or neoplas* or malignan* or carcinoma* or adenocarcinoma* or choriocarcinoma* or leukemia* or leukaemia* or metastat* or sarcoma* or teratoma*).ab,ti.

3. 1 or 2

4. exp survivors/ or exp cancer survivor/

5. (survivor* or survival).ab,ti.

6. 4 or 5

7. 3 and 6

8. life style/ or health behavior/ or Sedentary Behavior/

9. (health* or lifestyle* or "life style*" or behavio?r or "active living" or "health behavio?r" or sedentary*).ab,ti.

10. exp exercise/ or exp physical fitness/ or physical endurance/ or exp walking/ or resistance training/

11. ("Physical activity" or PA or exercise or "active living" or "activity level" or "physical fitness" or "physical endurance" or strength* or walk* or "resistance training" or aerobic*).ab,ti.

12. nutritional assessment/ or nutritional status/ or diets/ or food/

13. (nutrition* or diet* or food*).ab,ti.

14. body weight/ or weight loss/ or body mass index/

15. (weight* or "body weight" or "weight loss" or "weight management" or "weight control" or "body mass index" or BMI).ab,ti.

16. or/8-15

17. exp Randomized Controlled Trial/ or random allocation/

18. (random* or RCT or trial* or "clinical trial" or intervention or program or therapy).ab,ti.

19. 17 or 18

20. exp "Quality of Life"/

21. ("quality of life*" or QoL or QOL or "health related quality of life" or "health-related quality of life" or HRQoL or HRQOL).tw,kw.

22. 20 or 21

23. 7 and 16 and 19 and 22

24. limit 23 to humans

PsycINFO

1. exp neoplasms/

2. (cancer* or tumor* or tumour* or neoplas* or malignan* or carcinoma* or adenocarcinoma* or choriocarcinoma* or leukemia* or leukaemia* or metastat* or sarcoma* or teratoma*).ab,ti.

3. 1 or 2

4. exp survivors/

5. (survivor* or survival).ab,ti.

6. 4 or 5

7. 3 and 6

8. lifestyle/ or active living/ or lifestyle changes/ or health behavior/ or sedentary behavior/

9. ("healthy lifestyle" or "healthy living" or lifestyle* or "life style*" or “active living” or "lifestyle changes" or "health behavio?r" or sedentary*).ab,ti.

10. exp physical activity/ or exp exercise/ or active living/ or activity level/ or exp physical fitness/ or physical endurance/ or walking/ or physical strength/ or exp aerobic exercise/

11. ("Physical activity" or PA or exercise or "active living" or "activity level" or "physical fitness" or "physical endurance" or strength* or walk* or "resistance training" or aerobic*).ab,ti.

12. nutrition/ or diets/ or food intake/ or food/

13. (nutrition* or diet* or food* or "food intake").ab,ti.

14. weight control/ or body weight/ or weight loss/ or body mass index/

15. (weight* or "weight control" or "body weight" or "weight loss" or "weight management" or "body mass index" or BMI).ab,ti.

16. or/8-15

17. exp Intervention/

18. (random* or RCT or trial* or intervention or program or therapy).ab,ti.

19. 17 or 18

20. 7 and 16 and 19

21. exp "Quality of Life"/

22. ("quality of life*" or QoL or QOL or "health related quality of life" or "health-related quality of life" or HRQoL or HRQOL).tw,id.

23. 20 and 22

CINHAL

S1 (MH "Neoplasms+")

S2 TI (cancer* OR tumor* OR tumour* OR neoplas* OR malignan* OR carcinoma* OR adenocarcinoma* OR choriocarcinoma* OR leukemia* OR leukaemia* OR metastat* OR sarcoma* OR teratoma*) OR AB (cancer* or tumor* or tumour* OR neoplas* OR malignan* OR carcinoma* OR adenocarcinoma* OR choriocarcinoma* OR leukemia* OR leukaemia* OR metastat* OR sarcoma* OR teratoma*)

S3 (MH "Survivors+") OR (MH "Cancer Survivors")

S4 TI(survivor* OR survival OR survivorship) OR AB(survivor* OR survival OR survivorship)

S5 S1 OR S2

S6 S3 OR S4

S7 S5 AND S6

S8 (MH "Life Style Changes") OR (MH "Life Style+") OR (MH "Behavioral Changes") OR (MH "Life Style, Sedentary+")

S9 TI("healthy lifestyle" OR "healthy living" OR lifestyle OR active living OR "lifestyle changes" OR "health behavio?r" OR sedentary*) OR AB("healthy lifestyle" OR "healthy living" OR lifestyle OR active living OR "lifestyle changes" OR "health behavio?r" OR sedentary*)

S10 (MH "Exercise+") OR (MH "Physical Activity+") OR (MH "Physical Fitness") OR (MH "Aerobic Exercise+") OR (MH "Resistance Training")

S11 TI("Physical activity" OR PA OR exercise OR "active living" OR "activity level" OR "physical fitness" OR "physical endurance" OR strength* OR walk* OR "resistance training" OR aerobic*) OR AB("Physical activity" OR PA OR exercise OR "active living" OR "activity level" OR "physical fitness" OR "physical endurance" OR strength* OR walk* OR "resistance training" OR aerobic*)

S12 (MH "Nutrition+") OR (MH "Nutritive Value+") OR (MH "Food Intake+")

S13 TI(nutrition* OR diet* OR food* OR "food intake") OR AB(nutrition* OR diet* OR food* OR "food intake")

S14 (MH "Weight Reduction Programs") OR (MH "Body Weights and Measures+") OR (MH "Body Weight Changes+") OR (MH "Body Weight+") OR (MH "Weight Control") OR (MH "Weight Loss") or (MH "Body Mass Index")

S15 TI(weight* OR "weight control" OR "body weight" OR "weight loss" OR "weight management" OR "body mass index" OR BMI) OR AB(weight* OR "weight control" OR "body weight" OR "weight loss" OR "weight management" OR "body mass index" OR BMI)

S16 S8 OR S9 OR S10 OR S11 OR S12 OR S13 OR S14 OR S15

S17 (MH "Randomized Controlled Trials+") OR (MH "Clinical Trials+")

S18 TI(random* OR RCT OR trial* OR "clinical trial" OR intervention OR program OR therapy) OR AB(random* OR RCT OR trial* OR "clinical trial" OR intervention OR program OR therapy)

S19 S17 OR S18

S20 S7 AND S16 AND S19

S21 (MH "Quality of Life+")

S22 TW("quality of life" or QoL or QOL or "health related quality of life" or "health-related quality of life" or HRQoL or HRQOL)

S23 S21 OR S22

S24 S20 AND S23

Google scholar

(Cancer survivor) AND (health* OR lifestyle*) OR ("physical activity" OR exercise OR training) OR (diet OR nutrition OR food) OR (weight or body) AND (random* OR trial* OR intervention OR program) AND (“quality of life”)

Appendix C

Risk of bias assessment of studies included in the Chapter 2

Study	Randomization process	Deviations from intended interventions	Missing outcome data	Selection of the reported result	Overall
Broderick 2013	-	+	!	!	-
Daley 2007	+	+	+	!	!
Ohira 2006	+	+	+	!	!
Murtezani 2014	-	+	-	!	-
MCNEIL 2019	!	+	+	!	-
Toohey 2018	+	+	!	!	-
Fillion 2008	+	+	+	!	!
Lahart 2016	+	+	+	!	!
Park 2015	+	+	+	!	!
Willems 2017	+	+	+	!	!
Von Gruenigen 2009	!	+	+	-	-
Winkels 2017	!	+	-	+	-
Kampshoff 2015	+	+	+	!	!

Study	Randomization process	Deviations from intended interventions	Missing outcome data	Selection of the reported result	Overall
Kim 2019	!	+	!	!	-
Shobeiri 2016	!	+	!	!	-
Brown 2022	+	!	!	+	-
Wang 2021	+	+	+	!	!
Gorzelitz 2022	!	+	+	!	-
Singleton 2022	+	+	+	+	+
Reeves 2021	+	+	+	+	+
LongParma 2022	+	+	-	!	-
Demark-Wahnefried 2018	!	+	+	!	-
MuleroPortela 2008	-	+	-	!	-
McKenzie 2003	!	+	+	!	-
Scott 2013	+	+	+	!	!
Hagstrom 2016	+	+	-	!	-
Casla 2015	+	+	+	!	!
VandeWiel 2021	+	+	-	+	-

Study	Randomization process	Deviations from intended interventions	Missing outcome data	Selection of the reported result	Overall
Rogers 2015	+	+	+	!	!
Galiano-Castillo 2016	+	+	-	!	-
Bourke 2011	!	+	+	!	-
Braakhuis 2017	!	+	-	!	-
Koutoukidis 2019	+	+	-	+	-
Winters-Stone 2016	+	+	+	!	!
Ghavami 2017	-	+	+	!	-
Vallance 2020	+	+	+	!	!
Kim 2011	-	+	!	!	-
Strunk 2018	!	+	-	!	-
Koutoukidis 2020	+	-	+	-	-
Ruiz-Vozmediano 2020	+	+	!	!	-
Short 2015	+	+	+	!	!
Rogers 2009	+	+	+	!	!
Livingston 2015	-	+	+	+	-

Study	Randomization process	Deviations from intended interventions	Missing outcome data	Selection of the reported result	Overall
Golsteijn 2018	+	+	+	!	!
Holtdirk 2021	+	+	!	+	!
Garcia-Soidan 2020	+	+	+	!	!
Ho 2020	+	+	+	+	+
Kristensen 2020	+	!	+	+	!
Moraes 2021	+	+	+	!	!
Pisu 2017	!	+	+	!	-
Blair 2021	+	+	+	!	!
Mardani 2021	+	+	!	!	-
McGowan 2013	-	+	!	!	-
Reeves 2017	+	+	!	!	-
Burnham 2002	!	-	-	!	-
Littman 2012	!	+	+	!	-
Bail 2018	+	+	+	+	+
Basen-Engquist 2006	!	+	-	!	-

Study	Randomization process	Deviations from intended interventions	Missing outcome data	Selection of the reported result	Overall
Swisher 2015	+	+	!	!	-
Cramer 2015	+	+	+	!	!
Naumann 2012	!	+	+	!	-
Culos-Reed 2010	!	+	-	!	-
Culos-Reed 2006	!	!	+	!	-
DeLuca 2016	!	+	+	!	-
O'Neill 2018	+	+	+	!	!
Dieli-Conwright 2018	+	+	+	+	+

+	indicates low risk of bias
!	indicates some concerns about risk of bias
-	indicates high risk of bias

Appendix D

Chapter 3 published study

Material from: LESKE, M., KOCZWARA, B., BLUNT, J., MORRIS, J., EAKIN, E., SHORT, C.E., DALY, A., DEGNER, J. & BEATTY, L., MORRIS, J., & BEATTY, L, CO-DESIGNING HEALTHY LIVING AFTER CANCER ONLINE: AN ONLINE NUTRITION, PHYSICAL ACTIVITY, AND PSYCHOSOCIAL INTERVENTION FOR POST-TREATMENT CANCER SURVIVORS, JOURNAL OF CANCER SURVIVORSHIP, published 2024, Springer Nature

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Co-designing Healthy Living after Cancer Online: an online nutrition, physical activity, and psychosocial intervention for post-treatment cancer survivors

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Abstract

Purpose The aim of the present study was to co-design Healthy Living after Cancer *Online* (HLaC *Online*), an online intervention supporting cancer survivors to set and meet their healthy living goals.

Methods Adapted from an initial telephone-delivered Healthy Living after Cancer program, wireframes (PDF black and white mock-ups) of the proposed online program were presented in a series of focus groups and interviews to our stakeholder group, which consisted of cancer survivors, oncology healthcare professionals, and representatives from cancer support organisations. Stakeholders were prompted for feedback on the wireframe and given end-user scenarios to encourage deeper engagement with the co-design process. Transcriptions underwent thematic analysis to determine which features of the program needed change or expansion.

Results 27 participants took part in one of 8 focus groups or 10 interviews. Five themes were identified relating to (a) website design elements, (b) promoting and maintaining long-term engagement, (c) relatability and relevance, (d) navigating professional support, and (e) family and peer support. Recommended changes, such as simple activities and guidance videos, were integrated into the HLaC *Online* prototype.

Conclusions Involving end-users in the co-design process ensured the intervention's relevance and specificity to the needs of cancer survivors. Next steps include feasibility testing the prototype, prior to commencing a national randomised control trial of HLaC *Online*.

Implications for Cancer Survivors HLaC *Online* aims to support cancer survivors to improve their quality of life by making healthy lifestyle changes in their physical activity, healthy eating, weight management, mental health, and fatigue management.

Keywords Cancer survivors · Lifestyle intervention · Co-design · Digital intervention

Engaging in a healthy lifestyle after cancer, including regular physical activity and adequate nutrition, can reduce the risk of mortality, cancer recurrence [1–3], and comorbidities [4]. Further, healthy lifestyle behaviours have been shown to mitigate some of the challenging impacts of cancer and its associated treatments, including improving cancer-related fatigue [5] and reducing psychological distress [6]. Despite these benefits, many Australian cancer survivors are not

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meeting the healthy lifestyle recommendations outlined by national cancer support organisations [7, 8]. A report from Tollosa et al. [9] using data from the Australian Longitudinal Study on Women's Health showed that 41%, 36%, and 85.1% of female cancer survivors were not engaging in the health recommendations for physical activity, fruit intake, and vegetable intake, respectively. More recently, Elder-Robinson et al. [10] investigated health behaviours of Australian cancer survivors in rural and remote areas, demonstrating that up to 27% had reduced their fruit and vegetable intake and 70% had reduced their physical activity since their cancer diagnosis.

Face-to-face interventions have demonstrated efficacy in improving health behaviours; however, these interventions are not routinely implemented in clinical care at the completion of cancer treatment [11]. This evidence-practice gap has emerged due to implementation barriers experienced at the three levels of cancer survivorship care: (1) organisational level barriers, such as the cost and lack of reimbursement for delivering interventions, no established pathways for managing referrals and follow-ups, and absence of specialised staff to deliver the intervention; (2) provider level barriers, including limited time, competing priorities, not aware of existing programs, and not self-identifying as the right person to provide advice; and (3) consumer-level barriers, such as lack of guidance and support, not understanding the benefits of participating in health programs, low engagement in interventions due to competing priorities, and/or high levels of fatigue [12–15]. Cancer survivors who live in rural and remote areas of Australia experience additional accessibility barriers, imposed by the time and financial costs of travel [16]. Finally, the ongoing social distancing restrictions associated with the COVID-19 pandemic have reduced practitioners' ability to address health concerns and behaviours in face-to-face appointments [17]. These barriers highlight the importance of utilising cost-effective and accessible delivery modalities to increase the reach and availability of health interventions.

The telephone has previously be investigated as an accessible and acceptable modality for health interventions [18]. One such Australian intervention was the 6-month telephone-delivered program Healthy Living after Cancer [19]. The intervention targeted goal setting, physical activity, nutrition, weight loss, and behavioural maintenance strategies. Healthy Living after Cancer was delivered in several states by Cancer Council, an Australian not-for-profit cancer support organisation, using their existing telephone support infrastructure. While the program yielded significant clinical benefits to participants, including improvements in physical activity, dietary behaviours, physical quality of life, and cancer-related symptoms, sustainability barriers were encountered [19].The intervention was resource intensive, and Cancer Councils were unable to continue providing the program after the trial ceased. Furthermore, feedback from participants suggested that while many were satisfied with the telephone delivery, it did not suit all users' preferences. Some participants experienced challenges specific to the telephone delivery, including difficulties scheduling calls, feeling rushed, and a decrease in motivation when calls shifted from weekly to monthly delivery as per intervention protocol [20]. Therefore, other delivery modalities needed to be explored to improve sustainability of the program.

Digital health modalities, including patient portals, online support tools, and mobile applications, have emerged as a cost-effective and accessible way to deliver health-related services [21, 22]. Digital health modalities enable participants to self-tailor their information access and can integrate dynamic elements to support users to establish and achieve their health-related goals [23]. Adapting the Healthy Living after Cancer intervention into a digital health modality therefore has the potential to enhance the program's reach, flexibility, scalability, and long-term sustainability.

While approximately twenty English digital health interventions have been developed to address health behaviours in cancer survivors in the last decade [16, 24–27], none have previously utilised a co-design process. Co-design involves end-users at each stage of intervention development, resulting in an intervention that is both sensitive to consumer's specific needs and preferences and follows best-practice principles for consumer-led development of interventions [28, 29]. The Healthy Living after Cancer *Online* (HLaC *Online*) research team commenced the co-design process with a group of stakeholders to adapt the program iteratively from its telephone-delivered format using a five-phase Design Thinking Research Process, comprised of empathising, defining, ideating, prototyping, and testing [30]. The first round of stakeholder engagement addressed the first two phases (emphasising and defining). This round of stakeholder engagement [31] found that the HLaC *Online* program should target not only physical activity, healthy eating, and weight management, but also offer support for mental health, fatigue management, and peer support. Additionally, stakeholders reported that the intervention should offer a flexible format and long-term accessibility.

The present study aimed to conduct the third and fourth phase of the co-design process—ideate and prototype—through a second round of stakeholder engagement. This round involved presenting and receiving feedback on a wireframe, that is, a visual guide representing a skeletal framework containing all the proposed content of HLaC *Online*. Wireframes are an established methodology for ideating and prototyping interventions and have been used in the co-design of digital health interventions for people with cancer [32], knee osteoarthritis [33], and heart failure [30]. Specifically, the second round of stakeholder engagement sought to clarify cancer survivor's needs for healthy living guidance and support, whether these needs would be met by the new program, identify potential barriers for program engagement, and develop strategies to best support users.

Methods

Participants

Participants were recruited through two sources. First, stakeholders from the first round of engagement [31] were invited to return for the second round of stakeholder engagement. These participants included Australian cancer survivors, oncology healthcare professionals, and non-government organisation cancer support representatives. Second, additional participants were identified and invited through snowball sampling of the stakeholder participants' networks. Reasons for not returning for the second round of stakeholder engagement for cancer survivors included no longer being interested ($n=4$), engagement not occurring at a good time ($n=1$), or personal reasons ($n=1$). Three cancer survivors did not respond to contact. Reasons for not returning for healthcare professionals and cancer support representatives included no longer being interested ($n=2$), no longer working in cancer ($n=1$), or cancelling after focus group was rescheduled ($n=1$).

Wireframe

The wireframe of HLaC *Online* was developed based on the telephone-delivered Healthy Living after Cancer program [19] and the findings from the first round of co-design [31] (see Online Resource 1). The wireframe comprised nine modules, including five from the original telephone-delivered program (goal setting, physical activity, healthy eating, maintaining a healthy weight, staying on track) and four newly developed modules (mental health, fatigue management, finding the new normal, and peer support). Each module consisted of psychoeducation, activities based on the Social Cognitive Theory [34] constructs of self-efficacy, outcomes expectancies, and social support (e.g., goal setting, self-monitoring, problem solving, self-reward, and social support), and links to reputable resources (e.g., non-governmental cancer support organisations websites, such as Cancer Council Australia). The mental health module included activities based on cognitive behavioural therapy (e.g., thought records, and identifying and challenging unhelpful thoughts) and mindfulness relaxation. Finally, the finding of the new normal and the peer support modules included survivor testimonial videos.

Data collection

All stakeholders completed informed consent before participating. Focus groups ($M=87$ min, $SD=24$) and interviews ($M=72$ min, $SD=10$) were conducted between October and December 2020. Due to ongoing social distancing requirements of COVID-19 restrictions, stakeholders participated either via small face-to-face focus groups ($n=2$–3 per group), an online focus group, or interview held on a secure videoconferencing platform, Webex. Two cancer survivor stakeholders were interviewed via telephone due to internet difficulties. Stakeholders were provided with a summary of key findings from the first round of stakeholder engagement and presented with the HLaC *Online* wireframe.

Stakeholders were invited to provide feedback on the new content, along with one of the original modules from the telephone-delivered Healthy Living after Cancer, which was randomly selected for each focus group and interview. A semi-structured topic guide was utilised to facilitate feedback (see Online Resource 2), along with a persona task to facilitate discussion about how potential users might use the program and how they could best be supported. This task involved the stakeholders developing a hypothetical user of the program and included a description of their name, age, gender, cancer diagnosis, and healthy living goals (see Online Resource 3 for an example).

Data analysis

Audio recordings from the focus groups and interviews were transcribed verbatim. Transcriptions underwent inductive thematic analysis using the qualitative data analysis software, NVivo 12. Inductive thematic analysis was chosen to determine which features of the program should be considered for change or expansion based on the stakeholder's feedback. Two authors (ML, JB) independently undertook thematic analysis on a subset of the transcripts ($n=8$) to develop a preliminary coding framework. The coding framework was refined through discussion with authors with extensive qualitative research experience (BK and LB) to finalise and diagram the themes and subthemes. The final coding framework was then used to analyse all transcripts by a single author (ML).

Results

Participants

A total of 29 stakeholders (14 cancer survivors, 13 healthcare professionals, and 2 cancer support representatives) participated in one of seven focus groups or nine interviews, resulting in 16 transcripts. This equated to 71% of our original stakeholder group continuing their involvement from Round 1, along with one additional healthcare professional and one cancer support representative.

The majority of cancer survivors were female ($n = 8$, 57.1%) and aged between 44 and 81 years ($M = 61$, $SD = 12.17$). The most common cancer diagnosis was breast cancer ($n = 6$, 42.9%), followed by prostate cancer ($n = 3$, 21.4%), rectal cancer ($n = 2$, 14.3%), cervical cancer ($n = 1$, 7.1%), and Hodgkin's lymphoma ($n = 1$, 7.1%).

Most healthcare professionals were nurses ($n = 7$, 53.8%) but included medical oncologists ($n = 2$, 15.4%), a clinical psychologist ($n = 1$, 7.7%), and a physiotherapist ($n = 1$, 7.7%). Cancer support representatives included a support group representative and a representative from Cancer Council SA's support services.

Overview of themes and subthemes

A total of 5 themes and 16 subthemes emerged from the thematic analysis. Overall, the wireframe received positive feedback from participants. All participants agreed that the program addressed key concerns of cancer survivors and praised the addition of modules based on their previous feedback. Five themes emerged relating to (a) website design elements, (b) promoting and maintaining long term engagement, (c) relatability and relevance, (d) navigating professional support, and (e) family and peer support (see Fig. 1).

Theme 1: website design elements

As Fig. 1 shows, this theme related to how the web-program will be designed to increase accessibility, usability, and the ability to self-tailor the program.

Accessibility

One key subtheme to emerge was that HLaC *Online* must be developed in a way that ensures it is *accessible* to the diverse cancer survivor population. All stakeholder groups strongly endorsed that the program should be designed in a way to accommodate different devices and levels of digital literacy. Cancer survivors more frequently endorsed the use of different language settings so that the program is accessible to those for whom English is their second language.

> *"I come from basically Pakistan, and I speak another language. So, it would be good, when you're living here if you can find somebody who can speak your language also. If you can't speak English, which is, you know, if you're just alone by yourself and it's all English and you do not have the information… that would be a good idea to put in other languages, or to show that everybody's included"* (CS03).

In comparison, the healthcare professionals frequently highlighted that any suggested healthy lifestyle changes, such as the type of exercise, must be accessible to users with limited resources. This was especially important when

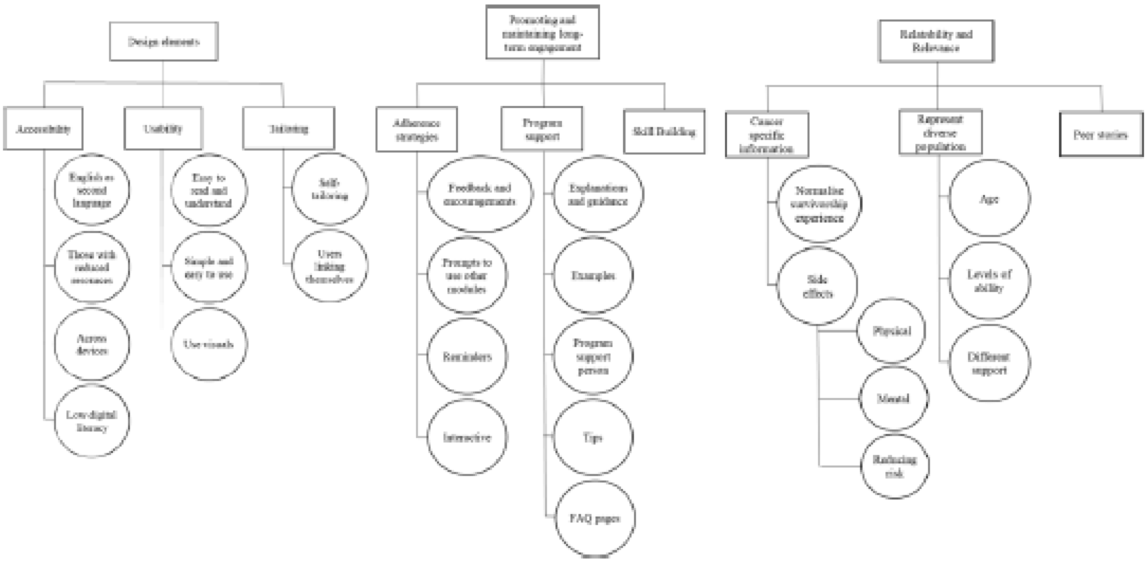

Fig. 1 Stakeholder themes from second round of co-design

considering potential users who live in rural and remote communities.

> *"With the aerobic work, a lot of people only really have walking as their accessible option because they can't get to a pool, they're not into jogging, and they can't ride a bike. So, I think you need to sort of perhaps, particularly focus on the walking side of aerobic because that is the again that was easily accessible for the majority of people"* (HCP06).

Usability

It was important to stakeholders that HLaC *Online* is *user friendly*; the website must be simple to use and easy to navigate, and information provided both easy to read and understand. Stakeholders promoted the use of visuals, such as videos, images, and diagrams, to reduce the reading burden on users.

> *"The most important resource would be actual patient experience, you know. Short videos is what I would sort of you know would recommended given this, the nature of the situation as well as how technology is taken over. To reading through lots, through lots and lots of text, I don't think they have much of an uptake overall"* (HCP05).

The wireframe received mixed feedback as to whether these needs were met. Overall, the stakeholders thought the program appeared easy to use; however, some activities may have been too complex for a self-guided program. One common piece of feedback from all groups was the need to simplify the thought record, where users can record and challenge their thoughts.

> *"I just wonder if it's too complicated. I think the mindfulness, I think is something that people can engage in quite easily. And this to me, like I get it, but I'm wondering how many people will engage in it or it'll just be a bit too complicated"* (HCP02).

Self-tailor

It was important to all stakeholder groups that HLaC *Online* offer users the ability to self-tailor the information, such that they can choose when and how they access the information and complete activities.

> *"It's fine because I think if think people will just read it, look at it and read it and choose the one that pertains to them at that time. And for some people, fatigue management might be first and for someone else it might be exercise. So, just have them all and then people will do what they want to do anyway"* (HCP11).

Cancer survivors more frequently suggested that the program be designed in a way that users could print and complete activities by hand. This was only mentioned once in the healthcare professional group and was not mentioned by cancer support representatives.

> *"Those might be something that we can look at where they can download the page for instance because some people are writers too. Some people are, not a lot of us are keyboard warriors and a lot of people enjoy writing on something instead of a keyboard"* (CS11).

Theme 2: promoting and maintaining long-term adherence

This theme related to feedback about how to engage users and maintain long-term adherence to the program and health behaviour changes.

All groups frequently endorsed the use of strategies to increase the adherence and usage of the program. During the persona task, a common description of a potential user was someone who is initially very engaged with the program and making healthy changes; however, this behaviour would gradually taper off. For example:

> *"He initially he would be in it for a number of weeks and then he has to be obviously encouraged to continue it. And that's probably where he might get off track. But, you know, in the initial stage, you'll probably be all gung ho about it. But in the weeks down the track he might get a bit blasé, or anything are not happening quick enough at all certainly falls into a trap. Getting into the junk food again"* (CS01).

Common recommendations to address these issues and increase engagement included using adherence strategies, promoting skill building, and providing program support. Each of these is outlined in detail below.

Adherence strategies

A variety of strategies to increase engagement and adherence with the program were suggested, including feeding back previously input information into later activities, encouragements throughout the program, prompts to use other areas of the program, interactive elements (e.g., activities, videos, audio files, and animations), and reminders to use the program. For example:

> *"Do they get the results of their trackers? Would that be included in the email? So, you've done so many steps. You know, we encourage great work. We encourage you to do and more or loss this much weight. So, it's like data being fed back to them as well as encouragement to keep going"* (HCP04).

There was mixed feedback for the frequency of reminders to use HLaC *Online*. However, the majority of stakeholders agreed that participants should be engaging with the program at least once a week, and reminders should be sent accordingly. One cancer survivor and one healthcare professional suggested this could be tailored, with the user able to determine the frequency of reminders.

Program support

All stakeholder groups suggested some level of guidance on *how* to use the program, although this was more frequently endorsed by cancer survivors. Cancer survivors' most frequently suggested form of guidance involved having a person to discuss the content with, either via regular phone calls or someone to contact when they require assistance.

> *"You could have regular phone calls from a cancer council nurse. Or text messaging service that help him. See how he's doing with his goals and helping sort of just keep him a bit motivated"* (CS07).

> *"I think it's pretty comprehensive and easy to use, but maybe if there was sort of a, I don't know, if someone you could contact, send an email, or ring or whatever so if you got any further questions or they want some more information that isn't there"* (CS14).

Other frequent suggestions included providing other forms of program support, such as guidance videos introducing each module, the use of pre-completed examples, and tips on how to apply the skills learnt in participants' daily lives. Two cancer survivor groups suggested a frequently asked question page, which was not mentioned by healthcare professionals or cancer support representatives.

Skill building

One element of the program praised by stakeholders was the inclusion of activities that build skills to help the user make lifestyle changes, rather than only providing information about what changes are required. All groups identified that this is especially helpful for developing mental health strategies (e.g., the mindfulness meditations and the thought record).

> *"You've got the resources there and those mindfulness meditations if they are no longer than about, you know, three to four minutes then that's ideal. Especially for people that start doing it"* (CS07).

Theme 3: relatability and relevance

Stakeholders emphasised that HLaC *Online* should normalise the after-treatment experience by including cancer-specific information and representative images of the diverse cancer survivor population.

Cancer-specific information

One concern frequently emphasised by all groups was ensuring that the program would be relatable and relevant to cancer survivors. It was important that the information and examples used within the program are cancer-specific.

> *"So, perhaps this section might just need to be a bit more impactful for people with cancer. Perhaps a little bit less. I mean there's some good things in there but maybe a bit more to kind of really connect it to a person with cancer what their experiences are"* (NGO02).

The need to normalise the survivorship experience was frequently identified by all stakeholder groups. Cancer survivors often discussed their own experience completing treatment and the emotional impact of no longer seeing oncology healthcare professionals as frequently, as well as the expectations from friends and family to quickly return to normal. All stakeholder groups felt strongly that this 'new normal' needed to be captured within the program.

Moreover, healthcare professionals more frequently identified the need for the program to include more education about the mental and physical impact of cancer and it's associated treatment.

> *"…I think it probably should be picked up somewhere in the program to acknowledge the side effects, the impact of the side effects and how to try to rectify them, or how to, yeah, work through them"* (HCP08).

Finally, all stakeholders endorsed including information about the benefits of engaging in a healthy lifestyle, particularly around reducing the risk of cancer- and treatment-related side effects.

> *"And just, I guess educating them on what good choices are, what benefits do you get from eating this sort of food, rather than don't have this because it's bad for you. Everyone knows that. It's everywhere. You don't need that… They are going to be thinking what can I be eating that's gonna stop me from getting cancer again"* (HCP02).

Represent a diverse population

The stakeholders advocated that HLaC *Online* should include images that represent the diverse cancer survivor population, including representing the variety in age, gender, ethnicity, and levels of ability and fitness.

> *"Yeah, so making maybe one of the start points or one of the picture representations a little bit more relatable to some of the people who aren't very fit"* (HCP04).

Peer stories

Stakeholders reported it would be beneficial to include peer stories within the program. Short videos of peer stories were included in the wireframe in finding the new normal and the peer support modules. However, stakeholders suggested adding a peer support video into each of the main sections, so that users can relate to someone who has been through a similar experience and how they made changes to achieve a healthy lifestyle.

> *"The videos with actual people telling their experiences, I think that is probably have the maximum impact. And because people will listen rather than kind of wade through loads and loads of text"* (HCP06).

> *"People have, you know, someone to relate to. They sort of be like oh wow I went through that as well"* (CS14).

Theme 4: navigating professional support

Navigating professional support covered the feedback relating to information about professional support access and providing links to additional resources.

Accessing professional support

All stakeholders emphasised the need for further information about professional support that is available to cancer survivors. Specifically, they suggested that information about how to access relevant health professionals and services was an important inclusion for each of the modules. This was particularly relevant to cancer survivors, who discussed their own experiences finding a mental health professional.

> *"I mean I've found talking to my GP, he had trouble finding somebody that kind of. I mean I specifically wanted to try and talk someone that, you know, dealt with people that had cancer and could relate to a lot of the things. So, for me, I mean, it would be great if there was something very specific in there, you know, give me a guess a list of practitioners that dealt with that"* (CS04).

Further, the cancer survivor group were interested in providing more information about other supportive services and organisations, particularly in the areas of mental health.

> *"And you have some links too for people [to] expand on if they need to. You know beyond blue or, you know, Black dog institute or whatever. So, having those numbers there and Lifeline all that. You know, having that there as backup underneath all of all of this stuff for people that are having dark thoughts"* (CS07).

Additional resources

The stakeholder groups suggested embedding links to credible information. Cancer survivors in particular emphasised that this program should be viewed as a starting point for healthy lifestyle change, and it should provide links to additional resources or mobile applications for users who wish to continue exploring ideas introduced in the program.

> *"Look at what the Cancer Councils already got and put some links in to those resources would be really good idea to be supportive rather than reinvent the wheel"* (HCP08).

Theme 5: peer and family support

The peer and family support theme encompassed (a) the stakeholders' need to involve families in the program, both as a supporter of the cancer survivor and as individuals in need of support themselves and (b) to incorporate other various forms of peer support into the program.

Family support

Offering support for families within the program was strongly identified as a need by the healthcare professionals and cancer support representatives. They recommended providing support either via the cancer survivors' user portal or by offering family members the opportunity to also sign up to use the program.

> *"What about the carers and what about the family members? They would really benefit from this. If you can click it can go, I'm the parent I'm the patient slash I'm the carer. Because, if the carer can do this and understand their emotions, often a patient and carer or patient and loved one that are looking at one another for support"* (HCP03).

Peer support

Providing multiple avenues for peer support in the program was frequently identified by cancer survivors.

> *"Because we all have different ways of looking for peer support. Some are one-on-one, some people like face-to-face support groups or can do it online, or sort of being online anonymously, you know, not like you and I, but where they can just use the discussion board.*

> *So, there's a real wide variety of how people connect with a peer support group"* (CS11).

Cancer survivors provided recommendations for users to access peer support, often based on their own experiences of the peer support that they found helpful. These recommendations included face-to-face support (e.g., support groups) and Facebook groups. Healthcare professionals and cancer support representatives more frequently recommended peer support services offered by their organisations, such as Cancer Connect (a free telephone peer support service offered by various Cancer Councils).

Discussion

This study fulfilled the *ideate* and *prototype* stages of the Design Thinking and Research Process co-design framework [30] by providing stakeholders with the opportunity to critique a prototype wireframe of the proposed HLaC *Online* program. Consistent with the first round of co-design, stakeholders continued to emphasise the importance of addressing mental health, fatigue management, and peer support [31]. However, the present study extended these previous findings and identified several new themes relating to program usability and support features: (a) specific website design considerations, (b) strategies for promoting and maintaining long-term user engagement, (c) enhancing relatability and relevance, (d) incorporating professional support, and (e) addressing the need for family and peer support.

A frequent observation made by all stakeholder groups was that maintaining engagement may pose a significant challenge to HLaC *Online*, a self-managed intervention. The majority of stakeholders described typical online program users as highly engaged within the first few weeks of a program, before gradually tapering off in interest and engagement. Consequently, the majority of the feedback focused on program features to encourage uptake and longer-term adherence to HLaC *Online*. These findings support previous investigations into engagement design features, which have consistently found that interventions should be easy to use, relevant to the target population, and include personalisation features, avenues for social support, and some level of guidance through, for example, reminders or a web-support contact [35, 36].

The stakeholder co-design process generated modifications to several aspects of the program, including simplifying activities viewed as too complex for a self-guided format, allowing consumers to self-select program reminder frequency, and providing further information on locating support from peers and healthcare professionals. These findings were induced and strengthened by the iterative nature of the co-design methodology, in which the current prototype was derived from the initial consultation of stakeholders, and prototype-feedback was then sought from that same group. As a result, stakeholders were enabled to provide guidance as to whether the needs identified in the first round of engagement had been sufficiently met and which needs required further consideration or development.

The involvement of different stakeholder groups, rather than a single group, enhanced the *ideate* and *prototype* stages of co-design [30]. Involving stakeholders who may be involved in the implementation of HLaC *Online* (e.g., through recommendation or program support) in addition to end-users enabled diverse feedback to be collated from cancer survivors, healthcare professionals, and cancer support representatives. Feedback provided by cancer survivor stakeholders largely focused on how to make the intervention relevant and accessible to the diverse cancer survivor population who will ultimately be the end-users of the program (i.e., through additional peer stories, different language settings, and printable options). In contrast, the healthcare professional and cancer support representatives drew from their expertise on how to best support users to make and sustain healthy lifestyle and long-term behaviour changes (i.e., beyond the intervention period of three months). This diversification of feedback ensured that suggested behaviour changes are accessible to all cancer survivors (e.g., focusing on walking instead of weighted exercises) and that it included information about the potential cancer- and treatment-related side effects that can complicate the behaviour change process. The benefit of including multiple stakeholder groups, particularly healthcare professionals and representatives from support organisations, has been noted in previous digital health intervention research [37].

Restrictions on stakeholders' consultation time and limited cultural and professional diversity in the stakeholder group are two limitations of this study. Focus groups and interviews were time consuming, and engagement often felt rushed, especially with busy healthcare professionals. Consequently, stakeholders may have lacked adequate time to review each wireframe page in depth and only able to provide feedback based on their first impressions. Alternative co-design methodologies to reduce such time-constraints that could be considered in the future include providing the summary of the findings from the previous engagement and the wireframe ahead of engagement to allow more discussion time [33], or asking participants to complete and provide feedback on a set number of activities included in the program [32]. Further, the participant sample had inadequate representation of different cultures, such as Aboriginal and Torres Strait Islander Australians or Culturally and Linguistically Diverse (CaLD) Australians. Further developments made to HLaC *Online* based on current stakeholder feedback may not suit the needs of Aboriginal and Torres Strait Islander or other culturally diverse Australian cancer survivors. Future iterations of the HLaC *Online* program should consider engaging stakeholders from Aboriginal and Torres Strait Islander and other cultural group communities, to ensure the program is culturally safe and meets the unique needs of these communities. Additionally, the study may have been improved with involvement of website design experts (e.g., computer programmer and graphic designer), who may have provided additional ideas about what would work within the program which end-user stakeholder could provide their perspectives on. This limitation will be addressed in the next stage of program development, whereby website design experts will be involved in the development of the HLaC *Online* website.

Stakeholder feedback was integrated into the website design of HLaC *Online*. Key changes to the intervention design included offering HLaC *Online* with a responsive design for use on different devices, guidance videos to assist users completing activities, use of a mood rating as an alternative to the thought record, more information regarding the unique impacts of cancer and its treatment, guidance in each module on how to access relevant healthcare professions, and multiple options for accessing peer support. The feasibility and usability of this design iteration will be evaluated in a pre-post trial prior to testing the efficacy of HLaC *Online* via a randomised controlled trial.

In summary, continuing the co-design process through a second round of stakeholder engagement has further refined the development of HLaC *Online*. Specific feedback and advice provided by the stakeholder group has been incorporated to ensure that the content best meets the needs of cancer survivors and supports their undertaking of the self-guided intervention. Future development of digital health interventions utilising the co-design approach should explore alternative co-design methodologies that address the potential time constraints of the stakeholder group and consider the recruitment of multiple, culturally diverse stakeholder groups to ensure the proposed intervention best meets the needs and expectations of their target population.

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Data availability The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval This study was approved by the Cancer Council Victoria Human Research Ethics Committee (Project HREC2106).

Consent to participate Informed consent was obtained from all individual participants included in the study.

Consent for publication Participants signed informed consent regarding publishing their data and quotes.

Competing interests The authors declare no competing interests.

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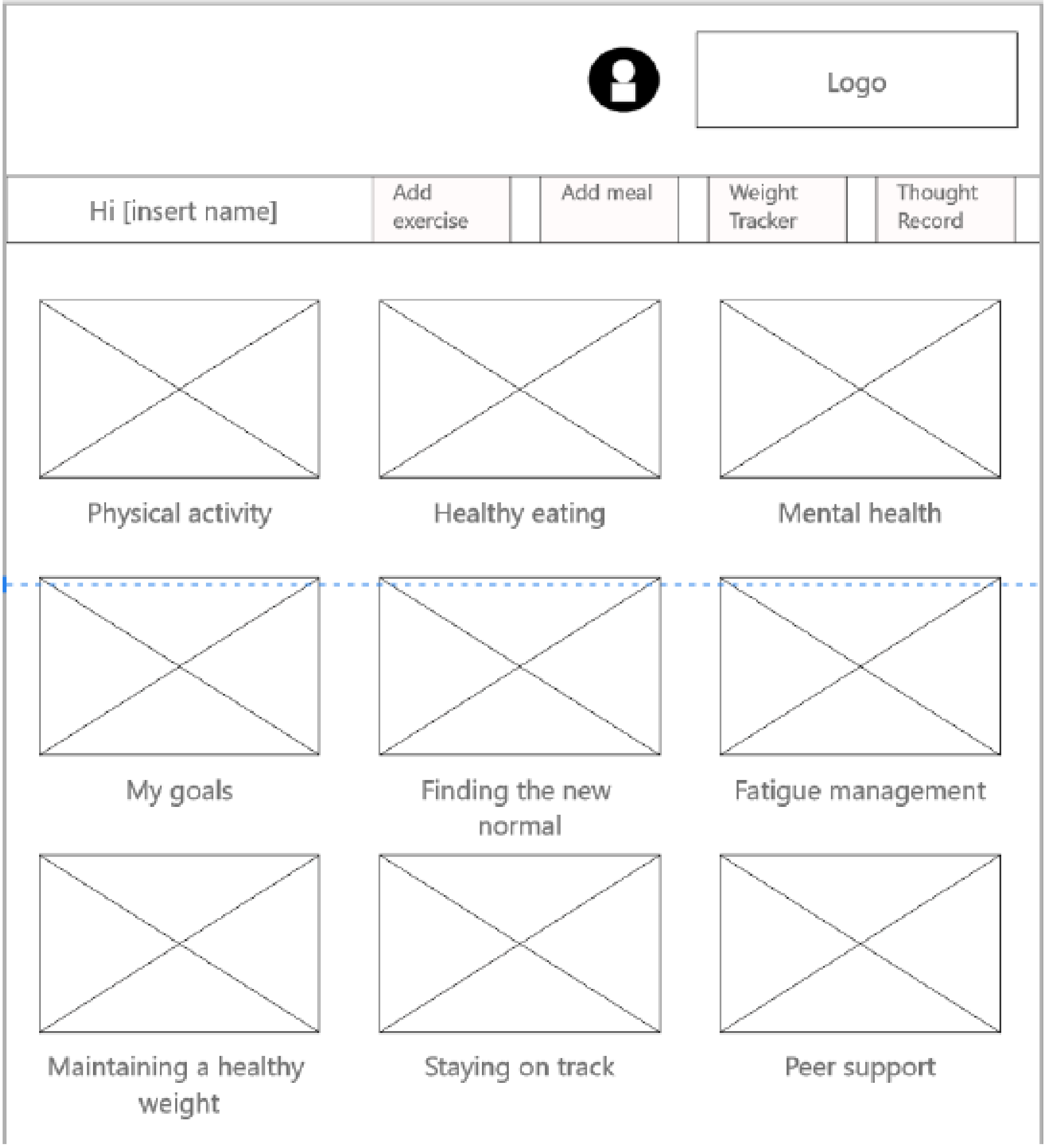
Appendix E

HLaC *Online* wireframe

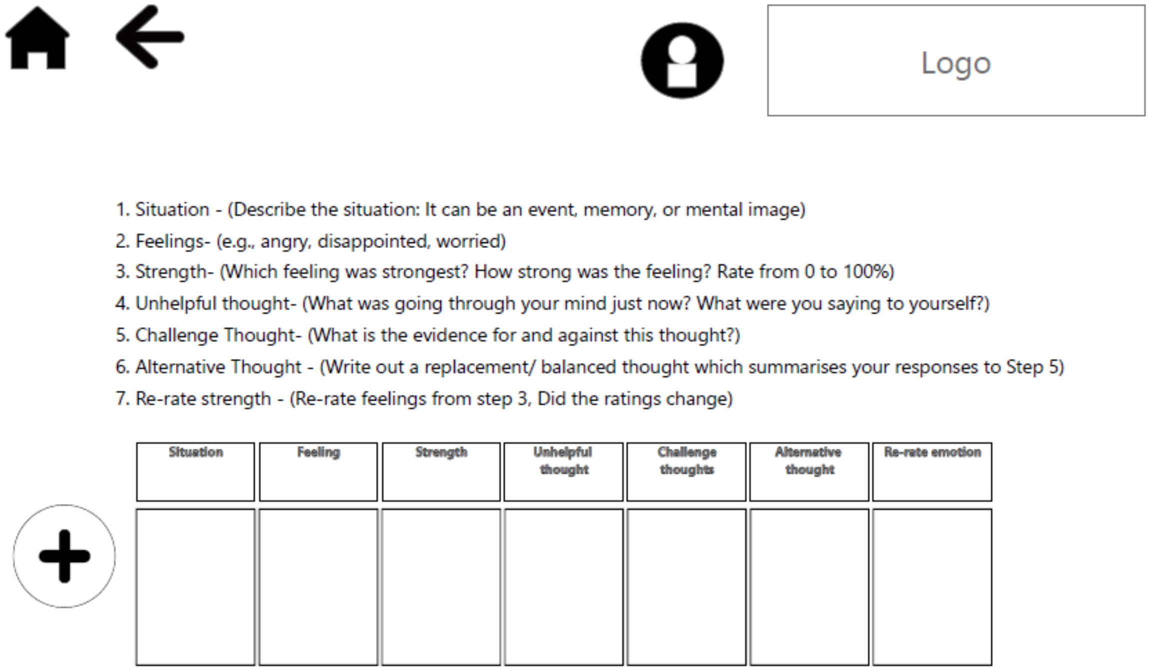
Supplementary Figure 1

Home Screen of wireframe



Supplementary Figure 2

Example thought record from HLaC Online wireframe

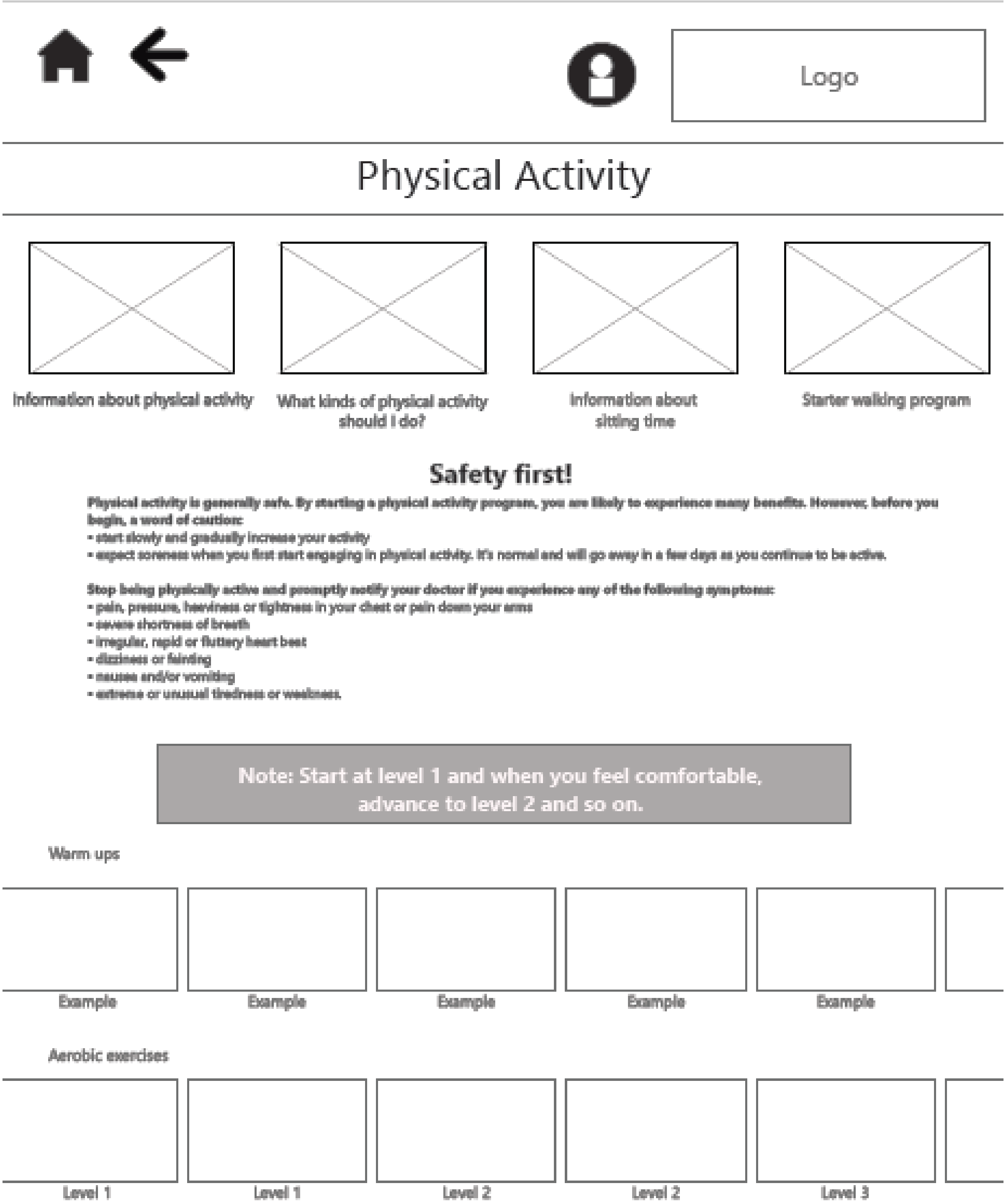


1. Situation - (Describe the situation: It can be an event, memory, or mental image)
2. Feelings- (e.g., angry, disappointed, worried)
3. Strength- (Which feeling was strongest? How strong was the feeling? Rate from 0 to 100%)
4. Unhelpful thought- (What was going through your mind just now? What were you saying to yourself?)
5. Challenge Thought- (What is the evidence for and against this thought?)
6. Alternative Thought - (Write out a replacement/ balanced thought which summarises your responses to Step 5)
7. Re-rate strength - (Re-rate feelings from step 3, Did the ratings change)

Situation	Feeling	Strength	Unhelpful thought	Challenge thoughts	Alternative thought	Re-rate emotion

Supplementary Figure 3

Example page for the physical activity module



Physical Activity

Safety first!

Physical activity is generally safe. By starting a physical activity program, you are likely to experience many benefits. However, before you begin, a word of caution:
- start slowly and gradually increase your activity
- expect soreness when you first start engaging in physical activity. It's normal and will go away in a few days as you continue to be active.

Stop being physically active and promptly notify your doctor if you experience any of the following symptoms:
- pain, pressure, heaviness or tightness in your chest or pain down your arms
- severe shortness of breath
- irregular, rapid or fluttery heart beat
- dizziness or fainting
- nausea and/or vomiting
- extreme or unusual tiredness or weakness.

Note: Start at level 1 and when you feel comfortable, advance to level 2 and so on.

Appendix F

Focus group and interview topic guide for Chapter 3

Section 1: Findings from last focus group

Powerpoint presentation about the key messages from round 1 of stakeholder engagement including the following:

1. Healthy living is defined as having good overall quality of life and includes physical health, mental health and adjustment to the new normal.
2. Healthy living programs should include mental health and peer support components and offer a flexible format with long term accessibility.

Section 2: Wireframe of the online program

Presentation of basic black and white template of the proposed program. Stakeholders were asked to provide their feedback on the home screen and modules with the following questions:

Home screen

- If you were signing into this page for the first time, how would you want it to look?
- What do you think of the layout?
- Do you think the important content readily available?

Modules

- What do you think of this page?
- Is this what you expected this section to look like?
- Is there anything else you would change or add?

Section 3: How can users best be supported?

Task to create a persona to represent a potential user of the program

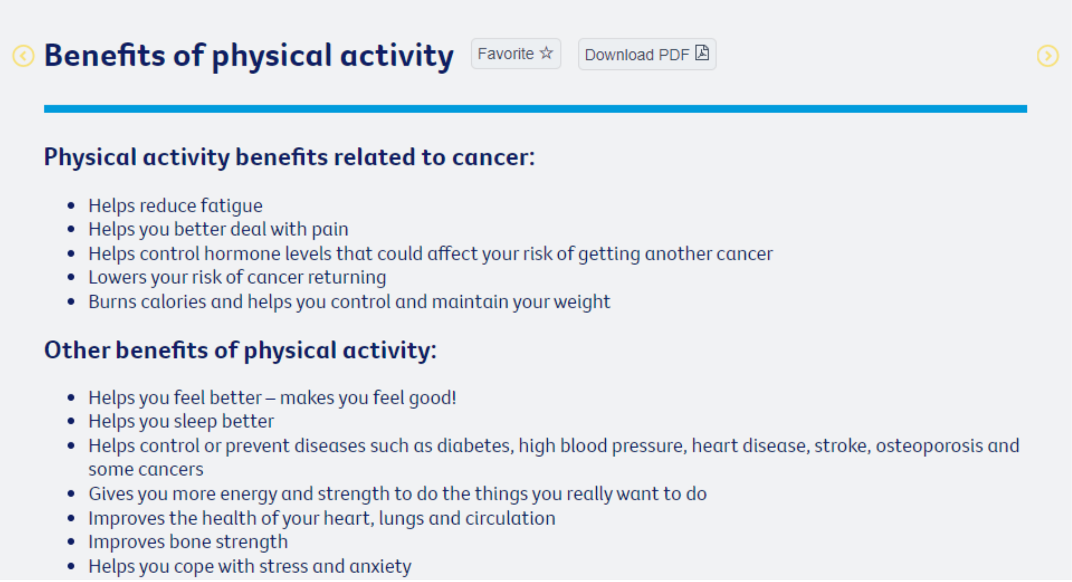
- How could this person use this program to achieve their healthy living goals
- How often would they intend to use a program like this?
- What device would they use the program on?
- How could we support them in using this program?

Appendix G

Examples from the HLaC *Online* website

Supplementary Figure 1

Example psychoeducation in the Physical Activity and Fatigue Management Modules



Benefits of physical activity

Physical activity benefits related to cancer:

- Helps reduce fatigue
- Helps you better deal with pain
- Helps control hormone levels that could affect your risk of getting another cancer
- Lowers your risk of cancer returning
- Burns calories and helps you control and maintain your weight

Other benefits of physical activity:

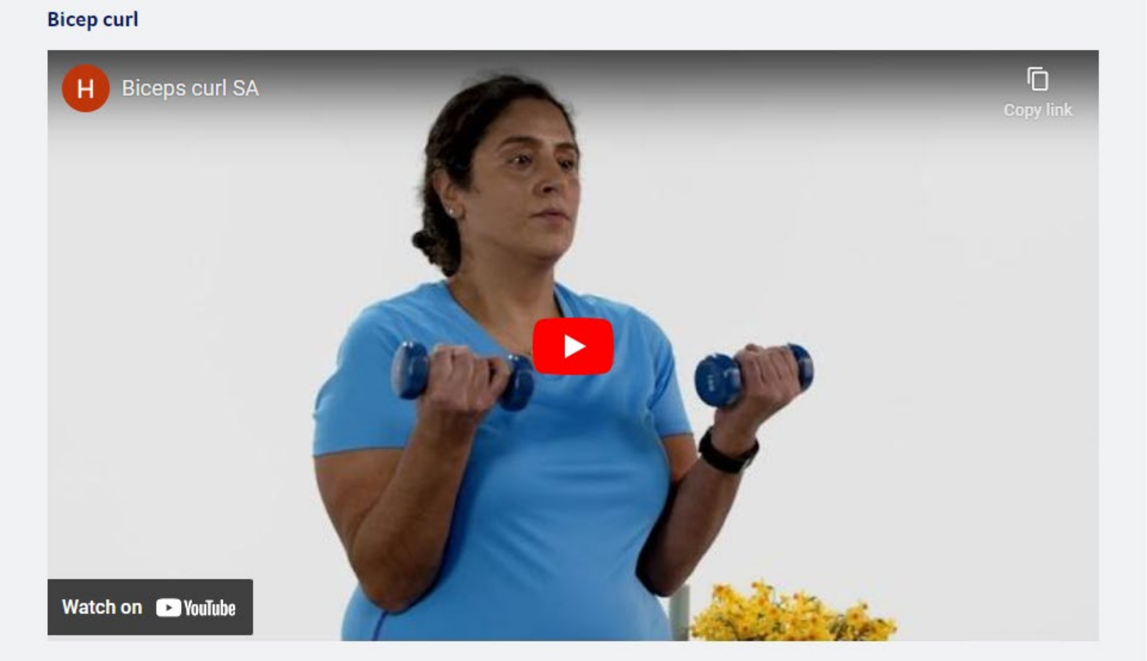
- Helps you feel better – makes you feel good!
- Helps you sleep better
- Helps control or prevent diseases such as diabetes, high blood pressure, heart disease, stroke, osteoporosis and some cancers
- Gives you more energy and strength to do the things you really want to do
- Improves the health of your heart, lungs and circulation
- Improves bone strength
- Helps you cope with stress and anxiety

What causes fatigue?

Below is a diagram that shows some common causes of fatigue.

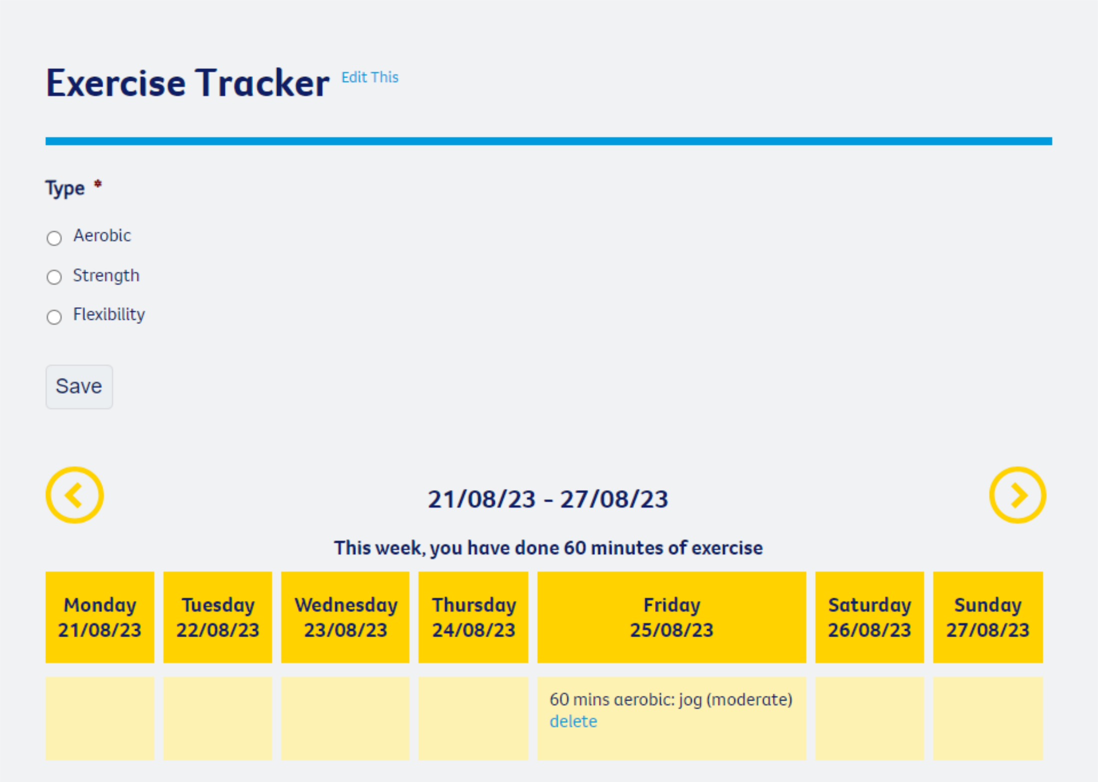
Supplementary Figure 2

Example exercise video



Supplementary Figure 3

Example exercise tracker



Type *

○ Aerobic
○ Strength
○ Flexibility

21/08/23 - 27/08/23

This week, you have done 60 minutes of exercise

Monday 21/08/23	Tuesday 22/08/23	Wednesday 23/08/23	Thursday 24/08/23	Friday 25/08/23	Saturday 26/08/23	Sunday 27/08/23
				60 mins aerobic: jog (moderate) delete		

Appendix H

Interview topic guide Chapter 4

Section 1: Accessing the program

This section asks questions about how you accessed Healthy Living after Cancer Online.

How did you hear about Healthy Living after Cancer Online?

What device did you usually use the program on?

Section 2: Satisfaction with program overall

This section asks questions about how you used Healthy Living after Cancer Online and to provide your feedback on the program overall.

How satisfied were you with the Healthy Living after Cancer Online Overall?

Very unsatisfied	**Unsatisfied**	**Neither satisfied nor unsatisfied**	**Satisfied**	**Very satisfied**

Is there anything you would change the look of the program?

How did you find navigating the website?

What aspects of Healthy Living after Cancer Online were the most useful to you?

What aspects of Healthy Living after Cancer Online were not useful?

Did you benefit from using the program? If so, how and if not, why not?

Are there any topics that are missing which you would like addressed in this program?

Section 3: Trackers

This section asks you to provide your feedback on each of the trackers included in the Healthy Living after Cancer Online program.

When providing your feedback on each of the trackers, you may consider the following questions:

- *How much did use this tracker?*
- *How helpful did you find this tracker?*
- *Is there anything you would change about this tracker?*

If you did not use one or more of the trackers, that is okay. You may also provide some feedback about why you chose not to use the tracker.

How satisfied were you with the trackers overall?

Very unsatisfied	**Unsatisfied**	**Neither satisfied nor unsatisfied**	**Satisfied**	**Very satisfied**

Section 4: Intervention modules

This section asks you to provide your feedback on each of the modules included in the Healthy Living after Cancer Online program. When providing feedback on each of the modules, you may consider the following questions:

- *Overall, what did you think of this section?*
- *How relevant was the information in this section?*
- *How helpful was the information is this section?*
- *Was the information easy to understand?*
- *What did you think of the activities included in this section?*
- *Is there anything you would change about this tracker?*

If you did not use the module, that is okay. You may also consider providing feedback about why you chose not to use the module.

Section 5: Email reminders

This section asks you to provide your feedback on the email reminders that you may have received while using Healthy Living after Cancer Online.

How satisfied were you with the email reminders?

Very unsatisfied	**Unsatisfied**	**Neither satisfied nor unsatisfied**	**Satisfied**	**Very satisfied**

Did you find the email reminders helpful?

Is there anything you would change about the reminders?

Appendix I

Chapter 5 Sensitivity analyses

Supplementary Table 1

Completers estimated means, standard errors, and between group effect sizes, and main effects of time for efficacy outcomes (n = 39)

Outcomes		Baseline	Post-intervention			1-month follow up			Main effect of time	Group x time interaction
		M (SE)	*M (SE)*	Within group over time *d* [95% CI][d]	Between group over time *d* [95% CI][d]	*M (SE)*	Within group over time *d* [95% CI][e]	Between group over time *d* [95% CI][e]	*F (p)*	*F (p)*
Quality of life										
Global	HLaC *Online* +coaching	68.53 (4.28)	73.49 (4.51)	0.23 [-0.07, 0.53]	-0.10 [-0.52, 0.33]	72.25 (4.72)	0.17 [-0.04, 0.40]	0.07 [-0.25, 0.38]	4.85 (.01)*	0.29 (.75)
	HLaC *Online*	77.04 (4.39)	83.86 (4.41)	**0.32 [0.03, 0.61]**		79.47 (4.57)	0.12 [-0.10, 0.33]			
Physical Well-being	HLaC *Online* +coaching	18.58 (1.22)	19.07 (1.41)	0.07 [-0.28, 0.42]	-0.28 [-0.78, 0.23]	19.30 (1.49)	0.11 [-13, 0.35]	-0.14 [-0.48, 0.21]	1.84 (.17)	0.74 (.48)
	HLaC *Online*	20.15 (1.33)	22.30 (1.38)	**0.31 [-0.03, 0.65]**		21.69 (1.44)	**0.23 [0.002, 0.47]**			
Social/family Well-being	HLaC *Online* +coaching	17.21 (1.41)	18.76 (1.56)	0.21 [-0.07, 0.49]	0.04 [-0.35, 0.45]	17.70 (1.63)	0.07 [-0.13, 0.27]	-0.03 [-0.26, 0.32]	2.62 (.08)	0.03 (.97)
	HLaC *Online*	20.54 (1.48)	20.76 (1.52)	0.17 [-0.10, 0.44]		20.85 (1.57)	0.04 [-0.15, 0.24]			

Supplementary Table 1. *continued*

Outcomes		Baseline	Post-intervention			1-month follow up			Main effect of time	Group x time interaction
		M (SE)	*M (SE)*	Within group over time *d* [95% CI][d]	Between group over time *d* [95% CI][d]	*M (SE)*	Within group over time *d* [95% CI][e]	Between group over time *d* [95% CI][e]	*F (p)*	*F (p)*
Emotional Well-being	HLaC *Online* +coaching	16.47 (1.07)	18.08 (1.14)	0.27 [-0.20, 0.73]	0.22 [-0.45, 0.89]	18.92 (1.23)	**0.27 [0.05, 0.49]**	0.16 [-0.16, 0.48]	1.23 (.30)	0.25 (.78)
	HLaC *Online*	17.50 (1.04)	18.08 (1.13)	0.09 [-0.36, 0.55]		18.18 (1.22)	0.12 [-0.09, 0.34]			
Functional Well-being	HLaC *Online* +coaching	16.26 (1.40)	17.60 (1.43)	0.20 [-0.07, 0.41]	-0.22 [-0.60, 0.17]	17.23 (1.49)	0.14 [-0.08, 0.37]	-0.01 [-0.34, 0.32]	6.45 (.003)*	0.90 (.41)
	HLaC *Online*	18.85 (1.36)	21.48 (1.40)	**0.39 [0.13, 0.66]**		19.87 (1.44)	0.15 [-0.07, 0.38]			
Fatigue	HLaC *Online* +coaching	30.11 (2.79)	30.25 (2.87)	0.01 [-0.36, 0.38]	-0.26 [-0.79, 0.27]	33.72 (3.02)	**0.27 [0.08, 0.46]**	0.03 [-0.25, 0.30]	1.56 (.22)	0.85 (.43)
	HLaC *Online*	35.80 (2.58)	39.01 (2.58)	0.23 [-0.12, 0.61]		39.05 (2.88)	**0.25 [0.07, 0.44]**			
MVPA	HLaC *Online* +coaching	283.90 (81.78)	348.87 (89.31)	0.13 [-0.41, 0.67]	-0.15 [-0.93, 0.63]	360.37 (91.39)	0.15 [-0.37, 0.66]	-0.30 [-1.05, 0.45]	1.49 (.23)	0.23 (.80)
	HLaC *Online*	333.80 (79.71)	451.01 (89.31)	0.24 [-0.29, 0.77]		514.43 (92.89)	0.36 [-0.15, 0.87]			
Average daily sitting time	HLaC *Online* +coaching	444.65 (41.47)	344.27(45.81)	**-0.43 [-0.86, -0.01]**	-0.26 [-0.87, 0.36]	260.16 (48.40)	**-0.70 [-1.27, -0.14]**	**-1.07 [-1.92, -0.22]**	3.83 (.03)*	3.30 (.05)*
	HLaC *Online*	339.21(40.42)	285.07(44.14)	-0.24 [-0.65, 0.18]		347.82 (46.40)	0.03 [-0.52, 0.58]			

Supplementary Table 1. *continued*

Outcomes		Baseline	Post-intervention			1-month follow up			Main effect of time	Group x time interaction
		M (SE)	*M (SE)*	Within group over time *d* [95% CI][d]	Between group over time *d* [95% CI][d]	*M (SE)*	Within group over time *d* [95% CI][e]	Between group over time *d* [95% CI][e]	*F (p)*	*F (p)*
Diet Quality	HLaC *Online* +coaching									
Fruit servings	HLaC *Online*	1.50 (0.22)	1.47 (0.23)	-0.03 [-0.53, 0.47]	-0.19 [-0.90, 0.52]	1.52 (0.25)	0.02 [-0.42, 0.46]	-0.27 [-1.00, -0.46]	0.20 (.81)	0.21 (0.81)
	HLaC *Online* +coaching	1.98 (0.21)	2.13 (0.23)	0.12 [-0.37, 0.60]		2.20 (0.24)	0.17 [-0.25, 0.60]			
Vegetable servings	HLaC *Online*	3.00 (0.35)	3.07 (0.37)	0.03 [-0.48, 0.55]	-0.15 [-0.88, 0.59]	3.93 (0.40)	0.42 [-0.16, 1.00]	-0.47 [-0.37, 1.31]	1.50 (.23)	1.08 (.35)
	HLaC *Online* +coaching	3.05 (0.33)	3.34 (0.38)	0.14 [-0.36, 0.64]		3.28 (0.39)	0.10 [-0.46, 0.67]			
Fat index	HLaC *Online*	3.40 (0.12)	3.58 (0.12)	**0.33 [0.06, 0.60]**	0.23 [-0.17, 0.62]	3.60 (0.13)	**0.35 [0.07, 0.63]**	0.20 [-0.20, 0.60]	3.27 (.05)*	0.58 (.56)
	HLaC *Online* +coaching	3.33 (0.12)	3.40 (0.12)	0.12 [-0.14,0.38]		3.44 (0.13)	0.18 [-0.09, 0.45]			
Fibre index	HLaC *Online*	2.82 (0.15)	2.97 (0.15)	0.21 [-0.06, 0.49]	-0.10 [-0.48, 0.31]	3.18 (0.16)	**0.48 [0.16, 0.80]**	0.40 [-0.07, 0.87]	4.18 (.02)*	1.89 (.16)
	HLaC *Online* +coaching	3.08 (0.14)	3.29 (0.15)	**0.29 [0.02, 0.56]**		3.18 (0.15)	0.14 [-0.18, 0.45]			

Supplementary Table 1. *continued*

Outcomes		Baseline	Post-intervention			1-month follow up			Main effect of time	Group x time interaction
		M (SE)	*M (SE)*	Within group over time *d* [95% CI][d]	Between group over time *d* [95% CI][d]	*M (SE)*	Within group over time *d* [95% CI][e]	Between group over time *d* [95% CI][e]	*F (p)*	*F (p)*
Symptom severity	HLaC *Online*	4.00 (0.46)	4.16 (0.48)	0.07 [-0.29, 0.43]	0.43 [-0.10, 0.95]	3.11 (0.51)	**-0.37 [-0.71, -0.03]**	-0.37 [-0.88, 0.12]	1.14 (.33)	4.01 (.02)*
	HLaC *Online* +coaching	3.36 (0.44)	2.67 (0.47)	-0.29 [-0.65, 0.06]		3.22 (0.50)	-0.06 [-0.39, 0.28]			
Symptom interference	HLaC *Online*	3.85 (0.53)	3.68 (0.56)	-0.06 [-0.42, 0.31]	0.32 [-0.21, 0.85]	2.91 (0.59)	**-0.35 [-0.62, -0.09]**	-0.05 [-0.43, 0.33]	2.68 (.08)	1.20 (.31)
	HLaC *Online* +coaching	2.88 (0.51)	1.98 (0.55)	-0.33 [-0.68, -0.03]		2.06 (0.58)	**-0.31 [-0.56, -0.05]**			
Fear of cancer recurrence	HLaC *Online*	19.05 (2.27)	14.14(2.24)	**-0.45 [-0.73, -0.17]**	-0.33 [-0.74, 0.08]	12.98 (2.37)	**-0.50 [-0.90, -0.10]**	**-0.65 [-1.25, -0.05]**	5.72 (.01)*	2.95 (.06)
	HLaC *Online* +coaching	15.35 (2.22)	13.72 (2.11)	-0.15 [-0.42, 0.12]		15.73 (2.40)	0.03 [-0.36, 0.42]			
Distress	HLaC *Online*	26.00 (4.75)	22.72 (4.92)	-0.14 [-0.46, 0.19]	0.08 [-0.39, 0.54]	23.15 (5.19)	-0.12 [-0.37, 0.13]	-0.09 [-0.50, 0.32]	1.52 (.23)	0.20 (.82)
	HLaC *Online* +coaching	20.80 (4.63)	15.90 (4.89)	-0.21 [-0.52, 0.11]		19.79 (5.14)	-0.04 [-0.28, 0.20]			

Supplementary Table 2

Estimated means, standard errors, and within group effect sizes, and main effects of time for preliminary efficacy outcomes while controlling for time since diagnosis

Outcomes		Time since diagnosis	Baseline	Post-intervention			1-month follow up			Main effect of time	Group x time interaction
		M	*M (SE)*	*M (SE)*	Within group over time *d* [95% CI][d]	Between group over time *d* [95% CI][d]	*M (SE)*	Within group over time *d* [95% CI][e]	Between group over time *d* [95% CI][e]	*F (p)*	*F (p)*
Quality of life											
Global	HLaC Online +coaching	5.22	71.27 (3.66)	75.79 (3.99)	0.21 [-0.04, 0.47]	-0.13 [-0.50, 0.24]	74.32 (4.42)	0.14 [-0.05, 0.33]	0.02 [-0.25, 0.29]	4.65 (.01)*	0.31 (.74)
	HLaC Online		75.90 (3.48)	82.83 (3.84)	**0.33 [0.08, 0.58]**		78.56 (4.14)	0.13 [-0.05, 0.31]			
Physical Well-being	HLaC Online +coaching	5.21	19.45 (1.11)	19.82 (1.24)	0.06 [-0.25, 0.35]	-0.31 [-0.75, 0.12]	20.00 (1.39)	0.08 [-0.13, 0.29]	-0.16 [-0.45, 0.14]	1.65 (.20)	0.81 (.45)
	HLaC Online		19.98 (1.05)	22.07 (1.20)	**0.31 [0.02, 0.60]**		21.40 (1.31)	**0.21 [0.01, 0.41]**			
Social/family Well-being	HLaC Online +coaching	5.22	17.02 (1.33)	18.55 (1.44)	0.20 [-0.03, 0.44]	0.02 [-0.32, 0.37]	17.58 (1.58)	0.07 [-0.10, 0.25]	-0.01 [-0.26, 0.24]	2.68 (.08)	0.01 (.99)
	HLaC Online		19.82 (1.26)	21.19 (1.38)	0.18 [-0.05, 0.42]		20.43 (1.48)	0.08 [-0.09, 0.25]			

Supplementary Table 2. *continued*

Outcomes		Time since diagnosis	Baseline	Post-intervention			1-month follow up			Main effect of time	Group x time interaction
		M	*M (SE)*	*M (SE)*	Within group over time *d* [95% CI][d]	Between group over time *d* [95% CI][d]	*M (SE)*	Within group over time *d* [95% CI][e]	Between group over time *d* [95% CI][e]	*F (p)*	*F (p)*
Emotional Well-being	HLaC Online +coaching	5.05	17.28 (0.89)	18.57 (1.05)	0.21 [-0.19, 0.62]	0.21 [-0.37, 0.79]	18.77 (1.20)	0.26 [-0.07, 0.46]	0.21 [-0.06, 0.48]	0.93 (.40)	0.25 (.78)
	HLaC Online		17.66 (0.85)	18.02 (1.04)	0.06 [-0.33, 0.45]		18.24 (1.15)	0.10 [-0.08, 0.29]			
Functional Well-being	HLaC Online +coaching	5.22	17.59 (1.19)	18.78 (1.28)	0.18 [-0.05, 0.41]	-0.25 [-0.59, 0.09]	17.94 (1.39)	0.05 [-0.15, 0.25]	-0.13 [-0.41, 0.16]	6.68 (.002)*	0.93 (.40)
	HLaC Online		18.37 (1.13)	21.04 (1.22)	**0.40 [0.18, 0.63]**		19.46 (1.31)	0.16 [-0.03, 0.36]			
Fatigue	HLaC Online +coaching	5.20	32.49 (2.29)	32.21 (2.57)	-0.02 [-0.34, 0.30]	-0.33 [-0.82, 0.16]	35.35 (2.82)	**0.21 [0.05, 0.38]**	-0.07 [-0.33, 0.19]	1.55 (.22)	1.02 (.37)
	HLaC Online		34.10 (2.18)	37.59 (2.49)	0.25 [-0.05, 0.55]		37.78 (2.71)	**0.27 [0.11, 0.43]**			
MVPA	HLaC Online +coaching	5.14	281.14 (69.76)	350.49 (85.94)	0.14 [-0.34, 0.61]	-0.07 [-0.74, 0.60]	381.29 (94.04)	0.19 [-0.27, 0.64]	-0.19 [-0.83, 0.46]	1.72 (.19)	0.18 (.84)
	HLaC Online		338.25 (66.62)	431.38 (85.94)	0.18 [-0.27, 0.64]		503.89 (90.77)	0.31 [-0.13, 0.75]			

Supplementary Table 2. *continued*

Outcomes		Time since diagnosis	Baseline	Post-intervention			1-month follow up			Main effect of time	Group x time interaction
		M	*M (SE)*	*M (SE)*	Within group over time *d* [95% CI]^d	Between group over time *d* [95% CI]^d	*M (SE)*	Within group over time *d* [95% CI]^e	Between group over time *d* [95% CI]^e	*F (p)*	*F (p)*
Average daily sitting time	HLaC Online +coaching	5.26	397.09 (46.26)	316.65 (53.84)	-0.27 [-0.64, 0.11]	-0.07 [-0.60, 0.45]	243.14 (59.93)	-0.43 [-0.92, 0.06]	-0.61 [-1.32, 0.05]	3.18 (.051)	1.65 (.20)
	HLaC Online		361.75 (43.90)	298.45 (51.20)	-0.21 [-0.56, 0.15]		347.60 (55.76)	-0.04 [-0.51, 0.43]			
Diet Quality											
Fruit servings	HLaC Online +coaching	4.93	1.39 (0.18)	1.35 (0.21)	-0.03 [-0.53, 0.47]	-0.28 [-0.89, 0.34]	1.42 (0.23)	0.02 [-0.42, 0.46]	-0.33 [-0.96, 0.29]	0.50 (.91)	0.47 (.63)
	HLaC Online		1.88 (0.18)	2.09 (0.22)	0.17 [-0.32, 0.65]		2.21 (0.23)	0.25 [-0.17, 0.67]			
Vegetable servings	HLaC Online +coaching	4.91	2.93 (0.30)	3.16 (0.36)	0.11 [-0.41, 0.62]	-0.05 [-0.67, 0.58]	3.98 (0.41)	0.43 [-0.15, 1.02]	0.54 [-0.19, 1.27]	1.95 (.15)	1.06 (.35)
	HLaC Online		3.02 (0.29)	3.31 (0.38)	0.13 [-0.37, 0.63]		3.62 (0.39)	0.10 [-0.47, 0.67]			
Fat index	HLaC Online +coaching	5.20	3.39 (0.10)	3.56 (0.11)	**0.33 [0.09, 0.56]**	0.25 [-0.09, 0.59]	3.64 (0.12)	**0.43 [0.19, 0.67]**	0.34 [-0.01, 0.69]	3.67 (.03)*	0.88 (.42)
	HLaC Online		3.41 (0.09)	3.47 (0.10)	0.11 [-0.12,0.33]		3.50 (0.11)	0.16 [-0.08, 0.39]			

Supplementary Table 2. *continued*

Outcomes		Time since diagnosis	Baseline	Post-intervention			1-month follow up			Main effect of time	Group x time interaction
		M	*M (SE)*	*M (SE)*	Within group over time *d* [95% CI][d]	Between group over time *d* [95% CI][d]	*M (SE)*	Within group over time *d* [95% CI][e]	Between group over time *d* [95% CI][e]	*F (p)*	*F (p)*
Fibre index	HLaC Online +coaching	5.20	2.92 (0.13)	3.05 (0.15)	0.17 [-0.06, 0.42]	-0.13 [-0.47, 0.22]	3.27 (0.16)	**0.42 [0.14, 0.71]**	0.36 [-0.05, 0.76]	4.19 (.02)*	1.91 (.16)
	HLaC Online		3.03 (0.13)	3.24 (0.14)	**0.28 [0.05, 0.52]**		3.14 (0.15)	0.14 [-0.13, 0.41]			
Symptom severity	HLaC Online +coaching	5.09	4.13 (0.38)	4.22 (0.44)	0.04 [-0.28, 0.35]	0.41 [-0.04, 0.86]	3.01 (0.49)	**-0.45 [-0.75, -0.15]**	**-0.51 [-0.94, -0.07]**	1.84 (.17)	4.37 (.02)*
	HLaC Online		3.51 (0.37)	2.82 (0.43)	**-0.29 [-0.59, -0.01]**		3.35 (0.47)	-0.06 [-0.35, 0.22]			
Symptom interference	HLaC Online +coaching	5.04	3.91 (0.46)	3.70 (0.52)	-0.08 [-0.39, 0.24]	0.30 [-0.15, 0.75]	2.82 (0.58)	**-0.38 [-0.61, -0.15]**	-0.11 [-0.43, 0.21]	3.26 (.05)*	1.17 (.32)
	HLaC Online		3.07 (0.44)	2.18 (0.51)	**-0.31 [-0.61, -0.01]**		2.24 (0.56)	**-0.29 [-0.51, -0.07]**			
Fear of cancer recurrence	HLaC Online +coaching	5.04	18.43 (1.94)	13.58 (2.10)	**-0.44 [-0.68, -0.20]**	-0.33 [-0.68, 0.01]	11.89 (2.31)	**-0.52 [-0.86, -0.17]**	**-0.71 [-1.22, -0.19]**	5.85 (.01)*	3.28 (.05)*
	HLaC Online		16.18 (1.85)	14.55 (2.06)	-0.17 [-0.40, 0.06]		16.48 (2.20)	0.02 [-0.31, 0.36]			

Supplementary Table 2. *continued*

Outcomes		Time since diagnosis	Baseline	Post-intervention			1-month follow up			Main effect of time	Group x time interaction
		M	*M (SE)*	*M (SE)*	Within group over time *d* [95% CI][d]	Between group over time *d* [95% CI][d]	*M (SE)*	Within group over time *d* [95% CI][e]	Between group over time *d* [95% CI][e]	*F (p)*	*F (p)*
Distress	HLaC Online +coaching	5.04	23.65 (3.91)	20.72 (4.35)	-0.13 [-0.41, 0.16]	0.08 [-0.32, 0.48]	22.00 (4.88)	-0.07 [-0.32, 0.18]	-0.05 [-0.41, 0.30]	1.39 (.26)	0.19 (.83)
	HLaC Online		20.51 (3.68)	15.96 (4.31)	-0.19 [-0.47, 0.08]		19.91 (4.70)	-0.03 [-0.26, 0.21]			

[d] Within group effect from baseline to post-intervention

[e] Within group effect from baseline to 1-month follow-up