Smartphone Applications for the Self-management of Low Back Pain

By

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Abbreviations

ABACUS	App behaviour change scale
ADDRF	African Doctoral dissertation research fellowship
Apps	Applications
AUD	Australian dollars
BP	Blood pressure
CASP	Clinical appraisal skills program
Co-KT	Cocreating knowledge translation
COM-B	Capability, opportunity and motivation –behaviour change
GP	General practitioner
HIV	Human immunodeficiency virus
ICC	Intraclass correlation coefficient
IQR	Interquartile range
LBP	Low back pain
LBP-SMART	Low back pain – Self-management app review tool
MARS	Mobile app rating scale
NGSE	New general self-efficacy scale
NICE	National institute for health and care excellence
NPRS	Numeric pain rating scale
ODI	Oswestry disability index
PhD	Doctor of Philosophy
PRISMA	Preferred reporting items for systematic reviews and meta-analyses
PROSPERO	International Prospective Register of Systematic Reviews
PSEQ	Pain self-efficacy questionnaire
QOL	Quality of life

RCT	Randomised controlled trial
RMDQ	Roland-Morris disability questionnaire
RTW	Return to work
SD	Standard deviation
SEIFA	Socio-economic indexes for areas
SES	Socio-economic status
SMS	Short messaging service
SMS-14	Self-management support checklist
SMST	Self-management self-test
TGA	Therapeutic goods administration
TIDieR	Template for intervention description and replication
TIPI	Ten-Item personality inventory
TMBT	Telerehabilitation-based McKenzie therapy app
USA	United States of America
VAS	Visual analogue scale

Summary

Low back pain (LBP) is a leading cause of disability worldwide and a global economic health issue. Low back pain is estimated to affect 70-90% of people at some time in their lives and is the second leading cause of disease burden in Australia. Current LBP guidelines recommend interventions that have been investigated by many studies over the years and these include self-management, active rehabilitation and exercise. Usual self-management varies, but includes a range of strategies such as exercise, advice from health professionals, pharmacological management and passive treatments. Smartphone applications (apps) are an easily accessible and cost-effective option that may help improve self-management. Most of the population in developed countries use a smartphone, and this is increasing at a steady rate. They offer consumers a mobile health platform that can be used in place of or as an adjunct to in-clinic treatment. As a result, they have the potential to decrease healthcare costs and improve access to health management guidance and monitoring. Apps offer the potential for widespread implementation of health care interventions.

This program of research was undertaken in a series of four studies. Study one is a systematic review aimed at synthesising the evidence of effectiveness of smartphone apps for the self-management of low back pain in adults and exploring participant adherence with smartphone apps for the self-management of LBP. Overall, the findings suggest that smartphone apps for the self-management of LBP provide more effective reduction in pain and disability than usual care or minimal interventions, however, the evidence is inconclusive. The limited number of papers and heterogeneity of the research make it difficult to determine what apps work best and with whom. Wider use of smartphone apps for the self-management of LBP and its effectiveness are still unclear.

Study two is a systematic assessment aimed at evaluating the availability, content, and quality of commercially available, self-contained smartphone apps for the self-management of low back pain in adults. The results showed that smartphone apps for the self-management of low back pain are of average to good quality, but few were designed to specifically incorporate self-management support and behaviour change potential, as such have questionable potential for self-management and behaviour change. A clear need for stricter regulation of application content and consumer education is highlighted due to the low quality information and advice provided for low back pain.

Study three used two online surveys, a health professional survey and a consumer survey, to explore consumers' and health professionals' choice of self-management options for low back pain and use of smartphone apps for the self-management of low back pain. The results showed that few health professionals and consumers used apps due to lack of knowledge. All consumer app users had LBP and most found that app use helped improve their LBP. The small percentage of both consumer and health professional app users outlines the underutilisation of this self-management tool.

Study four used workshops to co-design a tool for use by consumers to assess LBP self-management apps. The co-design process involved both consumer and health professional input, as well as input from the research team. A new app assessment tool was developed, and pilot tested for usability with a separate group of participants. The app assessment tool allows for quick, easy evaluation of currently available LBP self-management apps by consumers and health professionals. Apps are an underutilised, yet potentially cost effective, portable and scalable self-management tool for LBP and this tool was developed to increase adoption of app use.

Overall, this research adds to the knowledge base and contributes to the paucity of research in this area. To our knowledge this is the first program of research that combines key elements to inform consumer and health professional choice. The developed co-designed tool allows for fast, easy integration into the clinical setting.

Declaration

I certify that this thesis does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

Signed.....

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Publications and Conference presentations arising from this thesis

Publications

Didyk, C., Lewis, L. K., & Lange, B. (2022). Effectiveness of smartphone apps for the self-management of low back pain in adults: a systematic review. *Disability and Rehabilitation, 44*(25), 7781–7790. https://doi.org/10.1080/09638288.2021.2005161

Didyk, C., Lewis, L. K., & Lange, B. (2022). Availability, content and quality of commercially available smartphone applications for the self-management of low back pain: a systematic assessment. *Disability and Rehabilitation, 44*(24), 7600–7609. https://doi.org/10.1080/09638288.2021.1979664

Manuscripts under review

Didyk, C., Lange, B. & Lewis, L.K. (2023). Self-efficacy, self-management and use of smartphone apps for low back pain: an observational study. *Primary Health Care Research & Development*.

Didyk, C., Lewis, L.K. & Lange, B. (2023). Health professionals' use of smartphone apps for clients with low back pain: an observational study. *Primary Health Care Research & Development.*

Didyk, C., Lewis, L.K. & Lange, B. (2023). Co-design of a consumer-level tool to assess the quality of smartphone apps for the self-management of low back pain. *Games for Health.*

Conference presentations

*Denotes presenting author

Didyk, C.*, Lewis, L. K., & Lange, B. (2022). Effectiveness of smartphone apps for the self-management of low back pain in adults: a systematic review. *Disability and Rehabilitation, 44*(25), 7781–7790. https://doi.org/10.1080/09638288.2021.2005161

Virtual oral presentation at the International Society of Behavioral Nutrition and Physical Activity (ISBNPA) Conference. Phoenix, Arizona, USA 2022.

Didyk, C.*, Lewis, L. K., & Lange, B. (2022). Availability, content and quality of commercially available smartphone applications for the self-management of low back pain: a systematic assessment. *Disability and Rehabilitation, 44*(24), 7600–7609. https://doi.org/10.1080/09638288.2021.1979664

Virtual oral presentation at the International Society of Behavioral Nutrition and Physical Activity (ISBNPA) Conference. Phoenix, Arizona, USA 2022.

Evidence of Impact

November 2021

Flinders University Media release

Smartphone apps not offering proven medical solutions for back pain sufferers

Self-management support and behavioural training lacking in Aussie app stores

https://news.flinders.edu.au/blog/2021/11/11/smartphone-apps-and-back-pain-treatments/

11th November 2021

Medical Express

Smartphone apps and back pain treatments

https://medicalxpress.com/news/2021-11-smartphone-apps-pain-treatments.html

13th December 2021

ABC Morning Radio interview – **What Ails you?** Back Pain - With Simon Royal

22nd February 2022

Australian Physiotherapy Association – **Pain Committee Presentation (invited)**

Chapter 1 - Introduction

This chapter provides an introduction and background information on low back pain (LBP), including prevalence, economic and health impacts. Current management strategies for LBP are then outlined, as well as the challenges for managing this condition. An overview of self-management is then presented, as well as the use of technology and smartphone apps for self-management. Finally, the potential for LBP self-management apps to assist in LBP management is presented as well as potential barriers to adoption and future directions. An outline of the program of research aims and thesis format concludes this chapter.

Low back pain

Low back pain is not a disease. It is a symptom defined by its location between the buttock creases and the lower margin of the ribs (Dionne et al., 2008). It may also present with unilateral or bilateral leg symptoms, such as pain or neurological symptoms, but most (85%) (Mesner et al., 2016) often does not have a specific cause (Finucane et al., 2020; Hartvigsen et al., 2018; Maher et al., 2017). Although recurrence is thought to be common, little robust evidence is available regarding the factors that predict recurrence and rates of recurrence (da Silva et al., 2017). Low back pain is a global economic health issue and leading cause of disability based on prevalence (Vos et al., 2017; Vos et al., 2020), and does not discriminate by age or country (Maher & Ferreira, 2022). The point prevalence for LBP, in 2017, was 7.5% with approximately 577 million people globally experiencing LBP (Wu et al., 2020), with the highest number in people aged 45 to 54 years (Chen et al., 2022). The highest increases in years lived with disability (YLD) due to LBP occurred in low-middle income countries (Kahere & Ginindza, 2020), although disability resulting from

LBP can vary between countries due to the influence of health and social systems (Hartvigsen et al., 2018). As a result, models of care and management must be specific to the geographical context (Buchbinder et al., 2018; Hartvigsen et al., 2018).

In Australia, back pain (of which LBP is the most common), is the second leading cause of disease burden (4.2%) (Australian Institute of Health and Welfare [AIHW], 2022a) and the number one cause of non-fatal disease burden overall (8.1%) (AIHW, 2023b). Back pain prevalence is exceeding prediction (Arthritis and Osteoporosis [AOV], 2013), with four million Australians experiencing back pain in 2017-18 (Australian Bureau of Statistics [ABS], 2019; AIHW, 2023b). Low back pain numbers have continued to rise due to an aging population in Australia (AIHW, 2023a; Hoy et al., 2014) and accounts for 16% of Australians with chronic conditions (AIHW, 2019b). Low back pain is often combined with comorbidities (ABS, 2022a) and a cause of psychological distress, impacting activity levels and workforce participation (AIHW, 2023a, 2023b; Buchbinder et al., 2018; Du et al., 2019). As a result, back pain is a leading cause for early retirement in Australia (Schofield et al., 2012) and further contributes to economic burden. The considerable levels of pain and disability sometimes experienced during episodes of LBP can also result in hospitalisation (AIHW, 2023a). The hospitalisation rate for non-acute and sub-acute back pain in Australia has tripled in the decade from 2006 to 2016, (AIHW, 2019a).

Non-serious LBP hospitalisation rates are estimated to cost over AUD 390 million per year (Coombs et al., 2021). Global private health costs have also increased, with musculoskeletal claims the most common (Willis Tower Watson [WTW], 2022). In Australia, health insurance premiums rose by 2.4% in the year to September 2022 (Australian Prudential Regulation Authority [APRA], 2022). Increasing health insurance costs may potentially cause affordability issues (Australian Broadcasting Corporation [ABC-News],

2020) and lead to falling private health insurance memberships. This will ultimately impact private health insurance costs, which may result in a downward spiral in which private health insurers further increase their costs to cover the loss (ABC-News, 2020). Falling health insurance memberships will ultimately place a greater financial burden on the Australian public health system and may result in further non-serious LBP hospital admissions.

Back problems, of which LBP is the most common, accounted for 23% of health system expenditure costing the Australian health system AUD 3.3 billion in 2018-19 (AIHW, 2022a) an increase of AUD half a billion in three years (AIHW, 2019b). The indirect costs of LBP only add to this figure, resulting in a significantly higher overall cost, estimated to be AUD 4.79 billion in 2012 (AOV, 2013). Unfortunately, much of the focus globally is on developing lifesaving interventions for common causes of death rather than main contributors to disability, such as LBP, which do not routinely result in death (Vos et al., 2020). However, an ageing population will only experience more disability, adding to the disease burden and expenditure, and requiring low cost, novel and effective intervention strategies (Vos et al., 2020).

Current management

The impact of disability resulting from LBP varies across countries and is influenced by local health care and social norms (Hartvigsen et al., 2018). In Australia, LBP is predominantly managed with face-to-face appointments and is the third most common reason Australians see their General Practitioner (GP) (Britt et al., 2016). Current management practises are expensive and can provide low value care (Buchbinder et al., 2018).

In the current economic climate, regular face-to-face appointments with health professionals may not be affordable or easily accessible for those that live in rural and remote areas. Guideline recommended care for LBP is aimed at improving function, encouraging self-management and addressing psychosocial factors (Australian Commission on Safety and Quality in Health Care [ACSQHC], 2022b; National Institute for Health and Care Excellence [NICE], 2016). Recommendations include: patient specific graduated return to normal activity using a biopsychosocial management approach, education, non-pharmacological treatments, psychological programmes if required for those with ongoing symptoms and limited use of imaging and surgery (Foster et al., 2018). However, guideline recommended care is not always received by people with LBP for several reasons, including, time constraints, payment models that do not effectively cover physical or psychological treatment options and lack of clinician knowledge of the guidelines (Foster et al., 2018).

In 1997 in Australia, a media campaign was delivered using well know personalities to educate and improve LBP beliefs at a population level (Buchbinder et al., 2001). However, although steps have been undertaken to improve LBP knowledge and dispel unhealthy beliefs, the gap between evidence and practice and the lack of clinician knowledge of current best practice and guideline recommendations continues (ACSQHC, 2022b). This is an important area of LBP management that requires addressing to improve LBP outcomes (Foster et al., 2018). It is perhaps due to incorrect beliefs about LBP, both from clinicians and consumers, and the pain related fear associated with LBP, that back problems are one of the most common reasons people present to hospital emergency departments globally (Edwards et al., 2017). This adds to the financial burden of LBP and a potentially wasteful use of limited health resources (Buchbinder et al., 2018).

Low back pain is one of the most feared health conditions (ACSQHC, 2022a), leading to fear-avoidance beliefs which have been shown to be present in high levels early in people that experience LBP (Coudeyre et al., 2007) and can predict the development to chronicity (Yihunie et al., 2023). Fear reduction dialogue, with health professionals equipped with knowledge, should be a focus of management in the acute stage of LBP (Bunzli et al., 2017). Appropriate patient education may assist in the reduction of fear avoidance behaviour, pain, disability and progression to chronicity that can result from incorrect beliefs (Bunzli et al., 2017).

Research into better LBP management options continues and more recently, research has been undertaken in the United Kingdom involving triaging musculoskeletal patients directly to physiotherapists (Downie et al., 2019). Although, this has allowed for cost effective, quicker access to care and improved outcomes (Downie et al., 2019), implementation into clinical practice is not quick and generalisability to other countries would need to be ascertained. In Australia, a national clinical care standard for LBP (ACSQHC, 2022b) guides health practitioners on early LBP management, with the aim to reduce the conflicting advice provided by health professionals to people with LBP and progression to chronicity. The clinical care standards outline the need for a thorough initial examination to rule out any serious, but rare, causes for LBP (ACSQHC, 2022b). For the 16% of Australians that experience back pain, the standards encourage the more effective early management of LBP that includes active rehabilitation, pain education and self-management rather than medication, rest and imaging which have limited effectiveness and can hinder recovery (ACSQHC, 2022b).

Self-management of LBP

Self-management involves the active participation of a person in their treatment to manage the medical, emotional and behavioural aspects of their condition (Lorig & Holman, 2003), by following treatment plans, carrying out health promoting activities, monitoring symptoms and managing the impact of the condition on well-being (Dwarswaard & van de Bovenkamp, 2015). Current LBP guidelines recommend self-management (Meroni et al., 2021) to improve quality of life by enhancing the day-to-day management of LBP (Lorig & Holman, 2003). Self-management of LBP encourages activity and continuation of normal activities and work. A self-management plan should involve a discussion between the health professional and the person experiencing LBP, to develop a personalised plan that validates the person's thoughts and feelings and incorporates their preferences and needs (ACSQHC, 2022b). The aim of a LBP self-management plan is to give the person experiencing LBP the guidance and confidence to return to normal activities by avoiding bed rest, taking control of their pain, altering lifestyle factors that contribute to LBP, and navigating barriers (ACSQHC, 2022a). Targeted self-management interventions that are personalised and aimed at modifiable biopsychosocial factors, such as physical activity, depression, disability, kinesiophobia and catastrophising, have shown small to medium effects (Banerjee et al., 2022) in reducing pain intensity and disability in people with LBP (Du et al., 2017). Personal and environmental characteristics, health status, access to the health care system and available resources (Battersby et al., 2010; Schulman-Green et al., 2016), can impact self-management and adherence (Battersby et al., 2010; Schulman-Green et al., 2016).

Individual circumstances, differences and preferences require consideration in self-management behaviour change interventions (Stieger et al., 2020) as local health care and

social norms can influence and vary disability resulting from LBP (Hartvigsen et al., 2018). Ethnic differences (Hartvigsen et al., 2018) and personality traits may impact a person's openness to change (Baum et al., 2004; Chapman et al., 2014; Stieger et al., 2020), guiding health behaviour and resultant self-management (Courtenay et al., 2002; Peyrot et al., 2018). Those more likely to undertake self-management health promoting activities and self-manage better, are more emotionally resilient and manage stress well (emotional stability), open to new experiences (openness), cooperative (agreeableness), able to control impulses and thoughtful (conscientiousness), sociable and assertive (extroversion) (Dietmaier et al., 2022; Hampson et al., 2016; Mendoza-Catalán et al., 2022; Power & Pluess, 2015; Sirois & Hirsch, 2015; Zhang et al., 2019). Increased use of physical activity apps has been shown to be associated with higher levels of some personality traits in the general population (Petersen et al., 2020). However, further research is required as the personality traits outlined in this research do not directly align with those mentioned above.

Self-management programs for LBP (Du et al., 2017; Guzmán et al., 2001; Keogh et al., 2015; Oliveira et al., 2012; Toomey et al., 2015; van Tulder et al., 2000) have achieved a moderate reduction in pain intensity and disability (Du et al., 2017; Oliveira et al., 2012; van Tulder et al., 2000). Adherence to self-management programs can be challenging for people with LBP, but is required to improve outcomes (Schaller et al., 2017), and an important component of behaviour change (Prochaska et al., 1992). Smartphones are widely used in developed countries (Statista, 2020) and have capacity to improve pain (Bailey et al., 2020; Cavanagh et al., 2019; Thurnheer et al., 2018) and disability outcomes (Shebib et al., 2019) for people with LBP. Smartphones apps have great potential for self-management by offering a cost-effective, portable and scalable option that can reduce barriers to care for people with LBP (Merolli et al., 2022; Murray et al., 2016).

Smartphone and smartphone app use

The number of smartphone users globally in 2023 is projected to surpass 6.6 billion or over 86% of the world's population (Statista, 2023b). In 2022, 255 billion apps were downloaded globally (Statista, 2023a). The global revenue from apps in 2020 was just under AUD 480 billion (Statista, 2021). The global revenue from mHealth (mobile health) apps was valued at over AUD 65 billion in 2022, with an expected compound annual growth rate of over 11% (Grand View Research [GVR], 2023), with medical apps accounting for the largest revenue share (GVR, 2023).

Digital health technologies, such as telehealth, have become indispensable in addressing many public health problems and to deliver health interventions (Cucciniello et al., 2021; El Benny et al., 2021; Stark et al., 2022). The need for remote care was particularly highlighted during the Covid-19 pandemic (Petracca et al., 2020; Stark et al., 2022), when access to in-clinic care was limited (Accenture, 2020; Merolli et al., 2022). Digital health interventions (accessed via mobile phones, other handheld devices or via a computer) include apps or Web and computer-based programs and can provide self-management guidance (Nicholl et al., 2017). Research has shown efficacy for the use of digital health interventions (Hewitt et al., 2020; Marcolino et al., 2018) and smartphone apps for LBP self-management, have been shown to improve disability and pain (Bailey et al., 2020; Cavanagh et al., 2019; Du et al., 2020; Rintala et al., 2022; Shebib et al., 2019; Thurnheer et al., 2018) or at least provide similar outcomes (Stark et al., 2022). Most internet users globally (93%) reported doing so via smartphones compared with 63% that accessed the internet via laptop or desktop (Statista, 2023c) and spent most of the time (92.5%) using mobile apps rather than browsers (Datareportal, 2022). Although websites are accessible to anyone on the internet, smartphone apps are optimised for mobile

phones, offer a better user experience with more features (such as cameras and real time location) and allow for personlisation and compilation of sensor data, push notifications and offline access once downloaded onto a smartphone (Turner-McGrievy et al., 2017). The significant use of smartphones, and their apps, globally can assist in reducing barriers experienced by LBP patients in accessing care (Stark et al., 2022). However, a systematic review approach is often not used for commercially available LBP self-management apps. Hence, the accuracy of the content and the provision of evidence-based advice is not guaranteed (Kasperbauer & Wright, 2020).

Self-management apps for LBP

The Lancet LBP Series Working Group have recognised the urgent need for affordable, effective and scalable strategies that can be used to manage LBP (Foster et al., 2018). The current waste of resources on high cost, low value care is an unaffordable management option, particularly in low to middle income countries (Foster et al., 2018). Smartphones are readily available globally (Statista, 2023b) and can address resource constraints (Bennell et al., 2017). The apps available through smartphones are affordable, scalable, easy to access and have been shown to be effective in reducing pain and disability for people with LBP (Bailey et al., 2020; Cavanagh et al., 2019; Du et al., 2020; Rintala et al., 2022; Shebib et al., 2019; Thurnheer et al., 2018). Unfortunately, the apps used in research are often not available for consumer use or require health professional support (Didyk et al., 2022b). Apps have the potential to encourage guideline-based recommendation of self-management (Rintala et al., 2022) and activity maintenance in a cost-effective manner that can improve access to credible health management guidance (Iyengar et al., 2020; Murray et al., 2016; Stark et al., 2022; Stec et al., 2019; Whitelaw et al., 2020).

The Covid-19 pandemic accelerated digital health use (Accenture, 2020; Merolli et al., 2022; Windisch et al., 2020) due to a lack of access to health professional face-to-face appointments (Stark et al., 2022). Consumers have shown a desire to continue the use of digital health management as part of their care (Accenture, 2020; Merolli et al., 2022) and look to trusted health professionals for guidance (Accenture, 2020). Research has also shown app-based rehabilitation of LBP to be at least as good as standard physiotherapy care (Stark et al., 2022). However, the uptake of smartphone app use as a potential management option for LBP is limited (Gordon et al., 2020) and may be a result of clinical practice barriers experienced by health professionals (Gordon et al., 2020; Sarradon-Eck et al., 2021).

Barriers to app use

Consumers are interested in using digital health options due to convenience (Byambasuren et al., 2020; Deloitte, 2018), however, consumer concerns of lower quality, and less professionalism and personalisation of care requires addressing (Deloitte, 2018). Older age and the useability of apps have been documented as a barriers for consumer app use (Byambasuren et al., 2020). Consumers look to health professionals for guidance (Accenture, 2020; Byambasuren et al., 2020) and recommendation of apps (Byambasuren et al., 2020) which requires health professionals to have the knowledge, and tools, required to do so.

Despite 54% of consumers being willing to use digital health options from their usual health care providers to manage their care, only 11% of health care providers recommend digital tools for health management (Accenture, 2020). The current clinical practice of fee for service encourages short duration consults. Time constraints in clinical practice can

impact the delivery of high value care (ACSQHC, 2022b; Foster et al., 2018; Sarradon-Eck et al., 2021) and be a barrier to the uptake of novel health management options. Other barriers that could impact uptake include data protection concerns and medical liability (Sarradon-Eck et al., 2021). To better address any barriers to app use as a LBP management option in clinical practice, a clear understanding of the barriers is required as they have not been explored extensively.

Current and future directions

Despite the plethora of health and wellness apps that are readily available to consumers, these apps continue to be poorly regulated globally. The USA, Europe (NICE, 2022; World Health Organisation [WHO], 2018) and now Australia (Australian Digital Health Agency [ADHA], 2022), are attempting to regulate or implement processes to improve app quality from the development stage. Australia has launched an assessment framework for mHealth apps to assist developers in designing, and consumers and health professionals with choosing, credible mHealth apps to encourage app use in clinical practice (ADHA, 2022). The framework is newly developed, implementation is due from the second half of 2023 to mid-2024 and targeted to developers not consumers (ADHA, 2022). It is voluntary and requires app developers to pay to nominate the app for a four-stage process of assessment prior to uploading the outcomes to an app library where the app is endorsed and provided with a star rating (ADHA, 2022). This process does not present immediate changes that can be incorporated into clinical practice and app use remains underutilised in healthcare (Gordon et al., 2020).

Given the lack of knowledge about smartphone apps for the self-management of LBP, there is a need for evaluation of the evidence on and for the use of LBP self-

management apps aligned with current guidelines. Additionally, an understanding of the self-efficacy and self-management practises of people with LBP and their use of apps for self-management is also required to guide the development of targeted and scalable interventions to improve self-management of LBP. Further knowledge on the use of smartphone LBP self-management apps by first point of contact health professionals for LBP management could address the barriers to adoption of smartphone LBP self-management app use in clinical practice.

A clear need remains for consumers and health professionals to quickly and easily assess app quality and potential to improve self-management and behaviour change. A checklist of required features, that incorporates the views and opinions of all stakeholders, would allow for quick, easy and relevant (Ioannidis, 2016) app assessment to guide app choice. A consumer-focused checklist could increase confidence in app quality, and as health professionals would not be recommending a specific app, would minimise liability concerns for health professionals (Sarradon-Eck et al., 2021). This could potentially increase the recommendation, and use, of quality LBP self-management apps by health professionals and consumers and potentially decrease the personal and economic burden of LBP globally.

Aims and thesis outline

The overall aim of this program of research was to evaluate the use of commercially available LBP self-management smartphone apps by consumers and health professionals to better guide implementation and adoption of app use into LBP management. Additionally, adherence with smartphone apps, individual factors such as personality traits, self-management and self-efficacy and their contribution to app use, confidence in choosing

and recommending apps and the barriers to app use in clinical practice were also evaluated.

A series of four studies was undertaken to address the overall aim of the program of research. The four studies included:

- Study 1 (chapter 2) involved a systematic review that aimed to evaluate and synthesise the current evidence of effectiveness of existing smartphone apps for the self-management of LBP, with a secondary aim, to explore participant adherence with smartphone apps.
- Study 2 (chapter 3) was a systematic assessment which aimed to assess the availability, content, and quality of commercially available, self-contained smartphone apps for the self-management of LBP in adults. The associations between quality, in-app user ratings and cost were also explored.
- Study 3 aimed to understand and explore consumer and health professional practises for LBP self-management and use of smartphone apps. Chapter 4 presents the results from an observational study incorporating an online consumer survey. The consumer survey evaluated what LBP self-management app features consumers like and use as well as individual factors such as personality traits, self-management and self-efficacy that may contribute to app use and improve LBP outcomes. Chapter 5 then presents an observational study incorporating a health professional survey. The health professional survey was undertaken to evaluate what LBP self-management apps, and app features, health professionals like or use, and the barriers to app use in clinical practice.
- Study 4 (chapter 6) aimed to co-design and pilot test a LBP self-management app assessment tool with health professionals and consumers. The tool was developed with the aim of assessing the quality and behaviour change and self-management potential of LBP self-management apps to ease the process of app assessment and inform choice for consumers and health professionals.

The four studies are formatted and presented within the thesis as publication manuscripts. Studies 1 and 2 have been published in the *Disability and Rehabilitation* Journal (Q1). A further three manuscripts are currently under review with Q1 journals, two manuscripts from Study 3 (one for consumers and one for health professionals) and one for Study 4. As a result, there is some repetition within the introduction sections of each manuscript in the thesis.

Chapter Two – Study 1

Effectiveness of smartphone apps for the self-management of low back pain in adults: a systematic review.

This chapter answers the aim “to explore the effectiveness of smartphone apps for the self-management of LBP in adults in improving pain, function, quality of life and adherence”. This chapter describes a systematic review which was completed to determine the effectiveness of smartphone apps for the self-management of LBP and potential for recommendation of use in clinical practice. It was important to explore this prior to conducting the remaining studies where app quality and use were being evaluated.

Statement of co-authorship:

All authors were involved in formulating the concept and design of the review. Claudia Didyk conducted the literature search, Claudia Didyk and Belinda Lange conducted the data analysis, and Claudia Didyk completed the initial draft of the manuscript. All authors edited multiple revisions of the manuscript. See Appendix 1 for the signed co-authorship approval form. No conflict of interest is reported by the authors and funding was not provided for this review. The authors would like to acknowledge Josephine McGill (Academic Librarian) for her valuable assistance peer reviewing the search strategy for this systematic review.

This manuscript has been published by Taylor & Francis in Disability and Rehabilitation, a quartile one journal, on 02/12/2021. This publication has been cited three times, and has an Altmetric score of 13, being in the top 25% of all outputs scored by Altmetric (19/07/2023). The manuscript has been formatted for consistency with this thesis. The final published version of the manuscript is available via the following reference:

Didyk, C., Lewis, L. K., & Lange, B. (2022). Effectiveness of smartphone apps for the self-management of low back pain in adults: a systematic review. Disability and Rehabilitation, 44(25), 7781–7790. https://doi.org/10.1080/09638288.2021.2005161

Abstract

Purpose: To explore the effectiveness of smartphone apps for the self-management of low back pain in adults.

Methods: Prospectively registered systematic review of randomised controlled trials (2008-) published in English. Studies investigating smartphone apps for the self-management of low back pain (adults ≥18 years), including ≥1 NICE low back pain and sciatica clinical guideline recommended component and functioning without health professional input were included. Outcomes were pain, function, quality of life and adherence.

Results: Six studies were included (n= 2100 participants). All comparator groups incorporated some form of management (n=3 physiotherapy, n=2 GPs, n=1 not specified). Three studies reported a significant decrease in pain intensity in the intervention group compared with control. One study reported no significant difference between groups in pain self-efficacy. One study reported a significant reduction in disability (function) in the intervention group compared with control. Two studies reported no between group differences in quality of life. One study reported no correlation between adherence (app use) and change in pain intensity and one study reported that app use mediated the effect of teleconsultations on pain improvements.

Conclusions: Inconclusive evidence exists for the use of smartphone applications for the self-management of low back pain. Further research is needed.

Keywords: smartphone apps; low back pain; self-management; systematic review; adults

Introduction

Low back pain is a leading cause of disability worldwide and a global economic health issue (Vos et al., 2017). Back pain impacts activity levels and workforce participation, causes psychological distress (AIHW, 2016; Du et al., 2019), considerable levels of pain and disability (AIHW, 2019d) and can result in hospitalisation. The economic burden of back pain can be significant (AIHW, 2019c), with both direct and indirect costs such as community health expenditures, public health programs, aids and appliances, health administration, capital expenditures, productivity loss due to absenteeism, loss of superannuation and taxation revenue, carers and welfare (AOV, 2013). There is a clear need for proactive management responses and intervention programs to meet the financial and human costs of LBP.

Current LBP guidelines recommend self-management, active rehabilitation and exercise (NICE, 2016; Bernstein et al., 2017). Numerous studies have investigated interventions for people with LBP, many incorporating principles of self-management, active rehabilitation and exercise (Baena-Beato et al., 2014; Kim et al., 2015; Monro et al., 2015; Moon et al., 2015; Zhang et al., 2014). Self-management requires a person to actively participate in their treatment and be responsible for the daily medical, behavioural and emotional tasks required for the management of their condition (Lorig & Holman, 2003). To effectively self-manage, it is essential for a person to follow a treatment plan, such as taking medication as recommended, and monitor the symptoms of their condition as well as carry out health promoting activities, such as maintaining activity levels, and manage the impact of the condition on their well-being and personal relationships (Dwarswaard & van de Bovenkamp, 2015). Interventions aimed at self-management must address each of these

domains (medical, behavioural and emotional) in the management of a condition (Lorig & Holman, 2003), which can often be costly, time consuming and difficult to administer (Battersby et al., 2010). Additionally, internal and external factors, including personal and environmental characteristics, health status, available resources, and access to the health care system, can be barriers or enablers and affect an individual's capacity to self-manage and adhere to self-management programs long-term (Battersby et al., 2010; Schulman-Green et al., 2016).

Smartphone apps are an easily accessible and portable treatment modality that have the potential to encourage physical activity engagement and facilitate self-management. Smartphones are used by most of the population in developed countries, and this use is steadily increasing, with the number of smartphone users expected to reach 3.8 billion by 2021 (Statista, 2020). Smartphones offer a mobile health platform that is easily accessible and cost effective for consumers that may be used in place of, or as an adjunct to, in-clinic treatment (Wang et al., 2018). Although the concept of self-management is expansive, apps encouraging self-management should promote consumer involvement in their care and, provide advice and education to enhance skills required for daily symptom management such as unsupervised physical activity programs (Machado et al., 2016). Smartphone apps have great potential for widespread implementation of health care interventions by decreasing healthcare costs, improving access to health management guidance and monitoring (Stec et al., 2019), and improving health-related outcomes (Thurnheer et al., 2018) such as pain (Cavanagh et al., 2019) and disability (Shebib et al., 2019). However, content accuracy including alignment with current guidelines and evidence-based recommendations of apps is not well regulated (Cortez et al., 2014).

Given the lack of knowledge about smartphone apps for the self-management of LBP, there is a need for evaluation of the evidence for the use of these apps. Therefore, this review aimed to systematically identify, evaluate and synthesise the current evidence of effectiveness of existing smartphone apps for the self-management of LBP. The secondary aim was to explore participant adherence with smartphone apps for the self-management of LBP.

The questions for this review were:

1. What is the effectiveness of smartphone apps used for the self-management of LBP on pain, quality of life (QOL) and function?
2. How well do participants adhere with smartphone apps for the self-management of LBP and what are the relationships between adherence, pain, QOL and function?

Methods

A systematic review protocol was prospectively registered in PROSPERO (CRD42020184486). The review was conducted and reported according to PRISMA guidelines (Moher et al., 2009).

Identification and selection of studies

Literature search

In June 2021, a systematic literature search of nine electronic databases (Medline, The Cochrane Library, Scopus, CINAHL, Pedro, LILACS, Web of Science, ProQuest and IEEEXplore) was undertaken. The search strategy was peer reviewed by an academic librarian, and wherever possible, used a combination of keywords and subject headings for back pain and smartphone apps. The original search strategy was registered in PROSPERO, but following peer review, an additional five databases were added. An example of the search strategy (Medline) is presented in supplementary material table S2.1. No limits were applied at this stage.

Study selection

Two independent reviewers (CD and BL) screened all citations for relevance by title and abstract. Pre-specified eligibility criteria were applied and full-text analysis for eligibility was performed by two independent reviewers (CD and BL). The full text was obtained for citations with no abstract, or where ambiguity existed. Disagreements were resolved by consensus with a third member of the research team (LL). Reference lists of included studies and relevant systematic reviews were searched by two reviewers (CD and BL) for additional studies meeting the eligibility criteria.

Table S 2. 1.

Search Strategy – Medline (Via OVID)

Topic area	Keywords and subject headings
Back Pain	1. "back ache".mp. 2. "backache".mp. 3. "back pain".mp. or exp Back Pain/ 4. exp Low Back Pain/ 5. "LBP".mp. 6. "lumbago".mp. 7. "lumbar ache".mp. 8. "lumbar pain".mp. 9. "spinal ache".mp. 10. "spinal pain".mp. 11. or/1-10
Smartphone apps	12. "app".mp. 13. "application program*".mp. 14. "application software*".mp. 15. "cell* phone".mp. 16. exp Cellular Phone/ 17. "digital health".mp. 18. "digital intervention".mp. 19. "android".mp. 20. "iPad".mp. 21. "iPhone".mp. 22. "mobile application*".mp. 23. exp Mobile Applications/ 24. "mobile communication*".mp. 25. "mobile device".mp. 26. "mobile health".mp. 27. "mobile phone".mp. 28. "mobile technology".mp. 29. "smart phone".mp. 30. "smartphone".mp. 31. "smartphone app*".mp. 32. "smart phone app*".mp. 33. or/12-32 34. 11 and 33

Note. / Subject Heading; exp explode function; mp multi-purpose field in Medline (Title, Original Title, Abstract, Subject Heading, Name of Substance, and Registry Word fields).

Eligibility criteria

The following eligibility criteria were applied:

Design - Included studies were randomised controlled trials (RCTs).

Population - Studies involving community-dwelling adults aged ≥18 years with non-specific LBP of any duration were included. English language restrictions and publication year

restrictions, from 2008 to present, were placed on studies at full text review stage if required. This publication year restriction was applied as the Google play and Apple App stores opened in 2008.

Intervention – To be included, studies must have included smartphone apps for the self-management of LBP in adults. Self-management requires a person to actively participate in their treatment and be responsible for the daily medical, behavioural and emotional tasks required for the management of their condition (Lorig & Holman, 2003). This review included evidence of effectiveness of any existing apps, able to be accessed through a smartphone/tablet that provided self-management assistance for LBP with at least one NICE LBP and sciatica clinical guideline (NICE, 2016) recommended component. These self-management components include, exercise, psychological therapy, manual therapy (or a combination of physical, psychological and manual therapy) and return to work programs. Self-management support should be provided throughout the treatment pathway with person-specific advice and information related to LBP and encouragement to perform daily activities. Exercise can be in the form of mind-body, biomechanical, aerobic or a combination that suits the individual's preferences, needs and capabilities. Psychological therapy such as the cognitive behavioural method can be used in combination with exercise and manual therapy. Return to work should be encouraged as part of maintaining normal daily activities (NICE, 2016). To be included in the review, apps could function with or without health professional input.

Comparator - Comparator groups of health professional usual care, non-digital self-management or no intervention were included.

Outcomes – Primary outcomes of interest were app effectiveness on pain (e.g. measured by pain scales such as the Visual Analogue Scale (VAS) or the Numerical Pain Rating Scale (NPRS)), QOL (e.g. measured by the Health Related Quality of Life (HRQOL)

questionnaires such as AQol or RAND-36), and physical function (e.g. measured by questionnaires such as the Roland-Morris Low Back Pain and Disability Questionnaire, or scales such as the Oswestry Disability Index (ODI) the Back Pain Functional Scale or the Low Back Outcome Score Scale).

The secondary outcome of interest was adherence (e.g. measured by built-in app measures to evaluate app use and duration), recording of symptoms or exercise performance and adherence questionnaires such as the RAQ-M (the Modified Rehabilitation Adherence Questionnaire) a 25-item scale evaluating adherence barriers and a diary as a non-app outcome measure.

Studies were excluded if they recruited participants with spinal pain due to pregnancy, surgery, fracture, cancer or spinal cord injury. Studies were excluded if the app focus was related only to pharmacological monitoring or if devices other than a smartphone or computer tablet were used for data collection.

Assessment of characteristics of studies

Risk of bias

The Clinical Appraisal Skills Program (CASP) checklist for RCTs (Critical Appraisal Skills Programme [CASP], 2018) and the TIDieR checklist (Hoffmann et al., 2014) were used to assess risk of bias and completeness of reporting in included studies. Two reviewers (CD and BL) independently assessed risk of bias, and a third reviewer (LL) resolved disagreements. Final decisions were via consensus. The CASP checklist uses 11

questions (answered with either “yes”, “no”, “can’t tell” or free text responses) to address the broad areas of study validity, results and generalisability (CASP, 2018). The responses to the 11 questions guided the overall risk of bias assessment for each trial. Trials were not excluded based on risk of methodological bias. The TIDieR (Template for Intervention Description and Replication) checklist uses 12 items to guide the evaluation of completeness of reporting and replicability of interventions in published clinical trials (Hoffmann et al., 2014).

Data analysis

Data extraction and synthesis

Using a standardised data extraction template, two reviewers (CD and BL) independently extracted study characteristic data. Both reviewers then compared and collated data extraction. Study characteristics included country, study design, population, source, sample size, participant characteristics, eligibility criteria, intervention, control/comparator, assessment time points, outcome measures, estimate of treatment effects and summary of results. Both within and between group statistical analyses were extracted for all relevant outcomes. Included studies were examined for similarities in participants, interventions and outcomes. In the case of heterogeneity in studies, a narrative synthesis was planned.

Results

Flow of studies through the review

Study selection

The electronic database search yielded 1815 citations. After the removal of 756 duplicates, 1059 citations were screened by title and abstract. After title and abstract screening, a further 1042 studies were excluded, resulting in 17 studies for full-text screening. A further 11 studies were removed (7 ineligible interventions, 1 ineligible study design, 1 ineligible comparators, 1 conference abstract and 1 not available in English) and no further studies were identified from screening reference lists. Six studies were included (Figure 2.1).

Characteristics of studies

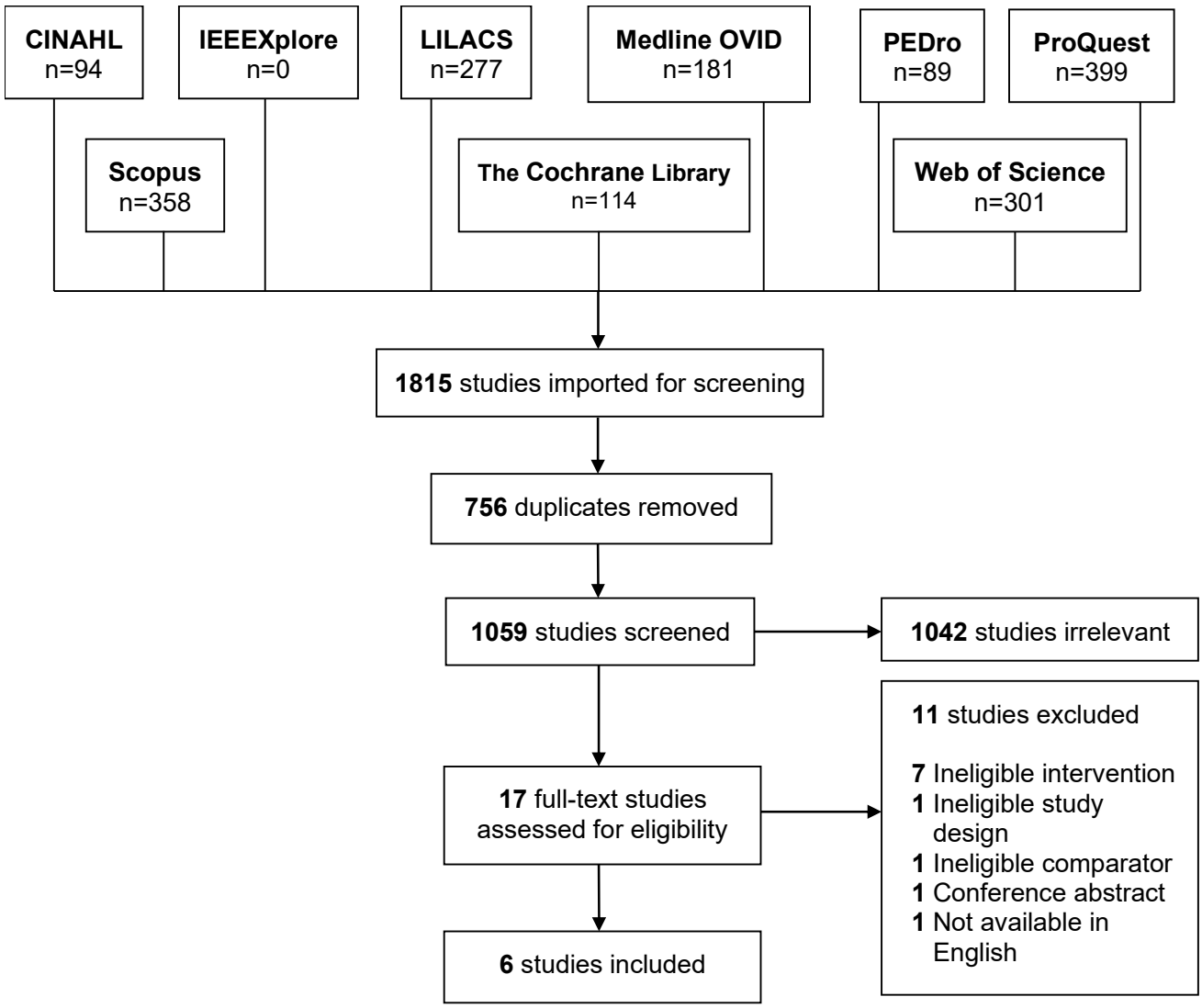
Description of included studies

One of the included studies was undertaken in India, one in the USA, one in Africa (Nigeria), two in Germany and one in China. All studies were published between 2015 and 2020. A total of 2100 participants were included, ranging from eight (Yang et al., 2019) to 1245 (Priebe et al., 2020) participants in individual studies. The six included studies were heterogeneous in their interventions and outcomes and although two studies (Chhabra et al., 2018; Irvine et al., 2015) compared app use to usual care, usual care differed in each study. One study explored app use versus physiotherapy in-clinic McKenzie therapy

(Mbada et al., 2017). Two studies (Toelle et al., 2019; Yang et al., 2019) explored app use versus usual physiotherapy care, however, the small number of participants (n=8) in Yang et al. (2019) meant that meta-analysis was not indicated (Higgins et al., 2019).

Figure 2. 1.

Flow of Studies Through the Review



Study population

The characteristics of the included studies are summarised in table 2.1. The duration of LBP symptoms, eligibility criteria, recruitment, content and delivery of interventions, intervention time points and outcome measures varied between studies.

Table 2. 1.

Summary of Included Studies

Study	Participants	Interventions	Primary Outcome Measures
Chhabra et al. (2018)	Intervention: n=45, Mean age (years) = 41, Female (%) = not reported Control: n=48, Mean age (years) = 41, Female (%) = not reported ≥ 18 years of age with LBP ≥ 12 weeks, Pain ≥ 5 on NRS consistently, Access to android mobile device with internet access, prescribed regular medication and some physical activity, fluent in written and spoken English Recruitment: Private hospital outpatient spine department	Intervention - Doctor's usual prescription + Snapcare smartphone app for 12 weeks to increase and maintain physical activity and increase engagement and compliance. Control - Usual care - Doctor's usual prescription of medication and exercise.	*Pain Intensity:* NPRS (0-10) *Disability:* MODI (0-100) Baseline and 12 weeks with no further assessment post intervention
Irvine et al. (2015)	Intervention: n=199, Alternative Care: n=199, Control: n=199, Mean age (years) = not reported, Female (%) = 60 (overall) 18-65 years of age, living in the USA, working ≥ part time, retired or a family member of a collaborating company employee, experienced LBP in previous 3 months, cleared of medical risks, access to internet that can play videos, a working email address. Recruitment: Internet	Intervention - FitBack Program - A mobile-Web based self-management program that provides tailored education, behaviour change and self-care strategies. Participants also had access to 30 videos on exercise and pain management. 8 weekly email reminders were sent to participants to log on to the program. Control - Usual care: no specific interventions but received emails to complete assessment questionnaires. Alternative Care: an initial email and 8 reminder emails to access links to 6 websites about NLBP	Primary outcomes not specifically stated. *Pain intensity:* 10-point pain dial (1-10), level, frequency and duration. Baseline, post intervention at 8 weeks and then another 8 weeks after the intervention had ceased, but access still granted, at 16 weeks.

Study	Participants	Interventions	Primary Outcome Measures
Mbada et al. (2017)	Intervention: n=21, Mean age (years) = 47, Female (%) = 67 Control: n=26, Mean age (years) = 50, Female (%) = 77 20-65 years of age, clinical diagnosis of chronic non-specific LBP, no obvious deformities affecting the trunk or upper and lower extremities. Recruitment: Outpatient physiotherapy department in a university teaching hospital	Intervention - Telerehabilitation-based McKenzie therapy (TBMT) app – personalised and self-guided back care education and McKenzie extension protocol (i.e., Extension Lying Prone, Extension in Prone, and Extension in Standing). Control - Clinic-based McKenzie therapy (CBMT) - McKenzie extension protocol (extension lying Prone, extension in prone, and extension in standing, repeated up to ten times) and a set of back care education instructions (9-item instructional guide on standing, sitting, lifting, and other activities of daily living for home).	Primary outcomes not specifically stated. *Pain Intensity* - Quadruple Visual Analogue Scale (QVAS). *Disability (Participation restriction)* - Oswestry Disability Index (ODI). Disability (*Activity limitation)* - Roland Morris Disability Questionnaire (RMDQ). *Health related QOL* - SF-12 General Health Status Questionnaire. Baseline, 4 weeks and 8 weeks
Priebe et al. (2020)	Intervention: n=933, Mean age (years) = 42, Female (%) = 65 Control: n=312, Mean age (years) = 37, Female (%) = 64 18-65 years of age, acute (up to 6 weeks) or subacute (6–12 weeks) non-specific LBP, ≤ 6 recurrent episodes not longer than 12 weeks, and ended ≥ 6 months prior to current episode, email access, intervention group required access to a smartphone or tablet to use the Kaia App, fluent in German and a member of the statutory health insurances AOK Bayern, BARMER or DAK Recruitment: Facebook advertisement and participating GPs	Intervention - STarT Back questionnaire and score at commencement of treatment, high-risk patients' GPs could undertake a teleconsultation and discuss appropriate treatment with a pain specialist at the Rise-uP head office. The Rise-uP supervision platform guided communication and data flow between patients, StatConsult and Kaia. Participants granted access to the Kaia back pain app and advised by their GP to use the app and complete the educational program, physiotherapy and mindfulness as frequently as possible. Control – national guideline standard of care by GP.	*Pain Intensity:* NPRS (0-10) *Baseline (T0) and 3 months (T1) via questionnaires.*
Toelle et al. (2019)	Intervention: n=53, Mean age (years) = 41, Female (%) = 73 Control: n=48, Mean age (years) = 43, Female (%) = 67 18-65 years of age with non-specific LBP ≥ 2 week and ≤ 12 months	Intervention - Kaia app - includes 3 modules 1) back pain specific education, 2) physiotherapy/physical exercise and 3) mindfulness and relaxation techniques. Participants encouraged to use the Kaia app on a smartphone 4 x a week for 3 months. All 3 modules included in daily content. Progress is adapted by the app daily.	*Pain Intensity:* NPRS (0-10) Baseline, 6 weeks and 12 weeks via hardcopy questionnaires

Study	Participants	Interventions	Primary Outcome Measures
	Pain ≥ 4 on NRS in the last 2 weeks and ongoing for the last 6 weeks to 12 months, no experience with the Kaia App, fluent in German. Recruitment: Pain Centre Facebook page, website/GPs	Control - 6 ≥ 20 minute, individual, face to face physiotherapy sessions once a week (manual therapy and exercise). Encouraged to maintain an active lifestyle and perform physiotherapy exercises at home. Additionally, 6 emails (one weekly), were sent with links to low back pain education and self-management websites.	
Yang et al. (2019)	Intervention: n=5, Mean age (years) = 35, Female (%) = 25 Control: n=3, Mean age (years) = 50, Female (%) = 75 ≥ 18 years of age with non-specific LBP ≥ 3 months, Access to android or Apple mobile device to download Apps, ability to perform brief exercises during working hours. Recruitment: University rehabilitation clinic	Intervention - Four-week Pain Care app providing a self-management program of individualised therapist prescribed exercises and daily app reminders to exercise and use the pain diary. The App consisted of three components: About and Tools to tailor reminders, New Pain Episode and Personal Report to enable early data retrieval. Control - Physiotherapy treatment - physiotherapy prescribed manual therapy, electrophysical therapy and traction.	*Pain Intensity*: VAS (0-100) *Self-efficacy*: PSEQ, *Disability*: RMDQ, *Health related quality of life*: SF36 Baseline, 2 weeks, post intervention (4 weeks) with no further assessment post intervention

Note. NPRS = Numeric Pain Rating Scale, MODI = Modified Oswestry Disability Index, VAS = Visual Analogue Scale, PSEQ = Pain Self-Efficacy Questionnaire, RMDQ = Roland Morris Disability Questionnaire, SF36 = Short Form Health Survey

Participants

Table 2.2 summarises the participant characteristics in the included studies. Participants were recruited from a variety of settings. Irvine et al. (2015) did not report the mean age of the sample, the percentage of female participants was not reported by Chhabra et al. (2018), and Irvine et al. (2015) did not separate gender for treatment and control groups and only provided an overall result of female participants.

Intervention

There were five different smartphone apps identified in the included studies. Five studies used apps that were not available commercially (Chhabra et al., 2018; Irvine et al., 2015; Mbada et al., 2017; Priebe et al., 2020; Toelle et al., 2019). The Snapcare and Kaia apps were developed by technology companies and provided to the researchers free of charge (Chhabra et al., 2018; Toelle et al., 2019). The telerehabilitation-based McKenzie therapy app (TMBT) was developed by the authors and the trial partly funded by an African Doctoral Dissertation Research Fellowship (ADDRF) re-entry grant (Mbada et al., 2017). The FitBack app was specifically developed for the study and funded by a small business research grant (Irvine et al., 2015). The Pain Care app, a commercially available app not currently available in app stores in the Oceania region, was used in the final study (Yang et al., 2019).

The five included apps had similarities in their function by providing personalised and tailored activity and home exercise programs and reminders to target engagement and compliance. The Snapcare and Kaia apps both updated content based on individual needs (Chhabra et al., 2018; Toelle et al., 2019). The FitBack app used a self-tailored cognitive behavioural approach by targeting self-efficacy and allowing individuals to control the strategies used (Irvine et al., 2015). The TMBT app used phone calls and SMSs to encourage engagement and compliance of the personalised exercises (Mbada et al., 2017), whilst the Pain Care app functioned by reminding individuals to undertake their therapist prescribed home exercise program and self-monitor pain and activity levels (Yang et al., 2019). The FitBack and Kaia apps also provided tailored education behavioural change

techniques such as a cognitive behavioural approach (Irvine et al., 2015) or mindfulness and relaxation techniques (Priebe et al., 2020; Toelle et al., 2019).

The duration of app use differed in the four studies. The apps also differed in some other features and directions for use. In the Snapcare app participants received daily activity goals and a standard written treatment prescription from the GP (Chhabra et al., 2018). Participants using the FitBack app received weekly self-care messages that encouraged self-tracking of pain and activity levels (Irvine et al., 2015). The Kaia app contained over 30 guideline and textbook-based educational units (Toelle et al., 2019). The Pain Care and TMBT apps did not generate an exercise program and exercises were therapist prescribed (Mbada et al., 2017; Yang et al., 2019).

Comparator

All included studies included some form of management in the comparator group/s. Three studies involved physiotherapy, two included GPs and one was not reported. Five of the four studies included two groups, intervention and comparator (Chhabra et al., 2018; Mbada et al., 2017; Priebe et al., 2020; Toelle et al., 2019; Yang et al., 2019), whilst one study included three groups with an additional ‘alternative care’ group (Irvine et al., 2015).

Outcomes

Five different primary outcomes were specified in the trials, however, two trials did not specify primary outcome/s (Irvine et al., 2015; Mbada et al., 2017). Of those that specified primary outcomes, the number in each trial ranged from one to four.

Pain intensity. All six included studies measured pain intensity, with three studies using the NPRS, one a 10-point pain dial adapted from the Wong Baker pain scale (Irvine et al., 2015), one the VAS (Yang et al., 2019) and one the QVAS (Mbada et al., 2017).

Function. Disability was reported as a primary outcome measure relating to function in three trials (Chhabra et al., 2018; Mbada et al., 2017; Yang et al., 2019). The Roland-Morris Disability Questionnaire (RMDQ) was used in two studies (Mbada et al., 2017; Jingyi Yang et al., 2019), the Oswestry Disabilty Index in one (Mbada et al., 2017) and the Modified Oswestry Disability Index (MODI) in the other (Chhabra et al., 2018).

Pain self-efficacy. Pain self-efficacy was measured in one trial (Priebe et al., 2020) using the Pain Self-Efficacy Questionnaire (PSEQ).

QOL. Health related QOL was assessed in two trials, one using the SF12 (Mbada et al., 2017) and the other using the SF36 (Yang et al., 2019). Both the SF12 and the SF36 measure eight subscales related to QOL (physical function, role physical, bodily pain, general health, vitality, social function, role emotional and mental health).

Adherence. All six included studies measured adherence, five using built-in app measures to evaluate app use and duration, and one using phone calls and SMSs to track adherence (Mbada et al., 2017). However, only two trials specifically reported adherence findings (Priebe et al., 2020; Toelle et al., 2019).

Risk of bias

Methodological risk of bias was assessed using the CASP RCT Checklist (table 2.2) (CASP, 2018). None of the trials blinded participants or health care providers, one blinded assessors (Chhabra et al., 2018), one blinded research assistants (Mbada et al., 2017) and one further trial reported single blinding but did not specify who (Yang et al., 2019).

Chhabra et al. (2018) was considered the lowest risk of bias as the other five trials all presented with bias in selection, performance and detection. Three trials (Irvine et al., 2015; Priebe et al., 2020; Toelle et al., 2019) prospectively registered protocols and four stated primary outcomes. Three trials reported intention to treat analyses (Chhabra et al., 2018; Irvine et al., 2015; Yang et al., 2019). Two trials (Chhabra et al., 2018; Toelle et al., 2019) reported receiving trial funding from the technology companies providing the app, but the authors declared either no financial gain or direct tech company involvement in the trial, respectively. One trial (Priebe et al., 2020) reported receiving government funding for the trial and, aside for remuneration for various services rendered for those involved in the trial, no further funder involvement occurred in the trial. Mbada et al. (2017) and Irvine et al. (2015) reported academic funding for the trial and Yang et al. (2019) did not report funding sources.

Table 2. 2.

Summary of CASP Randomised Controlled Trial Checklist

	Chhabra et al. (2018)	Irvine et al. (2015)	Mbada et al. (2017)	Priebe et al. (2020)	Toelle et al. (2019)	Yang et al. (2019)
1. Does the trial address a clearly focused issue?	Yes	Yes	Yes	Yes	Yes	Yes
2. Was the assignment of patients to treatment randomised?	Yes	Can't tell	Yes	Yes	Yes	Yes
3. Were all the patients who entered the trial properly accounted for at its conclusion?	Yes	Yes	No	No	No	Yes
4. Were patients, health workers and study personnel 'blind' to treatment?	No	No	No	No	No	Can't tell
5. Were the groups similar at the start of the trial?	Yes	Yes	Yes	No	Yes	Yes
6. Aside from the experimental intervention, were the groups treated equally?	Yes	Yes	Yes	No	No	Yes
9. Can the results be applied to the local population, or in your context?	Yes	Yes	Yes	Yes	Yes	Yes
10.Were all clinically important outcomes considered?	Yes	Yes	Yes	Yes	Yes	Yes
11. Are the benefits worth the harms and costs?	Yes	Yes	Yes	Yes	Can't Tell	Yes

Note. For simplicity of presentation, Items 7 and 8 in the CASP checklist are not included in the table as they required a text response on treatment effect size and significance and these data are outlined in the manuscript text.

The TIDieR checklist (Hoffmann et al., 2014), presented in supplementary material table S2.2, showed that two trials (Chhabra et al., 2018; Irvine et al., 2015) satisfied all the checklist items and provided all the information within the primary paper. One other trial (Toelle et al., 2019) also provided all the required information within the primary paper but also provided supplementary material for five of the checklist items (4 - What, 5 - Who, 6 - How, 7 - Where, 8 – When and how much). Three trials (Mbada et al., 2017; Priebe et al., 2020; Yang et al., 2019) all lacked some detail in their reporting of the intervention, ranging from one to four items. One trial (Yang et al., 2019) lacked sufficient detail for two checklist items (4 - Who, 5 – How). One trial (Mbada et al., 2017) lacked sufficient detail for two checklist items (5 – Who, 8 – When and how much) and did not report on two other items (10 – Modifications, 12 – How well: actual), item 10 was not applicable. One trial (Priebe et al., 2020) did not report on one checklist item (10 – Modifications) as it was not applicable.

Table S2. 1.

TIDieR Checklist

	Chhabra et al. (2018)	Irvine et al. (2015)	Mbada et al. (2017)	Priebe et al. (2020)	Toelle et al. (2019)	Yang et al. (2019)
1. Brief Name	Yes	Yes	Yes	Yes	Yes	Yes
2. Why	Yes	Yes	Yes	Yes	Yes	Yes
3. What – Materials	Yes	Yes	Yes	Yes	Yes	Yes
4. What – Procedures	Yes	Yes	Yes	Yes	Yes	Yes
5. Who Provided	Yes	Yes	?	Yes	Yes	?
6. How	Yes	Yes	Yes	Yes	Yes	?
7. Where	Yes	Yes	Yes	Yes	Yes	Yes
8. When and How Much	Yes	Yes	?	Yes	Yes	Yes
9. Tailoring	Yes	Yes	Yes	Yes	Yes	Yes
10. Modifications	Yes	Yes	N/A	N/A	Yes	Yes
11. How Well – Planned	Yes	Yes	Yes	Yes	Yes	Yes
12. How well – Actual	Yes	Yes	N/A	Yes	Yes	Yes

Note. ? = if information about the element is not reported/not sufficiently reported
N/A = N/A if an item is not applicable for the intervention

Effects of interventions

Table 2.3 summarises the effectiveness of smartphone app interventions in the included studies.

Pain Intensity

Pain intensity was an outcome measure in all six included studies. One study reported pain as a combination of pain intensity, duration and frequency (Irvine et al., 2015) and another reported pain as that at the time of assessment, average pain, pain at its best and at its worst (Mbada et al., 2017). Three of the six included trials reported a significant reduction in pain intensity in the intervention compared with comparator groups (Table 2.3) (Irvine et al., 2015; Priebe et al., 2020; Toelle et al., 2019).

Function

Three included studies reported results on disability outcome measures related to function (Chhabra et al., 2018; Mbada et al., 2017; Yang et al., 2019). Although Irvine et al. (2015) stated the ODI as a primary outcome in their trial registration, no results were reported for this measure. Chhabra et al. (2018) reported a significant difference between group MODI scores at baseline. After adjusting for this difference, they showed a significant reduction in disability in the intervention compared with comparator groups (Chhabra et al., 2018).

Table 2. 3.

Summary of Effectiveness of Interventions in the Included Studies

Pain Intensity	
Trial	*Results*
Irvine et al. (2015)	Significant between group difference in favour of the intervention compared with usual care (**p=0.002** at 16-weeks)*
Mbada et al. (2017)	No significant between group difference (**p>0.05**)
Priebe et al. (2020)	Significant between group difference in favour of the intervention compared with control (**p<0.001** at 3-months)*
Toelle et al. (2019)	Significant between group difference in favour of the intervention (**p=0.021** at 12-weeks)*
Yang et al. (2019)	No significant between group difference (**p=0.24**)
Chhabra et al. (2018)	No significant between group difference (**p=0.23**)
Disability	
Trial	*Results*
Chhabra et al. (2018)	Significant between group difference in favour of the intervention (**p<0.001**)*
Mbada et al. (2017)	No significant between group difference (**p>0.05**)
Yang et al. (2019)	No significant between group difference (**p=0.16**)
Pain Self-efficacy	
Trial	*Results*
Yang et al. (2019)	No significant between group difference (**p=0.18**)
Health Related QOL	
Trial	*Results*
Mbada et al. (2017)	No significant between group difference (**p>0.05**) ↑ vitality (**p=0.011**)*
Yang et al. (2019)	No significant between group differences (**p>0.05**) ↓ bodily pain (**p=0.008**)* ↑ mental health (**p=0.013**)*

Note. n=6
***** = Significant between group difference (p≤0.05)

Pain self-efficacy

Pain self-efficacy was measured using the Pain Self-Efficacy Questionnaire (PSEQ) in one trial (Yang et al., 2019) which found no significant difference between intervention and comparator groups.

Health Related QOL

Yang et al. (2019) reported that two of the eight subsections (bodily pain and mental health) of the health related QOL measures showed significant within group improvements in post intervention results in the intervention group (Yang et al., 2019). No significant between group differences were reported (Yang et al., 2019). Mbada et al. (2017) reported that the vitality subsection showed significant between group differences at eight weeks.

Adherence

Frequency of use was recommended and recorded in all studies, however, adherence was not reported in the findings for four of the six trials. Toelle et al. (2019) and Priebe et al. (2020) were the only included studies that specifically reported findings on participant adherence. Toelle et al. (2019) reported that the intervention group used the Kaia app an average of 35 (SD=22) of the 90 days in the trial. There was no correlation between app use and change in pain intensity ($p>0.05$). This trial also measured adherence in the physiotherapy and online education comparator group. Participants attended 90% (mean=5.39 sessions, SD=1.22) of the six sessions, 62% of participants used the online links at six weeks and 41% at 12 weeks. The trial also reported no correlation between completed sessions and outcome measures. Priebe et al. (2020) reported that the intervention group used the Kaia app on 25 days of the 90-day trial. There was no correlation between app use and change in pain intensity ($p>0.05$). This trial also measured the effect of teleconsultation pain improvement and app use, and found that the effect of teleconsultation was not significant ($p>0.05$) when adherence was entered as a covariant,

and fully mediated by app use. All app interventions aimed to increase adherence by attempting to maintain participant engagement towards home exercising. The Snapcare app collected daily activity data based on patient use (Chhabra et al., 2018). One study allowed unlimited access to the intervention (the Fitback app) but did not mention requirements for frequency of use, however, a weekly reminder was emailed to participants for the duration of the eight week trial (Irvine et al., 2015). One trial used the Pain Care app and sent participants four reminders through the app each day, to perform exercises, for the four week duration of the trial (Yang et al., 2019). One trial encouraged participants to use the Kaia app at least four times a week during the three month duration of the trial (Toelle et al., 2019), whilst the other trial that also used the Kaia app (Priebe et al., 2020) encouraged participants to use the app as frequently as possible. One trial tele-monitored adherence via phone calls and SMSs to participants to encourage app use (Mbada et al., 2017). Although four of the six studies provided participants with a recommended frequency of use (Chhabra et al., 2018; Priebe et al., 2020; Toelle et al., 2019; Yang et al., 2019) none recommended a duration of use per session. Although, all trials recorded use data, only two (Priebe et al., 2020; Toelle et al., 2019) reported the results.

Discussion

Advances in technology have allowed for the capacity to use smartphones apps to deliver, monitor and manage health conditions such as LBP. This technology is increasingly available and an accepted adjunct to formal clinician-lead health management protocols. This systematic review of the literature on smartphone apps for the self-management of LBP reports on the current evidence of effectiveness and participant adherence when using

smartphone apps for self-management. Only six RCTs met the inclusion criteria. More than 10 studies were excluded due to ineligible interventions, design, comparator or not in English. It is noteworthy that there were over 40 protocol papers identified in the systematic search and demonstrates that a wave of research in this area is imminent.

After systematically reviewing the literature, we have identified that the evidence for the effectiveness of smartphone apps in the self-management of LBP is limited, with methodological biases in selection, performance, detection and attrition and mixed results. None of the included studies reported blinding of health workers or study personnel, leading to high risk of potential bias. However, double blinding is not always possible in self-management studies such as those included in this systematic review and will always present as an increased risk of bias in performance (Lorig, 2003). Half of the included studies did not account for all the participants at the end of the trial, leading to reduction in the confidence of the results without an intention to treat approach to the statistical analyses. Finally, we cannot be confident that the results from the two included studies which did not treat the intervention and comparator groups equally were due to the intervention alone. Whilst three studies reported significant reduction in pain intensity in the smartphone apps groups compared with control (Irvine et al., 2015; Priebe et al., 2020; Toelle et al., 2019), three further studies reported no difference between groups (Chhabra et al., 2018; Mbada et al., 2017; Yang et al., 2019). The country of origin may have been a factor due to cultural differences impacting self-management outcomes (Abdulrehman et al., 2016; Durlak et al., 2015). The three studies that reported significant between group differences were undertaken in the USA (Irvine et al., 2015) and Germany (Priebe et al., 2020; Toelle et al., 2019) and the remaining three were undertaken in India (Chhabra et al., 2018), Africa (Mbada et al., 2017) and China (Yang et al., 2019). High income countries

such as Germany and the USA may have more capacity to implement health related infrastructure, compared to middle income countries such as China, India and Nigeria (World Bank Group, 2021) and allow for people to access health services and technology. Self-management has been shown to be culturally embedded (Omodara et al., 2022) and that external social-cultural factors and practices, understanding and interpretation of health management, education status and health beliefs can influence self-management behaviours and adherence to treatment recommendations (Abubakari et al., 2013). This may be as a result of cultural preferences for traditional treatment options provided in the control groups (Pillay et al., 2014), rather than new, technological options such as apps. Non-western social-cultural differences may also result in pain expression differences, as a result of stoicism in those that have historically experienced hardship seeing pain as a sign of weakness, or as a result of age and gender where older females are more likely to report pain (Pillay et al., 2014).The number of participants were also higher in the three studies undertaken in USA and Germany, allowing for increased power and greater certainty in the results. The significant results in one study (Toelle et al., 2019) for pain intensity may have been impacted by changes in the delivery of the control group treatment, from face to face manual therapy to email, at six weeks. This change may account for the significant difference between groups at 12 but not at six weeks. The factors that may have affected the results of the three trials that reported on function (disability) (Chhabra et al., 2018; Mbada et al., 2017; Yang et al., 2019), include the usual care undertaken in the control group and the duration of the interventions. Unfortunately, the 12-week intervention did not record results at four or eight-weeks to allow for comparison. Interestingly, the control group in the Snapcare app study consisted of GP prescribed medication and a home exercise program (Chhabra et al., 2018), whilst the control groups in the Pain Care app and TBMT studies used a more ‘hands on’ approach (Mbada et al., 2017; Yang et al., 2019). The GP

prescribed medication may have decreased pain intensity allowing for improved function and affected the between group findings. Pain self-efficacy was reported in only one study (Yang et al., 2019), and health related QOL was reported in two studies (Mbada et al., 2017; Yang et al., 2019), all with small numbers of participants and short trial durations (Mbada et al., 2017; Yang et al., 2019). None showed a significant difference between intervention and comparator groups and should be interpreted with caution.

Adherence to home exercise programs is a common challenge for people with LBP (Schaller et al., 2017). It is an important component of behaviour change and according to the Transtheoretical Model of behaviour change, it may take at least six months to change behaviour (Prochaska et al., 1992). The six included studies all had intervention lengths of less than six months (Chhabra et al., 2018; Irvine et al., 2015; Mbada et al., 2017; Priebe et al., 2020; Toelle et al., 2019; Yang et al., 2019). Adherence to self-management programs has frequently been reported in the literature as an essential component to improve outcomes (Ha Dinh et al., 2016; Machado et al., 2016; Moller et al., 2017). Although, one included study used gamification to provide instant gratification and maintain engagement and adherence (Chhabra et al., 2018) only two studies (Priebe et al., 2020; Toelle et al., 2019) reported on adherence as an outcome. The studies reported no correlation between app use or completed sessions and outcome measures. This is an interesting finding and should be interpreted with caution as the results are of two studies reporting on the Kaia app with relatively short intervention duration (12-weeks). Further research with intervention durations of at least six months (Prochaska et al., 1992) should be undertaken to add clarity to these results.

There was heterogeneity in content, delivery and reported outcomes among the six included studies, making comparison difficult. As a result, meta-analysis was not indicated (Higgins et al., 2019). Overall, 85% of the apps used in the six included trials are not available commercially for general consumers. The five apps used in the studies were either developed for the studies (Irvine et al., 2015), the researcher was involved in the development of the app (Chhabra et al., 2018) or the app was provided by the technology company, for the study, free of charge (Toelle et al., 2019). Only one app was commercially acquired for the study (Yang et al., 2019). Commercially available apps do not undergo the same level of quality control (Cortez et al., 2014; Machado et al., 2016) as apps developed for research. Research apps often differ from those available commercially as they are more likely to have undergone pilot testing to ensure that they align with guideline recommendations (NICE, 2016; Bernstein et al., 2017), incorporate consumer preferences (Machado et al., 2016), and evidence-based self-management features (Lorig & Holman, 2003) that have the capacity to improve outcomes. Further evaluation of commercially available apps is required to guide and instil confidence in consumers and health professionals that consumer accessible apps are reasonable quality and may lead to improved outcomes.

Strengths and limitations

This systematic review had several methodological strengths. The review was conducted according to PRISMA guidelines (Moher et al., 2009), the search strategy was peer reviewed and all included studies were appraised for risk of methodological bias. The focus was on apps for self-management which is the current gold standard for the management of LBP. There are also some limitations which must be acknowledged. The

small number of studies and the heterogeneity, of apps, interventions and outcome measures, in the six included studies precluded the use of meta-analyses. To offset this, a detailed narrative comparison of the study outcomes was presented. One of the studies (Irvine et al., 2015) did not specifically outline the process of randomisation, and numerous attempts were made to contact the authors to add clarity to the process of randomisation, but no return communication was received. As it was clearly stated in the primary paper and the protocol, that a randomised controlled trial was undertaken, it was included in the review. In 2008 the Apple App store went live, followed by the Google play store later that year, when apps became available to the wider population. As a result, apps are a relatively new addition to self-management. None of the included eligible apps required direct health professional input. This eliminated the additional self-management guidance that would normally be provided by a health professional and allowed only for the self-management support provided by the app alone. As a result, the findings of this review are generalisable to the way the general population may use smartphone apps for the self-management of LBP (i.e. download the app and apply, rather than seeing a health professional). In addition, apps available for consumer download from an app store differ from those available to health professionals and that require their input.

Implications

This review provides inconclusive evidence for the use of apps for the self-management of LBP. Consumer adherence data can commonly be collected via apps, allowing for potential recording of use, symptoms and exercise type. These data can allow consumers to monitor self-management progress and share data with health professionals.

The use of smartphone apps for self-management is a rapidly expanding area of research as was evidenced by over 40 protocols that did not meet our inclusion criteria. This evidence will grow rapidly and an update of this review will be warranted. High quality, longer duration and larger-scale RCTs incorporating consumer and health professional preferences, are necessary for future evaluation of commercially available smartphone apps for the self-management of LBP, as well as systematic assessment of the quality of commercially available smartphone apps for the general population.

Chapter Three – Study 2

Availability, content and quality of commercially available smartphone applications for the self-management of low back pain: a systematic assessment.

This chapter answers the aim “to systematically assess the availability, content, and quality of commercially available, self-contained smartphone apps for the self-management of LBP in adults, and to explore associations between quality, in-app user ratings and cost”. This chapter describes a systematic app assessment that was completed to determine the availability, content, and quality of commercially available apps for the self-management of LBP, to gain a better understanding of the included features in commercially available apps that may benefit LBP outcomes. As concluded in the systematic review (study 1, chapter 2) smartphone apps for the self-management of LBP provide more effective reduction in pain and disability than usual care or minimal interventions, however, the evidence is inconclusive due to limited and heterogenous research, making it difficult to make comparisons. Additionally, apps available in research settings are often not the same as those available commercially, and in this research, none of the apps were available commercially in this region for general consumers, which made it difficult to transfer this knowledge to practice.

Statement of co-authorship:

All authors were involved in formulating the concept and design of the review. Claudia Didyk and Belinda Lange conducted the systematic app search, Claudia Didyk and Belinda Lange conducted the data analysis, and Claudia Didyk completed the initial draft of the manuscript. All authors edited multiple revisions of the manuscript. See Appendix 1 for the signed co-authorship approval form. No conflict of interest was reported by the authors and funding for app purchases was provided by the Flinders University Research Student Maintenance (RSM) support.

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Didyk, C., Lewis, L. K., & Lange, B. (2022). Availability, content and quality of commercially available smartphone applications for the self-management of low back pain: a systematic assessment. *Disability and Rehabilitation, 44*(24), 7600–7609. https://doi.org/10.1080/09638288.2021.1979664

Abstract

Purpose: Explore smartphone apps that may be recommended by clinicians for the self-management of low back pain.

Methods: Prospectively registered systematic assessment of self-contained apps for self-management of low back pain on the Google Play and Apple App stores (Oceania), including ≥1 NICE low back pain and sciatica clinical guideline recommended component and functioning without health professional input. Outcomes were quality (Mobile App Rating Scale; MARS), and self-management (Self-Management Support Checklist; SMS-14) and behaviour change potential (App Behaviour Change Scale; ABACUS).

Results: 25 apps were included. The average quality of included apps was acceptable (Mean MARS score of 3.9 out of a maximum possible 5). The self-management support and behaviour change potential of included apps appeared low (mean SMS-14 score was 3.4/14; mean ABACUS score was 5.4/21). The apps showed no significant correlation between app consumer ratings and MARS score. App quality was significantly correlated with app price (p=0.049) but not consumer ratings, however, these findings were based on a small number of studies and the overall model was not significant.

Conclusions: Smartphone apps for the self-management of low back pain are of average to good quality, with questionable potential for self-management and behaviour change. Clinicians should consider that few apps were designed to specifically incorporate self-management support and behaviour change potential when recommending apps to clients. Further development in these areas of app design would be of benefit.

Keywords: smartphone apps; low back pain; self-management; behaviour change; systematic assessment

Introduction

Digital health technologies have developed and grown in popularity in the last 20 years to become essential in addressing many public health problems (El Benny et al., 2021). Efficacy for the use of digital health interventions has been shown in chronic disease management, such as chronic pulmonary disease and heart failure, glycemic control in diabetes, BP in hypertensive patients and improving adherence to tuberculosis and HIV treatments (Marcolino et al., 2018). The use of technology to deliver health interventions is rapidly increasing, particularly with the growth of telehealth and digital public health services during the current Covid-19 pandemic (Windisch et al., 2020). Technology such as smartphones, and the apps available through them, have the potential to deliver and facilitate large-scale health interventions and/or messaging (Iyengar et al., 2020; Whitelaw et al., 2020). Most people in developed countries have smartphones, with 3.8 billion people estimated to have a device this year (Statista, 2020). With the accessibility of smartphones and apps, simple messaging regarding lifestyle behaviours can be disseminated effectively to the general population (Lee et al., 2018). Examples include app-based interventions to promote healthy diet, physical activity and general lifestyle improvements (Lee et al., 2018). E- and m-health interventions also have immense potential in low- and middle-income countries with poor access to health resources, with digital health technology use enabling access to health provision without infrastructure (Lee et al., 2018). Smartphones are easily accessible and can be a cost-effective option for health monitoring and advice, particularly for those who are time poor, have financial constraints, transport difficulties or live in rural areas with poor access to health care (Stec et al., 2019). Smartphone apps also have the capacity to be an adjunct to face to face management (Wang et al., 2018) particularly for prevalent conditions such as LBP.

Low back pain is the leading cause of disability worldwide and a global public health and economic concern (Vos et al., 2017). The economic burden of LBP is estimated to be in the billions of dollars (AUD) per year (AIHW, 2019c; AOV, 2013), including the financial implications of public health programs, productivity loss, loss of taxation and superannuation revenue (AOV, 2013). The human costs of LBP including pain, disability (AIHW, 2019d), hospitalisations and psychological distress are also significant and impact work participation (Du et al., 2019). There is a need for low cost, easily accessible, reliable, tailored interventions that can address health inequities by enabling the immediate delivery of high level public health services to address the economic and personal costs of LBP (Grady et al., 2018). This is of particular importance to communities lacking access to conventional forms of healthcare to manage LBP for reasons of affordability or inaccessibility (Grady et al., 2018).The National Institute for Health and Care Excellence LBP guidelines recommend self-management and exercise as the gold standard in non-invasive LBP management (NICE, 2016). Self-management is multifaceted and incorporates patient involvement in the decision making and all steps of the treatment pathway (Lorig & Holman, 2003). It involves a person taking responsibility for their well-being by undertaking healthy behaviours and managing the daily symptoms and general physical and emotional requirements of their condition (Dwarswaard & van de Bovenkamp, 2015; Machado et al., 2016). Considerable research has been undertaken into LBP and the use of self-management interventions (Du et al., 2017; Elbers et al., 2018). Self-management interventions should provide information on the nature of LBP, encouragement to continue with normal activities and tailored advice to guide self-management through all stages of the condition (NICE, 2016). Recent research has shown

that smartphone apps can improve patient outcomes for people with LBP (Thurnheer et al., 2018) including disability (Shebib et al., 2019) and pain (Cavanagh et al., 2019).

The rapid rate that health and wellbeing apps are developed makes it difficult to monitor and effectively regulate content quality (Kasperbauer & Wright, 2020). Apps for LBP self-management have potential to support individuals with LBP, however, these apps are not regulated and the accuracy of the content and the provision of evidence-based advice is not guaranteed (Kasperbauer & Wright, 2020). Software based medical devices that fit the definition for medical devices are required to be registered and regulated by a government regulatory body such as the Therapeutic Goods Administration (TGA) in Australia (Australian Government Federal Register of Legislation, 2021). While several EU countries have installed national regulation and certification systems in an attempt to control the health app market (Digital health, 2021), the majority of app content is currently not registered or controlled globally. A systematic review of smartphone apps for the self-management of LBP in 2016 found that although most of the eligible apps included guideline recommended interventions, the overall quality of the apps was low (Machado et al., 2016). With the rapid increase in availability of apps for LBP, there is a clear need to update the evidence on LBP self-management apps aligned with current guidelines. The aim of this study was to systematically assess the availability, content, and quality of commercially available, self-contained smartphone apps for the self-management of LBP in adults, and to explore associations between quality, in-app user ratings and cost.

Methods

The systematic assessment protocol was prospectively registered (Open Science Framework: DOI: 10.17605/OSF.IO/D3UQX). Wherever possible, principles from the PRISMA guidelines were followed (Moher et al., 2009).

Search

In November 2020, a systematic search of the Google Play and Apple App stores was undertaken using three terms (‘low back pain’, ‘back pain’, ‘lumbago’). These terms were used in previous research (Coe-O’Brien et al., 2020; Machado et al., 2016) and recommended by the Cochrane Back and Neck Group (Furlan et al., 2015).

Procedure

Commercially available smartphone apps were systematically identified by name and app description and assessed for eligibility based on predetermined criteria by two independent reviewers (CD and BL). Eligible apps were downloaded on either an Apple or Android device (iPAD Air 3 iOS® 14.4 or Galaxy Tablet Android 10). If multiple versions of the app were available for download (free/paid, lite/pro), then the paid and pro versions were downloaded. A full review and quality assessment of eligible apps was undertaken by two independent reviewers (CD and BL). All the functions of the downloaded apps were used for at least 10 minutes (Stoyanov et al., 2015) and scored independently. Prior to scoring, both reviewers undertook web-based scoring training (Stoyanov, 2016).

Differences of opinions regarding app eligibility and quality were discussed until consensus was reached. Inter-rater reliability was calculated between raters for all instrument scores.

Eligibility criteria

The following inclusion criteria were applied:

Free and paid self-contained apps without the need for external devices or add-ons aimed at self-management of LBP in the Apple App store and Google play store (available in English and in the Oceania region). Apps needed to contain at least one NICE guideline recommended self-management component of active rehabilitation, exercise, psychological therapies and/or return to work facilitation. Apps that included advice and education consistent with the first recommendation in the NICE guidelines ("Provide people with advice and information, tailored to their needs and capabilities, to help them self-manage their low back pain with or without sciatica, at all steps of the treatment pathway. Include: information on the nature of low back pain and sciatica; encouragement to continue with normal activities.") (NICE, 2016) were included if the advice or education pertained to any of the recommended components. Self-management is defined as actively participating in one treatment such as following a treatment plan, maintain activity levels and seeking counselling (Dwarswaard & van de Bovenkamp, 2015).

Self-management advice should encourage active rehabilitation such as group exercise or biomechanical (Pilates, McKenzie exercises, range of motion, strengthening, stretching or motor control exercises), aerobic (increase cardiovascular endurance and fitness such as running or walking), mind-body (Yoga, Tai chi and mindfulness) or combination exercise options (combination of the previous exercise categories). The NICE

guideline recommended physical activity interventions have been classified previously (Machado et al., 2016), and we have used the same classifications for this study (Machado et al., 2016). Self-management advice should also encourage psychological therapies using a cognitive behavioural approach (preferably in a group context but taking into consideration a person's specific needs) but only in combination with exercise and/or manual therapy. Return to work and normal activities should also be encouraged.

Apps were excluded if they focused on prevention, diagnostic tests, offered treatments for pregnancy-related LBP or were aimed at identifying risk factors, were not interventional or solely focused on pain monitoring or geared towards advertising specific products or health centres (Machado et al., 2016). Apps were also excluded if they provided only general information such as anatomy or risk factors or did not provide specific information on the nature of LBP and self-management advice or management plan to follow. Apps were also excluded if they did not contain features that allowed consumers to tailor or customise the LBP management options provided within the app to their specific needs (as recommended by the NICE guideline), such as duration, exercise choice, difficulty level, and frequency of use.

Where eligible apps were available on both platforms only one version of the app was downloaded for final analysis (on iOS®). iOS® was chosen due to their rigorous publishing guidelines (Developer Apple App store, 2021).

Outcomes

App quality

The quality of the apps was assessed with the 23-item Mobile App Rating Scale (MARS) (Stoyanov et al., 2015). Each MARS item was scored using a five-point scale (1-inadequate, 2-poor, 3-acceptable, 4-good, 5-excellent with an option for not applicable). The MARS is a reliable tool (Stoyanov et al., 2015) with four categories including engagement, functionality, aesthetics and information. An overall app subjective quality scale is also calculated.

App potential for developing self-management

All included apps were addressed for their potential for developing self-management with the Self-management Support Checklist (SMS-14).

The SMS-14 was developed from the Stanford Self-management Support Model (Devan et al., 2019), a 14-item checklist to evaluate app content potential for developing self-management (Devan et al., 2019). The SMS-14 has six core self-management skills categories including: (1) self-efficacy building (with seven subsections: pain education, activity pacing, thought and behavioural management, exercises - biomechanical or aerobic, relaxation, meditation and mindfulness and distraction techniques), (2) self-tailoring, (3) self-monitoring of symptoms, (4) goal setting and planning, (5) problem solving, and (6) partnership between views of patient and clinicians. The checklist also has, two ‘functions’ categories (social support and cultural relevance). One point (possible score 0-14) was scored for each of the features present in the app.

App behaviour change potential

The behaviour change potential of the included apps was assessed using the reliable (McKay et al., 2019) 21-item App Behaviour Change Scale (ABACUS).

The scale has four broad categories including: knowledge and information, goals and planning, feedback and monitoring, and actions. One point (possible score 0-21) was scored for each of the features present in the app.

Data extraction and synthesis

The app characteristics metadata were extracted, by both reviewers independently, from the relevant store and entered into a Microsoft Excel spreadsheet under the headings of App name, developer, version, update date, cost, presence of in-app purchases and platform availability, consumer rating (where available) and type of intervention (Machado et al., 2016). Results from the MARS, SMS-14 and ABACUS tools were inputted.

Descriptive statistics were completed for all variables as appropriate (means, standard deviations [SD], medians, ranges). MARS total score, SMS-14 and ABACUS scores were used to determine the best performing app. Inter-rater reliability was assessed using a two-way random effects intraclass correlation coefficient ($ICC_{2,1}$) with a 95% confidence interval using Statistical Package for Social Science (IBM SPSS) version 27 for Windows. An ICC value greater than 0.8 was considered good reliability between scorers and greater than 0.9 was considered excellent.

Multivariate regression was undertaken to explore associations between app quality, in-app rating and price. The dependent variable was app quality (mean MARS total score) and the independent variables were price and consumer ratings. This analysis could only be undertaken on those apps with the cost associated. Some apps provided a free to trial of less than one month duration and then required a fee or monthly fee to continue use or access necessary features. The monthly fee was considered the cost to access the app for one month, regardless of the free trial, as it was required to access the app for the remainder of the month. The cost to access the app for one month was calculated to allow for free trial apps to be included in the analysis. Alpha was set at 0.05.

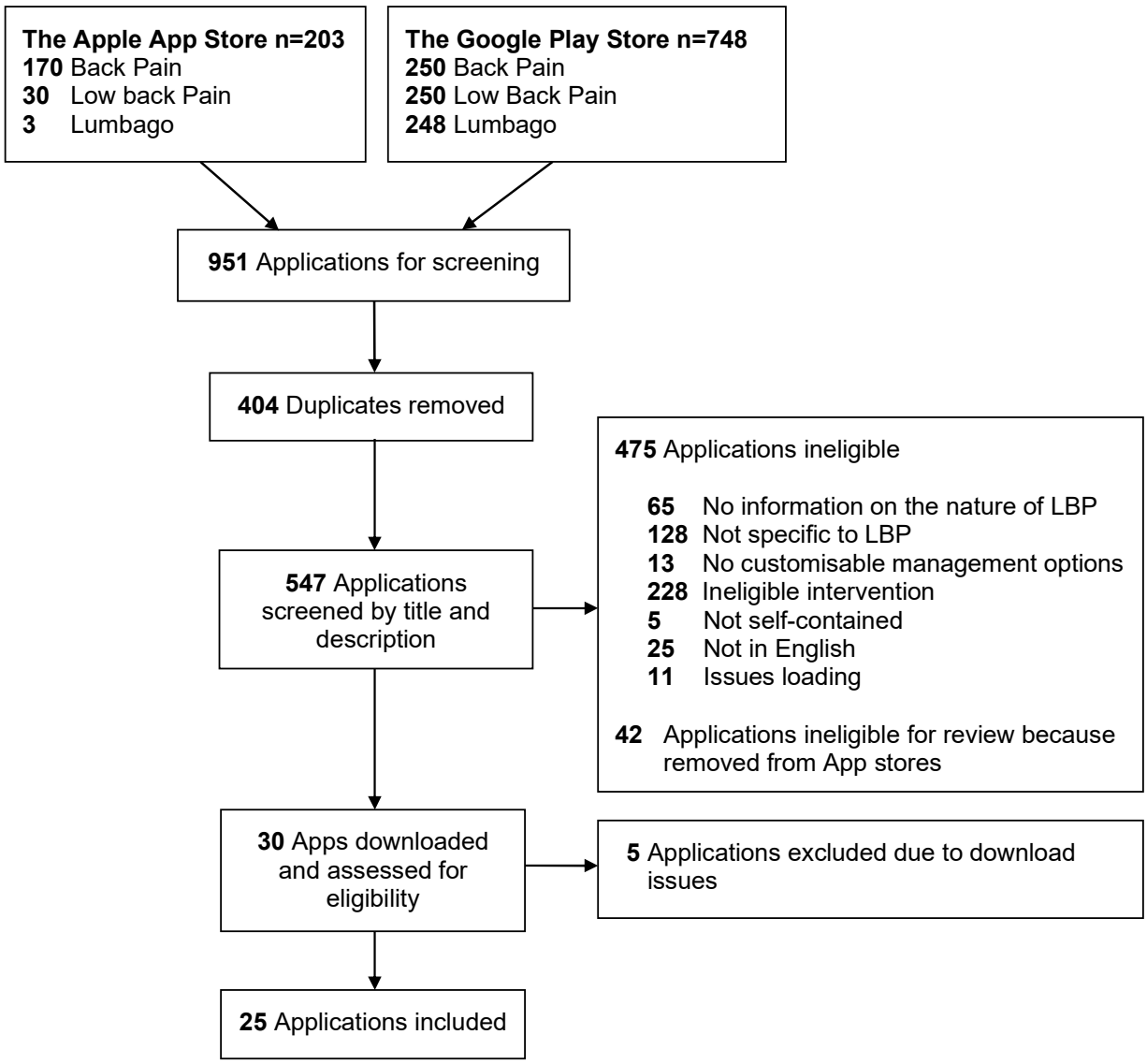
Results

App selection

The systematic search yielded 951 apps (n=203 Apple App store; n=748 Google Play store, Figure 3.1). After the removal of 404 duplicates, 547 apps were screened by name and app description. Five apps had download issues - app developers were messaged either directly or through app reviews. As no response was received from the developers the apps were removed. No apps were excluded due to date of update as it was agreed that if the app was eligible, downloadable and functional then it could be included. Twenty-five apps (13 Android, nine iOS® and three available on both platforms) met the eligibility criteria and were included.

Figure 3. 1.

App Selection Flow Diagram



Description of included apps

Twenty-five apps were eligible for inclusion (Table 3.1), three (12%) were available in both the Apple App and Google Play stores, nine (36%) were from the Apple App store and 13 (52%) were from the Google Play store. Seventeen apps were free, six were free

trial (from $0.99 to $14.99 per month) and two were paid (from $4.99 (for one week)-$17.99). Only nine of the eligible apps included consumer ratings. The median consumer rating for the nine apps was 4.4 (out of a maximum possible 5) and the number of ratings ranged from one (Lower Back Yoga – Floor Class) to 1000 (Exercise for Back, Neck and Posture – MoovBuddy). App interventions included either education and advice, or exercise (biomechanical, mind-body or a combination).

Table 3. 1.

Summary of Included Apps

App name (Version)	Developer	Platform	Cost	User rating this version (n)	Users rating this version (n)	Intervention Type
Injurymap - Effective exercise therapy (V1.6.73)	Injurymap ApS	iOS®/Android	Free trial then $14.99 per month, $66.99 for 12 months	2.5	2	Biomechanical
TrackActive Me: Virtual Physio (V1.11.0)	Active Health Tech Ltd	iOS®	Free trial then pay for use $8.49 monthly, $66.99 annual	5	6	Biomechanical
The Truth About Low Back Pain (*)	Clinically Relevant Technologies	iOS®	Free	N/A	N/A	Education, advice
Pocket Spine Doc (V1.0.16)	Zebitz Solutions SND.BHD	iOS®/Android	Free but then $7.99 for exercises (prevention exercises - for life, personalised exercises for 90 days)	N/A	N/A	Biomechanical
Exercises for Back, Neck and Posture – MoovBuddy (V2.1.13)	MoovBuddy	Android	Free trial then $14.90 per month, $89.90 for 12 months and $56.90 for 6 months	4.2	1K	Biomechanical
SelfBack – Guest (*)	Trade eXpansion	iOS®	Free	N/A	N/A	Education, advice
The Back Pain App (V1.0)	The Foundation PTS	Android	Free	N/A	N/A	Biomechanical

App name (Version)	Developer	Platform	Cost	User rating this version (n)	Users rating this version (n)	Intervention Type
BackTrainerHD (V2.0)	Hanno Welsch	iOS®	$17.99	N/A	N/A	Biomechanical
Regimen - Back Pain Relief (V1.02)	Oyebimpe Oguntola	iOS®	Free	N/A	N/A	Biomechanical
Lower Back Pain and Sciatica Relief Exercises (V4.2.4)	App4Life dev	Android	Free	4.2	90	Biomechanical
Symmetry Exercise for Lower Back Pain (V1.2)	Right-be Inc	iOS®	Free but app description states that is on sale from $3.99 down to $0.99	N/A	N/A	Biomechanical
Lower Back Yoga - Floor Class (V2.5.0)	Centre de Yoga	iOS®	Free to download but requires subscription for more exercises or classes $2.99	5	1	Mind-body
Bella's Lower Back Pain App (V1.3)	PM Health	iOS®/Android	$4.49 weekly, $14.49 monthly, $41.99 yearly	N/A	N/A	Biomechanical
My Back Injury (V1.3)	Regen Health Technology Pty Ltd	iOS®	Free	5	2	Biomechanical
NHS 24 MSK help (V2.1.0)	NHS 24	iOS®	Free	N/A	N/A	Biomechanical
Back Pain Relief in 7 Days - Yoga, Exercise & Diet (V3.6)	Dr. Zio - Yoga Teacher	Android	Free	4.9	573	Mind-body
Back Pain - causes, symptoms, treatments (V1.0.0)	Cursed Apps	Android	Free	4.6	14	Education, advice
Yoga Poses for Lower Back Pain Relief (V2.2)	Gonga dev	Android	Free	4.2	369	Mind-body
Back Pain Relief (V1.0)	Pro Learning Apps	Android	Free	N/A	N/A	Education, advice
BACK PAIN EXERCISES (V1.0)	Supportive Apps	Android	Free	N/A	N/A	Biomechanical
Lower Back Pain Treatment - Tips and Knowledge (V1.1)	Vission Assist	Android	Free	N/A	N/A	Education, advice
BACK PAIN CAUSES &	salim garba usman	Android	Free	N/A	N/A	Education, advice

App name (Version)	Developer	Platform	Cost	User rating this version (n)	Users rating this version (n)	Intervention Type
TREATMENT (V1.0)						
Lower Back Pain (V1.0)	TeckGeek	Android	Free	N/A	N/A	Combination Exercise
Sciatica Treatment (V5.0.0)	PassionSoft	Android	Free	N/A	N/A	Combination Exercise
Home Remedies For Sciatic Nerve Pain (V1.0)	RK Unit	Android	Free	N/A	N/A	Education, advice

Note. (*) – Version not supplied
N/A - Not Available

Seven apps (28%) provided education on the nature of LBP and management advice (5 Android, 2 iOS®). Thirteen apps (52%) provided biomechanical exercises as the intervention (3 available on both platforms, 6 available on iOS® and 4 on Android). None of the included apps provided solely aerobic exercise interventions. Three (12%) provided mind-body exercise (2 Android, 1 iOS®) and two Android apps (8%) provided a combination of exercise interventions.

App Quality

The mean MARS total score (Table 3.2) for the 25 apps was 3.86. Across the included apps, the engagement category scored the lowest (mean 3.22), and the functionality category the highest (mean 4.67). Most apps performed well, were easy to use and navigate and with intuitive gestural design features. The mean score for aesthetics was 3.93. The mean MARS total score for information was 3.63. In the information category (item 19), only one app (SelfBack) was found to be published in the scientific literature. However, evaluation was undertaken on the guest version of the SelfBack app which is

freely available to consumers. This version does not provide the monitoring and feedback that would be available to users of the RCT version used for research. Nine apps scored a three (acceptable) or above on item 18 for developer credibility. However, only three of the 25 apps scored below a three (acceptable) for the quality of information provided (item 15). The inter-rater reliability was excellent for the MARS total score (ICC 0.95) and ranged from good to excellent for the sub-sections (ICC 0.86 to 1.00).

Associations between in-app rating, price and quality

Nine of the 25 eligible included apps provided both consumer ratings and a cost for download and were therefore included in the multiple regression analysis. In-app consumer rating was not a significant predictor of mean MARS total score (app quality) (p=0.965). The cost to access the app for one month was calculated to allow for free trial apps, allowing for four (44%) paid apps to be included in the analysis. App price ranged from $2.99 to $14.99 for one month's access and is a significant predictor of mean MARS total score (p=0.049). There was a significant correlation between app price and MARS score and together accounted for 60% of the variance in MARS score. However, the overall regression model was not significant $F(2,6) = 4.584$, R^2 (9) = 0.604, p = 0.062.

Table 3. 2.

The Mobile Application Rating Scale (MARS) Quality Mean[a] Scores

App name	MARS Engagement mean score	MARS Functionality mean score	MARS Aesthetics mean score	MARS Information mean score	MARS App quality mean score
TrackActive Me: Virtual Physio	5.0	5.0	4.7	4.8	4.9
Injurymap - Effective exercise therapy	5.0	4.8	5.0	4.3	4.8
The Truth About Low Back Pain	3.4	5.0	5.0	4.3	4.4
Pocket Spine Doc	3.8	4.8	4.7	4.0	4.3
Exercises for Back, Neck and Posture - MoovBuddy	4.0	4.5	4.7	3.7	4.2

SelfBack	2.4	5.0	4.7	4.1	4.1
The Back Pain App	3.0	5.0	4.0	4.2	4.1
BackTrainerHD	3.2	5.0	4.3	3.7	4.1
Regimen - Back Pain Relief	4.0	4.5	4.0	3.7	4.0
Lower Back Pain and Sciatica Relief Exercises	2.8	5.0	4.3	4.0	4.0
Lower Back Yoga - Floor Class	3.6	4.8	4.0	3.7	4.0
Back Pain - causes, symptoms, treatments	2.8	4.8	4.0	3.8	3.8
Bella's Lower Back Pain App	3.2	4.8	3.7	3.7	3.8
BACK PAIN CAUSES & TREATMENT	2.4	5.0	4.0	3.8	3.8
NHS 24 MSK help	3.0	4.5	3.7	4.0	3.8
My Back Injury	3.6	4.0	3.3	3.7	3.7
Lower Back Pain Treatment - Tips and Knowledge	2.6	5.0	3.7	3.3	3.7
Yoga Poses for Lower Back Pain Relief	4.0	4.0	3.7	2.8	3.6
Lower Back Pain	2.4	5.0	3.7	3.4	3.6
Symmetry Exercise for Low Back Pain	3.2	4.3	3.3	3.2	3.5
Back Pain Relief in 7 Days - Yoga, Exercise & Diet	3.6	4.3	2.7	3.3	3.5
BACK PAIN EXERCISES	2.8	4.5	3.0	3.5	3.5
Sciatica Treatment	2.4	4.3	3.7	3.2	3.4
Home Remedies For Sciatic Nerve Pain	2.6	4.3	3.3	2.8	3.3
Back Pain Relief	1.8	5.0	3.3	1.7	3.0
Range all apps	1.8-5.0	4.0-5.0	2.7-5.0	1.7-4.8	3.0-4.9
Mean (SD) all apps	3.2 (0.8)	4.7 (0.3)	3.9 (0.6)	3.6 (0.6)	3.9 (0.5)

Note. [a] Mean scores - items are rated on a 5-point scale (1=Inadequate to 5=Excellent).

App potential for developing self-management

The mean SMS-14 total score (Supplementary materials Table S3.1) for all included apps was 3.44 (SD=1.61), with a range of one to eight. Across all included apps, the sub-section of “exercises” in the self-efficacy building section was most prevalent, with 20 apps providing information on biomechanical or aerobic exercise self-management. None of the included apps rated in the “social support” and “cultural relevance” sub-sections.

The inter-rater reliability for the total SMS-14 score was excellent (ICC 0.96) and ranged from good to excellent for the subsections (ICC 0.87 to 1.00).

App behaviour change potential

The mean ABACUS total score (Supplementary materials Table 3.2) for all included apps was 5.40 (SD=3.61), with a range of one to 14. Although many apps provided access to social media platforms, this section was scored as a ‘no’ unless it allowed for sharing of behaviours and social comparison and not simply access to informational updates. The sections on instructions for behaviour (ABACUS item 1.4) and encouragement of practice or rehearsal (4.3) were rated in over 75% of included apps. However, the sections on willingness for behaviour change (2.1), sharing behaviours with others (3.3), ability to export data (3.5) and rewards or incentives (3.6) were not rated in any of the included apps and indicates a need for further work by developers in these areas. Inter-rater reliability was excellent for the total ABACUS score (ICC 1.00) and ranged from good to excellent for the subsections (ICC 0.88 to 1.00).

Table S3. 1.

Self-management Support (SMS-14) Checklist Scores

App name	Core self-management skills														
	Self-efficacy building										Functions				
	PE[a]	AP[b]	TB[c]	E[d]	R/B[e]	M/M[f]	D[g]	ST[h]	SM[i]	GS[j]	PS[k]	PV[l]	SS[m]	CR[n]	Total(14)
TrackActive Me: Virtual Physio	Y	Y	-	Y	-	Y	-	Y	Y	Y	-	Y	-	-	**8**
NHS 24 MSK help	Y	Y	Y	Y	-	-	-	Y	-	-	Y	-	-	-	**6**
SelfBack - Guest	Y	Y	-	Y	-	-	-	Y	Y	-	Y	-	-	-	**6**
Injurymap - Effective exercise therapy	-	Y	-	Y	-	-	-	Y	Y	Y	-	-	-	-	**5**
BACK PAIN CAUSES & TREATMENT	Y	-	-	Y	-	Y	-	Y	-	-	-	-	-	-	**4**
Back Pain Relief in 7 Days - Yoga, Exercise & Diet	-	-	Y	-	-	Y	-	Y	-	Y	-	-	-	-	**4**
Exercises for Back, Neck and Posture - MoovBuddy	-	Y	-	Y	Y	-	-	-	Y	-	-	-	-	-	**4**
Lower Back Pain Treatment - Tips and Knowledge	Y	Y	-	Y	-	-	-	Y	-	-	-	-	-	-	**4**
Sciatica Treatment	Y	-	-	Y	-	Y	-	Y	-	-	-	-	-	-	**4**
The Back Pain App	Y	-	-	Y	-	-	-	Y	-	-	-	Y	-	-	**4**
Yoga Poses for Lower Back Pain Relief	-	-	-	-	Y	Y	Y	Y	-	-	-	-	-	-	**4**
Back Pain - causes, symptoms, treatments	Y	-	Y	-	-	-	-	Y	-	-	-	-	-	-	**3**
BACK PAIN EXERCISES	Y	-	-	Y	-	-	-	Y	-	-	-	-	-	-	**3**
Lower Back Pain	Y	-	-	Y	-	-	-	Y	-	-	-	-	-	-	**3**
Lower Back Pain and Sciatica Relief Exercises	-	-	-	Y	-	Y	-	Y	-	-	-	-	-	-	**3**
Pocket Spine Doc	Y	Y	-	Y	-	-	-	-	-	-	-	-	-	-	**3**
Regimen - Back Pain Relief	-	-	-	Y	-	-	-	Y	Y	-	-	-	-	-	**3**
The Truth About Low Back Pain	Y	-	-	Y	-	-	-	Y	-	-	-	-	-	-	**3**
Back Pain Relief	Y	-	-	Y	-	-	-	-	-	-	-	-	-	-	**2**
Bella's Lower Back Pain App	-	-	-	Y	-	Y	-	-	-	-	-	-	-	-	**2**
Lower Back Yoga - Floor Class	-	Y	-	-	-	Y	-	-	-	-	-	-	-	-	**2**
My Back Injury	-	Y	-	Y	-	-	-	-	-	-	-	-	-	-	**2**
Symmetry Exercise for Lower Back Pain	-	Y	-	Y	-	-	-	-	-	-	-	-	-	-	**2**
BackTrainerHD	-	-	-	Y	-	-	-	-	-	-	-	-	-	-	**1**
Home Remedies For Sciatic Nerve Pain	Y	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**
Total score per category	**14**	**10**	**3**	**20**	**2**	**8**	**1**	**16**	**5**	**3**	**2**	**2**	**0**	**0**	

Note. [a]PE: pain education; [b]AP: activity pacing; [c]TB: thoughts and behavioural management; [d]E: exercises (biomechanical/aerobic); [e]R/B: relaxation/breathing; [f]M/M: meditation/mindfulness; [g]D: distraction techniques; [h]ST: self-tailoring; [i]SM: self-monitoring of symptoms; [j]GS: goal setting and planning; [k]PS: problem solving; [l]PV: partnership between views of patient and clinicians; [m]SS: social support; [n]CR: cultural relevance

Table S3. 2.

App Behavior Change Scale (ABACUS) Scores

Scale: item number and question	Apps																									Total subsection scores
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
1. Knowledge and information																										
1.1	-	Y	Y	Y	Y	Y	Y	-	Y	Y	Y	-	-	Y	Y	Y	-	Y	-	-	-	-	-	-	-	**13**
1.2	Y	-	Y	Y	Y	-	Y	-	-	Y	-	-	-	Y	Y	Y	Y	Y	-	Y	Y	Y	Y	Y	Y	**17**
1.3	-	Y	Y	Y	Y	-	-	-	Y	-	Y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**6**
1.4	-	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	-	Y	Y	Y	-	-	Y	Y	-	**20**
1.5	Y	-	Y	Y	Y	-	Y	Y	-	Y	Y	Y	-	-	-	-	-	-	Y	-	-	-	-	-	-	**10**
2. Goals and planning																										
2.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0**
2.2	-	-	Y	Y	-	-	-	-	-	-	-	-	-	-	-	Y	-	-	-	-	-	-	-	-	-	**3**
2.3	-	Y	Y	Y	-	-	-	-	-	-	Y	-	-	-	-	Y	-	-	-	-	-	-	-	-	-	**5**
3. Feedback and monitoring																										
3.1	-	Y	Y	Y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**3**
3.2	-	Y	Y	Y	-	-	-	-	-	Y	Y	-	-	-	-	Y	-	-	-	-	-	-	-	-	-	**6**
3.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0**
3.4	-	Y	Y	Y	-	-	-	-	-	Y	-	-	-	-	-	Y	-	-	-	-	-	-	-	-	-	**5**
3.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0**
3.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0**
3.7	-	-	Y	-	-	-	-	-	-	-	-	-	-	-	-	Y	-	-	-	-	-	-	-	-	-	**2**
4. Actions																										
4.1	-	Y	Y	Y	-	-	-	-	-	Y	Y	-	-	-	Y	Y	-	Y	-	-	-	-	-	-	-	**8**
4.2	Y	Y	Y	Y	-	-	-	-	-	Y	Y	-	Y	-	Y	Y	-	Y	-	-	-	-	-	-	-	**10**
4.3	-	Y	Y	Y	Y	Y	Y	Y	Y	Y	-	-	Y	Y	Y	Y	-	Y	Y	Y	Y	-	Y	Y	-	**19**
4.4	-	-	-	-	-	-	Y	-	-	-	-	-	-	-	Y	-	-	-	-	-	-	-	-	-	-	**2**
4.5	-	-	-	-	-	-	-	-	Y	-	-	-	-	-	-	-	-	-	-	-	Y	Y	Y	Y	-	**5**
4.6	Y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**
Total (21)	**4**	**10**	**14**	**13**	**6**	**3**	**6**	**3**	**5**	**9**	**8**	**2**	**3**	**4**	**7**	**11**	**1**	**6**	**3**	**3**	**3**	**2**	**4**	**4**	**1**	

Note. Y = Yes and scored as 1

Apps:

1.The Truth About Low Back Pain; **2**.Regimen - Back Pain Relief; **3.**TrackActive Me: Virtual Physio; **4.**Injurymap - Effective exercise therapy; **5.**Pocket Spine Doc; **6.**BackTrainerHD; **7.**SelfBack - Guest; **8.**Lower Back Pain and Sciatica Relief Exercises; **9.**The Back Pain App; **10.**Exercises for Back, Neck and Posture - MoovBuddy; **11.**Symmetry Exercise for Lower Back Pain; **12.**Lower Back Yoga - Floor Class; **13.**Bella's Lower Back Pain App; **14.**My Back Injury; **15.**NHS 24 MSK help; **16.**Back Pain Relief in 7 Days - Yoga, Exercise & Diet; **17.**Back Pain - causes, symptoms, treatments; **18**.Yoga Poses for Lower Back Pain Relief; **19.**Back Pain Relief; **20.**BACK PAIN EXERCISES; **21.**Lower Back Pain Treatment - Tips and Knowledge; **22.**BACK PAIN CAUSES & TREATMENT; **23.**Lower Back Pain; **24.**Sciatica Treatment; **25.**Home Remedies For Sciatic Nerve Pain

Highest rating apps

The overall highest rated app for quality, self-management and behaviour change potential was the TrackActive Me: Virtual Physio app with a mean MARS score of 4.87, an SMS-14 score of eight out of 14 and an ABACUS score of 14 out of 21. The TrackActive Me: Virtual Physio app has many features and the capacity for customisation. Although it is not specifically a LBP app, it has the capacity to be customised for LBP by the personal information entered and body area chosen. The app contained detailed information, which can be selected by the user, with external links to full journal articles and also contains personalised information videos. The app has excellent graphics, a chat function and the ability to connect to health professionals online or in the user's area via the app, but this is not necessary for the app to function. Users can track progress, log steps if connected to Apple Health, set reminders, give program tips and set goals. The app also explains why exercises are helpful and links to full text articles for evidence. TrackActive Me: Virtual Physio also provides users with motivational quotes and also sends users motivational emails (Table 3.3).

Table 3. 3.

MARS, SMS-14 and ABACUS Total Scores

App name - Version	MARS App quality mean score	SMS-14	ABACUS
TrackActive Me: Virtual Physio - (V1.11.0)	4.9	8.0	14.0
Injurymap - Effective exercise therapy - (V1.6.73)	4.8	5.0	13.0
The Truth About Low Back Pain	4.4	3.0	4.0
Pocket Spine Doc - (V1.0.16)	4.3	3.0	6.0
Exercises for Back, Neck and Posture - MoovBuddy - (V2.1.13)	4.2	4.0	9.0
SelfBack - Guest	4.1	4.0	6.0
The Back Pain App - (V1.0)	4.1	4.0	5.0
BackTrainerHD - (V2.0)	4.1	1.0	3.0
Regimen - Back Pain Relief - (V1.02)	4.0	3.0	10.0
Lower Back Pain and Sciatica Relief Exercises - (V4.2.4)	4.0	3.0	3.0
Lower Back Yoga - Floor Class - (V2.5.0)	4.0	2.0	2.0
Back Pain - causes, symptoms, treatments - (V1.0.0)	3.8	3.0	1.0
Bella's Lower Back Pain App - (V1.3)	3.8	2.0	3.0
BACK PAIN CAUSES & TREATMENT - (V1.0)	3.8	4.0	2.0
NHS 24 MSK help - (V2.1.0)	3.8	6.0	7.0
My Back Injury - (V1.3)	3.7	2.0	4.0
Lower Back Pain Treatment - Tips and Knowledge - (V1.1)	3.7	4.0	3.0
Yoga Poses for Lower Back Pain Relief - (V2.2)	3.6	4.0	6.0
Lower Back Pain - (V1.0)	3.6	3.0	4.0
Symmetry Exercise for Low Back Pain - (V1.2)	3.5	2.0	8.0
Back Pain Relief in 7 Days - Yoga, Exercise & Diet - (V3.6)	3.5	4.0	11.0
BACK PAIN EXERCISES - (V1.0)	3.5	3.0	3.0
Sciatica Treatment - (V5.0.0)	3.4	4.0	4.0
Home Remedies For Sciatic Nerve Pain - (V1.0)	3.3	1.0	1.0
Back Pain Relief - (V1.0)	3.0	2.0	3.0
Range all apps	3.0-4.9	1.0-8.0	1.0-14.0
Mean (SD) all apps	3.9 (0.5)	3.4 (1.6)	5.4 (3.6)

Discussion

This systematic assessment found that smartphone apps for the self-management of LBP that function with or without health professional input were numerous, of average to good quality, with poor engagement ratings and marginal levels of self-management and

behaviour change support. There was variability in the types of apps identified in this systematic assessment. All included apps contained at least one of the NICE guideline for LBP components and this was mostly the provision of biomechanical exercises. There was a similar number of included apps available on Apple and Android and most of the apps were free to download or trial. Many of the apps were not developed by individuals with a clear health related background. At times the language and grammar were of poor-quality, making comprehension of the information provided difficult. Only seven of the apps had been updated in the previous six months. Most of the apps (80%) recommended biomechanical/aerobic exercises. This may have been due to biomechanical and aerobic exercises being the first exercise recommendations in the NICE guidelines (NICE, 2016), have been researched extensively and provide additional health benefits (Shiri et al., 2018).

The apps were of variable quality, ranging from acceptable (MARS score 3) to good (4) (Machado et al., 2016; Stoyanov et al., 2015). The lowest rating MARS domain was engagement, and demonstrates the lack of features in apps aimed at improving engagement with the lowest scores in customisation settings and interactivity. This has also been reported in previous research (Machado et al., 2016; Mauch et al., 2018) and is concerning as it can impact long-term adherence. The highest rating MARS domain was for functionality and confirms that many of the apps functioned well and were easy and logical to learn. However, as was reported in previous research (Machado et al., 2016; Mauch et al., 2018), it was difficult to score this domain below a three if the app functioned and was not highly nonintuitive. The aesthetics domain required some discussion to reach consensus as there was a level of subjectivity to what one reviewer considered appealing compared to the other despite both reviewers undergoing online scoring training.

There is a clear need for higher quality apps that have been evaluated and are from reliable sources. Only one of the apps, the SelfBack app, had been trialled and evaluated in randomised controlled trials. The credibility of the developer was just acceptable (MARS score 3) (Machado et al., 2016; Stoyanov et al., 2015) for about a third of the apps. App consumer ratings were variable and were not correlated with app quality, which supports findings in previous research (Machado et al., 2016). Therefore, consumer ratings may not be an appropriate indicator of app quality. This assessment also found a correlation between price and app quality as was found by Machado and colleagues (Machado et al., 2016) and shows that higher cost apps are likely to be better quality. It could be hypothesised that apps that cost more may have higher development costs, possibly associated with more time used to research content and develop higher quality internal software architecture. High internal quality enables programmers to more easily fix defects, add new features and allows for a better consumer experience of external app features.

The apps had a variable number of self-management support components. The highest rating app for self-management support only scored just over half (eight) for the SMS-14. The highest rating SMS-14 subsection was “Exercises (biomechanical/aerobic)” in the self-efficacy building section, with most apps (80%) providing information on biomechanical/aerobic exercises. The low self-management support scores demonstrate that apps may not be developed with self-management support in mind. To be included in the review, apps were required to have a LBP self-management aim and include at least one NICE guideline for LBP recommended self-management component. While it is possible that included apps may have performed differently against alternate criteria, the focus of this review was on the self-management of LBP, and the results suggest that there is great potential to improve app content in this area. The lowest rating subsections were

“social support” and “cultural relevance” in the functions section, with scores of zero. Although many apps provided access to social media platforms, the “social support” section was scored as a ‘no’ unless it provided the support options listed and not simply access to informational updates. However, sharing health information online requires that this information be held securely, similar to that of national electronic health records throughout the world (World Health Organisation [WHO], 2021). This may pose a privacy security dilemma for app developers with potential ransomware attacks as occurred with Garmin in July 2020 (BBC News, 2020). As such joining online app communities would be required to be voluntary, with customised privacy features, the information provided willingly and with the knowledge that it is freely available to other members of that online community, much like the very popular online community for the STRAVA app (STRAVA, 2021). Additionally, although all included apps were able to be used by all English language speakers, the “cultural relevance” section was scored as a ‘no’ if the app did not specifically offer culturally tailored information for different ethnicities, religions, socioeconomic status, disability or sexual orientation. This may be as a result of included apps being in English. It may also be unreasonable to expect this level of customisation and information from LBP self-management apps. Cultural adaptations may be of little relevance in LBP and as such not routinely included as they perhaps would be for other areas such as sexual health and advice. None of the apps had an app function that allowed for access to an app community for emotional, information and appraisal support or reported culturally tailored information and developers should concentrate on addressing these areas in the future. These results demonstrate that apps are not designed with self-management support options and as such, the area of self-management support in LBP self-management app design would benefit from further development.

The included apps had a variable number of behaviour change potential elements. The app with the highest behaviour change potential (ABACUS score 14) only met just over two thirds of recommended behaviour change criteria. The highest scoring ABACUS subsection (1.4) was instructions to perform the behaviour, with most apps (80%) providing information on how to perform the behaviour. The low behaviour change potential of the apps may reflect a minimal focus on behaviour change during development. There is great scope to improve behaviour change potential for apps for LBP self-management. The willingness for behaviour change (2.1), sharing behaviours with others (3.3), ability to export data (3.5) and rewards or incentives (3.6) all scored zero, demonstrating that none of the apps asked about willingness for behaviour change, had the ability to share behaviours with others to allow for social comparison or to export data from the app, nor did they provide rewards or incentives. These could be areas of future focus for app developers. Apps are not designed with behaviour change promotion options (Mauch et al., 2018) and as such, the area of behaviour change potential in LBP self-management app design would benefit from greater priority.

Strengths and limitations

This systematic assessment had numerous methodological strengths. The search strategy was based on comparable reviews and was systematic and assessed a great number of apps. The study protocol was prospectively registered and guided by PRISMA principles for systematic searching (Moher et al., 2009). The comprehensive search was performed in line with current processes and available search format. Both reviewers undertook MARS training prior to data collection, data collection was undertaken in duplicate by two independent reviewers and inter-rater reliability was excellent. The tools

used for assessment were also reliable and validated. This presents a high level of confidence in the findings of this systematic assessment. The focus of the assessment was on apps for the self-management of LBP which is the current gold standard for LBP management according to guidelines. The apps included within this systematic assessment are representative of those that consumers may download for immediate use rather than necessitating organised input from a health professional. Apps were not excluded based on date of update allowing for the inclusion of a higher number of apps than previous reviews. The assessment of self-management support and behaviour change capacity offers novel information for consumers and health professionals.

The developer credibility domain, in the MARS rating scale, presented a scoring difficulty and required a great deal of online searching to score. This information was generally not available within the app or in the app description in the app store and was difficult due to a lack of standardised search protocol. Another limitation was the small sample size for the analysis of associations. Only nine apps reported cost and consumer ratings and were therefore included in the multivariate regression analyses to investigate associations between price, consumer ratings and quality. Therefore, these results should be interpreted with caution.

Implications

Future research

Despite most of the apps receiving an acceptable quality rating, the engagement domain consistently rated poorly. Developers should co-design future apps together with health professionals and consumers to improve engagement in the hope of improving

adherence and LBP outcomes. Another component of app design that may increase the quality of LBP self-management apps would be to trial them in randomised controlled trials and ensuring that developers are from a credible source. Scientifically evaluating LBP self-management apps for effectiveness in improving LBP outcomes, would provide evidence-based apps and improve the credibility and quality of apps and ratings in the information domain. Currently, information quality and accuracy are not assessed across any tools. Although one app has been used in scientific research, none of the included apps have been tested to determine if they can improve LBP outcomes, self-management and behaviour change. This limits consumer confidence in the product. This would be an area of app development that could be scored and marketed to provide evidence for app quality. It is possible that an accreditation or scientific rating process may improve consumer confidence. There is also need for exploration of cut-off scores or guidelines for self-management support and behaviour change potential to provide meaningful information for consumers. Currently, there are no clear cut-off scores in the literature for the ABACUS or SMS-14 scales to provide an indication of weighting of importance. These tools provide a continuous score and do not provide a numerical rating to reflect self-management or behavioural outcomes or correlation between app scores and outcomes (Devan et al., 2019; McKay et al., 2019).

Implications for clinical practice/consumers

All eligible apps were scored for potential to improve behaviour change and self-management support. Self-management support and behaviour change potential are areas that require greater priority for future LBP self-management app development to improve LBP outcomes. These results show that current LBP self-management apps do not have a

high chance of improving self-management or encouraging behaviour change. This review also reported no significant correlation between in app ratings and app quality and as such consumers should be cautious of using in app ratings to guide app choice. Although, app price and quality showed a significant correlation, price should not exclusively be used to guide app choice. The results of this assessment confirm that app quality continues to be poorly regulated and even higher quality apps may not significantly improve self-management and behaviour change which are required components to improve LBP outcomes.

The development of smartphone apps is a rapidly growing industry that is poorly regulated making quality assessment by consumers difficult. Smartphone apps for the self-management of LBP without health professional input are numerous, of average to good quality, with poor engagement scores and with marginal levels of self-management support and behaviour change components. This systematic assessment demonstrated that although apps may have the potential to cost effectively improve LBP self-management outcomes much development is required in the areas of self-management and behaviour change potential. Developers need to work together with consumers and health professionals to incorporate increased self-management and behaviour change content and subsequently trial apps to establish effectiveness and engagement.

Chapter Four – Study 3 (Consumers)

Self-efficacy, self-management and use of smartphone apps for low back pain: an observational study

This chapter answers the aim “to explore the self-efficacy and self-management practises of people with low-back pain (LBP), including associations between participant characteristics, self-efficacy and self-management” and the secondary aim “to describe the characteristics of people with LBP who use smartphone apps for self-management, including app preferences”. This chapter describes the findings of an online consumer survey. The survey was completed to explore consumers’ choice of self-management options for low back pain and use of smartphone apps for the self-management of low back pain. The systematic assessment (study 2, chapter 3) found that commercially available apps are of average to good quality, but few were designed to specifically incorporate self-management support and behaviour change potential. As such, commercially available apps have questionable potential for self-management and behaviour change. This made it difficult to transfer this knowledge to practice to encourage app use. To gain a better understanding of the landscape around app use and LBP management an understanding of the self-efficacy and self-management practises of people with LBP and their use of apps for LBP management was required.

Statement of co-authorship:

All authors were involved in formulating the concept and design of the study. Claudia Didyk completed the initial version of the survey. All authors contributed to create the final version of the survey. Claudia Didyk conducted the data analysis and completed the initial draft of the manuscript. All authors edited multiple revisions of the manuscript. See Appendix 1 for the signed co-authorship approval form. No conflict of interest was reported by the authors and funding for participation voucher purchases was provided by the Flinders University Research Student Maintenance (RSM) support. Ethical approval was gained from the Flinders University Human Research Ethics Committee (HREC) (no. 2818). Prior to undertaking the survey, online informed consent was gained from all participants. The authors are grateful to the survey participants who contributed information about LBP self-management.

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Abstract

Aim: The primary aim was to explore the self-efficacy and self-management practises of people with low-back pain (LBP), including associations between participant characteristics, self-efficacy and self-management. The secondary aim was to describe the characteristics of people with LBP who use smartphone apps for self-management, including app preferences.

Methods: Prospective cross-sectional online survey of Australian adults with current or previous LBP. Descriptive statistics were completed for all variables and normality was assessed. Associations between participant characteristics, self-efficacy and self-management were explored through logistic and linear regression, and non-parametric tests for skewed variables. Alpha was 0.05.

Results: 136 survey responses were included (55.5±14.5 years, 74% female). Most participants (93%) had LBP at the time of the survey and reported constant or daily (58%) pain of moderate severity. Nearly all participants managed their LBP on their own (91%), with the most frequently used self-management options including exercise (47%), advice from health professionals (38%,) and pharmacological management (37%). Most participants self-managed either moderately (35%) or fairly (32%,) well, with a mean self-management score of 11.9±4.0 out of 20, and a median self-efficacy score of 3.9 (IQR 0.9), well above mid-range. Lower SES and all personality trait scores (conscientiousness, agreeableness, openness, emotional stability and extroversion) were associated with higher self-efficacy ($p<0.05$). Longer duration and increased recurrence of LBP were associated with lower self-efficacy ($p<0.05$). Participants with higher self-management were female, with increasing age, higher traits scores in personality domains aside from agreeableness and lower severity of low back pain ($p<0.05$). Seventeen participants (13%) used apps, 75% found them helpful and 92% at least slightly effective for prevention. Popular

behaviour change app features included monitoring, advice, goal setting, prompts and social support options.

Conclusion: Most adults with LBP self-managed well and had above average self-efficacy. Smartphone app use was limited, with lack of knowledge a perceived barrier.

Keywords: smartphone apps; low back pain; self-management; self-efficacy; personality traits; behaviour change; consumers

Introduction

Low back pain (LBP) is a global health and economic concern and is rated as the number one cause of disability worldwide (Vos et al., 2017). It occurs in all age groups, but most commonly in working age (Vos et al., 2017), in all countries, regardless of income level, and often without a specific nociceptive cause (Maher et al., 2017). Although recovery can be rapid, recurrence is common (Hartvigsen et al., 2018). In Australia, LBP is the most common musculoskeletal condition (AIHW, 2023a), with an estimated four million people experiencing LBP in 2017-18 (ABS, 2019). The burden of LBP is increasing with an ageing population, high inflation, rising healthcare usage post pandemic and increasing global private health costs (WTW, 2022). Innovative low cost, scalable self-management options are required to manage the burden of LBP.

Self-management requires continuous self-regulation (Barlow et al., 2002) and is a key recommendation in current LBP guidelines, together with active rehabilitation and exercise (NICE, 2016; Bernstein et al., 2017). Self-management involves consumer participation in decision making (Lorig & Holman, 2003), and monitoring and management of treatment, physical symptoms and psychosocial requirements of the condition (Barlow et al., 2002). Self-management has been shown to reduce pain intensity and disability in people with LBP (Du et al., 2017). Targeted self-management interventions, personalised to specific groups of people may be the most beneficial, with small to medium effects reported (Banerjee et al., 2022). Modifiable biopsychosocial factors, such as physical activity, disability, catastrophising, kinesiophobia and depression, impact self-management (Banerjee et al., 2022). Additionally, self-management, health behaviour (Courtenay et al., 2002; Peyrot et al., 2018) and a person's openness to change (Baum et al., 2004;

Chapman et al., 2014; Stieger et al., 2020) may be impacted by ethnic differences (Hartvigsen et al., 2018) and personality traits. Disability resulting from LBP varies and is influenced by social norms and local health care (Hartvigsen et al., 2018). Therefore, individual preferences, needs, personality traits, self-efficacy and self-management capacity, require consideration in behaviour change interventions (Stieger et al., 2020).

Smartphones apps have potential to facilitate self-management of LBP (Rintala et al., 2022), providing a cost-effective option to improve access to health management guidance and monitoring (WHO, 2019; Iyengar et al., 2020; Murray et al., 2016; Stec et al., 2019; Whitelaw et al., 2020). The Covid-19 pandemic necessitated increased use of digital technology in health (Accenture, 2020; Merolli et al., 2022; Windisch et al., 2020), as consumers experienced difficulties accessing health care (Stark et al., 2022). Smartphones are ubiquitous in developed countries (Statista, 2020) and have capacity for great reach at low cost as scalable self-management interventions (Bennell et al., 2017). Apps have capacity to improve pain (Bailey et al., 2020; Cavanagh et al., 2019; Thurnheer et al., 2018) and disability outcomes (Shebib et al., 2019) or at least provide similar pain outcomes to physiotherapy for people with LBP (Lara-Palomo et al., 2022; Stark et al., 2022). Despite consumers being willing to use digital health technologies (Merolli et al., 2022) to more actively manage their health (Accenture, 2020), apps continue to be underutilised (Gordon et al., 2020).

International studies have explored self-management of LBP to address current clinical practice and increase self-management (Adam et al., 2020; Banerjee et al., 2022; Chala et al., 2022; Kongsted et al., 2021). In Australia, studies have explored the needs and experiences of people with LBP in primary care (Ahern et al., 2019) and beyond (Chou

et al., 2018). Self-efficacy and self-management of people with LBP have not been explored as primary outcomes in the Australian context, and we currently do not know whether and how people with LBP in Australia are using apps for self-management. There is a clear need to better understand the self-efficacy and self-management practises of people with LBP and their use of apps for self-management. This information may guide the development of targeted and scalable interventions to improve self-management of LBP.

The primary aim of this study was to explore the self-efficacy and self-management practises of people with LBP, including associations between participant characteristics, self-efficacy and self-management. The secondary aim was to describe the characteristics of people with LBP who use smartphone apps for self-management, including app preferences.

Methods

Design

This study used a prospective cross-sectional online survey (Qualtrics). Ethical approval was gained from the Flinders University Human Research Ethics Committee (no. 2818). The survey was disseminated from April to July 2022 through social media (Facebook, Twitter) and relevant support groups accessed through Pain Australia. People were eligible if they resided in Australia, were aged at least 18 years, and had experienced LBP of any duration. Informed consent was gained online prior to undertaking the survey. Based on using two-sided confidence intervals for one proportion (95% confidence interval) a sample size of 139 was proposed (Newcombe, 1998).

Survey instrument

Existing validated instruments relating to self-efficacy, self-management and use of technology or apps for people with LBP were identified through a literature search. Several valid and reliable instruments were integrated into the development of the survey for this study. The draft survey was pilot tested for usability (clarity, time taken to complete, flow of questions) on a small group of adults (n=4).

The final survey consisted of 40 items (36 closed, 4 open) in the following sections:

- *Personal information*, including age, gender, ethnicity, language, highest level of education and employment status. Postcodes were used to identify socio-economic status (SES) by using the Australian Bureau of Statistics Socio-Economic Indexes for Areas (SEIFA standardised mean of 1000, SEIFA Decile – is divided into 10 equal groups, the lowest scoring 10% of areas = 1, highest 10% of areas =10), which ranks areas in Australia according to relative socio-economic advantage and disadvantage (ABS, 2022c). A high score indicates a relative lack of disadvantage and greater advantage in general.
- *Personality traits* were assessed with the Ten-Item Personality Inventory (TIPI), a reliable assessment (convergent correlations (mean r=0.77), test-retest reliability (mean r=0.72)) of personality dimensions including: (1) Extraversion, (2) Agreeableness, (3) Conscientiousness, (4) Emotional Stability, and (5) Openness to Experience (Gosling et al., 2003). The TIPI consists of 10 personality trait pairs requiring a rating (7 point scale- disagree strongly (1) to agree strongly (7)) as to what extent the pair of traits apply (Gosling et al., 2003). The higher the score for each trait, the more likely a person's behaviour and thoughts reflect the characteristics of that trait (Gosling et al., 2003). The published norm scores for each personality trait were applied for analyses.

- *Self-efficacy* was assessed using the New General Self-efficacy scale (NGSE) (Chen et al., 2001), a reliable measure (internal consistency (a=0.86), reliability (a=0.90), test-retest reliability (r=0.67)) which asks respondents to rate their level of agreement with eight self-efficacy related statements (Chen et al., 2001). A higher score indicates greater self-efficacy (5 point scale - strongly disagree (1) to strongly agree (5)) (Chen et al., 2001).
- *Low back pain information* included duration, frequency, average pain rating (11-point numeric pain rating scale, NPRS (Jensen et al., 1986)) and management approaches.
- *Self-management* competence was assessed using the reliable (convergent validity (Pearson r=-0.40 to -0.64) internal consistency (Cronbach α=0.80), test-retest reliability (r=0.71)) 5-item Self-Management Self-Test (SMST) (Wehmeier et al., 2020) consisting of five questions and scored using a five-point scale (Wehmeier et al., 2020). A final self-management score is calculated, with a higher score indicating better self-management (Wehmeier et al., 2020).
- *Smartphone app use and preferences* were explored. For app users, the quality of the apps they used was explored with items based on the Mobile App Rating Scale (MARS) (engagement, functionality, aesthetics and information) (internal consistency (alpha = .90) and interrater reliability intraclass correlation coefficient (ICC = .79)) (Stoyanov et al., 2015). App potential for developing self-management survey items were based on the Self-management Support Checklist (SMS-14) (Devan et al., 2019), in the following categories: (1) self-efficacy building, (2) self-tailoring, (3) self-monitoring of symptoms, (4) goal setting and planning, (5) problem solving, and (6) partnership between views of patient and clinicians. The behaviour change potential of the identified apps was assessed using the App Behaviour Change Scale (ABACUS) (knowledge and information, goals and planning, feedback and

monitoring, and actions) (McKay et al., 2019), whilst the COM-B model for behaviour change (capability (C), opportunity (O), and motivation (M) – the three factors capable of changing behaviour (B)) (Michie et al., 2011) informed the creation of behaviour change survey questions. Finally, participants were asked about the features of apps that they liked or disliked, and whether specific features helped with LBP self-management. In this context effectiveness was self-reported.

Data management and analysis

Survey data were exported into Microsoft Excel. Survey responses that were not located in Australia, were 'bot' responses, or provided only demographic details were excluded. Where participants answered only the first part of a multi-component question, the incomplete question items were treated as missing data. The final dataset was exported into the Statistical Package for Social Science (IBM SPSS) version 28.0.1.1 for Windows for analyses. Normality of continuous variables were checked using histograms and Shapiro-Wilk tests. Descriptive analyses were completed on all variables, with means, standard deviations (SD) and ranges calculated for normally distributed data, medians and inter quartile ranges (IQR) for skewed data. Missing data were omitted, and complete case analysis was used. To explore associations between participant characteristics, self-efficacy and self-management, non-parametric statistics were completed for non-normally distributed variables, and parametric for those that were normally distributed. Logistic (categorical dependant variables) and linear (continuous dependent variables) regression analyses, and non-parametric tests (correlations, Mann-Whitney U, Kruskall-Wallis) were used. Significance was set at 0.05.

Results

A total of 208 survey responses were received, with 73 excluded (53 incomplete or 'bot' responses, 17 international postcodes), leaving 136 responses in the final dataset for analysis.

Participant characteristics

Whole sample

Participants (n=136) were aged 55.5 (±14.5) years (range 18 to 80 years) and 74% were female (Table 4.1). Most participants had English as a first language (95%) and were born in the Oceania region of Australia and New Zealand (72%). Four per cent (n=5) identified as Aboriginal or Torres Strait Islander. Mean SEIFA disadvantage score was 995.6 (±46.7) (range 906 to 1115) (below the standardised mean of 1000) and the median SEIFA decile score was seven (IQR 4). Most participants had university level education (56%) and 55% were not employed. Most had below norm extroversion (70%, n=95), openness (64%, n=87) and emotional stability (58%, n=79) and above norm conscientiousness scores (51%, n=69).

Most participants had access to an iPhone (65%, n=81) or android phone (44%, n=54) and 51% (n=63) had access to an iPad or other tablet device (24%, n=29). Three participants (2.2%) did not have access to any smartphone or tablet device. Most participants (87%, n=111) rated themselves at least moderately confident using smartphone or tablet devices.

Most participants (93%, n=127) had LBP at the time of the survey and reported constant or daily (58%, n=69) pain with median pain severity of 6 out of 10. Most participants reported pain lasting longer than 12 weeks (67%, n=91) and experienced a recurrence of LBP constantly to daily (58%, n=69) (Table 4.1).

Table 4. 1.

Participant Characteristics for Whole Sample and App Users

	Whole sample (n=136)	**App users (n=17)**
Gender n (%) (Female)	100 (73.5 %)	13 (76.5 %)
Age (years) mean ± SD (range)	55.5 ± 14.5 (18-80)	55.8 ± 15.7 (19-80)
English 1st Language n (%)	129 (94.9%)	15 (88.2%)
Aboriginal or Torres Strait Islander n (%)	5 (3.7%)	3 (17.7%)
Country born n (%)		
Oceania (Australia, New Zealand)	98 (72.1%)	13 (76.5%)
Europe	23 (16.9%)	1 (5.9%)
Asia	7 (5.1 %)	1 (5.9%)
North America	2 (1.5%)	1 (5.9%)
Africa	6 (4.4%)	1 (5.9%)
Country mother born n (%)		
Oceania (Australia, New Zealand)	85 (62.5%)	12 (70.6%)
Europe	38 (27.9%)	4 (23.5%)
Asia	8 (5.9%)	1 (5.9%)
North America	1 (0.7%)	-
Africa	4 (2.9%)	-
Country father born n (%)		
Oceania (Australia, New Zealand)	82 (60.3%)	12 (70.6%)
Europe	41 (30.1%)	3 (17.7%)
Asia	7 (5.1 %)	1 (5.9%)
North America	2 (1.5%)	1 (5.9%)
Africa	4 (2.9%)	-
Highest education n (%)		
High school not completed	16 (11.8%)	2 (11.8%)
High school completed	15 (11.0%)	1 (5.9%)
TAFE or trade school	29 (21.3%)	3 (17.7%)
Bachelor degree	27 (19.9%)	3 (17.7%)
Graduate Certificate or Diploma	29 (21.3%)	3 (17.7%)
Masters or Doctoral degree	20 (14.7%)	5 (29.4%)
Employment status n (%)		
Employed	61 (44.9%)	6 (35.3%)
Unemployed -	75 (55.1%)	11 (64.7%)
Retired	44 (32.4%)	7 (41.2%)
Looking for work	7 (5.2%)	1 (5.9%)
Student	6 (4.4%)	1 (5.9%)
Not looking for work	5 (3.7%)	-

	Whole sample (n=136)	App users (n=17)
Disability support pension	5 (3.7%)	2 (11.8%)
Carer	3 (2.2%)	-
Home duties	2 (1.5%)	-
Other	3 (2.2%)	-
SEIFA		
Disadvantage Score mean ± SD (range)	995.6 ± 46.7 (906 – 1115)	1015 ± 41.9 (954 – 1092)
Decile Score median, IQR (range)	7, 4 (2-10)	8, 4 (4-10)
Personality trait scores median, IQR (range)		
Extroversion (norm=4.4)	4.0, 2 (1-7)	3.0, 1.8 (1-7)
Agreeableness (norm=5.2)	5.0, 2.0 (3-7)	4.5, 1 (2.5-7)
Conscientiousness (norm=5.4)	5.5, 2.0 (1-7)	4.5, 1.3 (3.5-7)
Emotional stability (norm=4.8)	4.5, 3.0 (1-7)	5.0, 2.8 (2-7)
Openness (norm=5.4)	5.0, 2.0 (2-7)	4.5, 2 (3.5-7)
Current LBP n (%)	127 (93.4%)	17 (100 %)
Average LBP Severity Median (IQR)	6 (2)	6 (4)
Duration of LBP n (%)		
< 6 weeks	33 (24.3%)	3 (17.7%)
6-12 weeks	12 (8.8%)	-
>12 weeks	91 (66.9%)	14 (82.4%)
Recurrence of LBP n (%)		
constantly-daily	69 (58.0%)	12 (70.6%)
<daily-monthly	20 (16.8%)	2 (11.8%)
<monthly-yearly/randomly/activity dependent	30 (25.2%)	3 (17.7%)

SEIFA - Statistics Socio-Economic Indexes for Areas
LBP – Low Back Pain

LBP self-management options

Use

The majority of participants reported managing their LBP on their own (n=124) and used exercise (n=123) (Table 4.2). The most frequently used self-management options were exercise (47%, n=59), advice from health professionals (38%, n=48) and pharmacological management (37%, n=47) (Table 4.2). Other self-management options used frequently (25%) included self-treatment such as self-adjustments, medication, and passive treatments (e.g. Traditional Chinese Medicine, psychological/mindfulness therapies). The self-management options used rarely or not at all were return to work

(RTW) programs (91%, n=114), psychological therapies with physical programs (69%, n=93) and internet information (50%, n=62).

Table 4. 2.

Frequency of Use of Self-management Options for LBP

	Never/Rarely n (%)	Occasionally n (%)	Frequently/Very frequently n (%)
Advice from health professionals (n=126)	27 (21.5)	51 (40.5)	**48 (38.1)**
Internet information (n=125)	62 (49.6)	47 (37.6)	16 (12.8)
Exercise (n=126)	27 (21.5)	40 (31.7)	**59 (46.8)**
Manual therapies (n=126)	37 (29.4)	52 (41.3)	37 (29.4)
Psychological therapies with physical programs (n=126)	93 (69.0)	26 (20.6)	13 (10.3)
Return to work programs (n=126)	114 (90.4)	9 (7.1)	3 (2.4)
Pharmacological management (n=132)	48 (38.1)	31 (24.6)	**47 (37.3)**
Other (n=98)	76 (77.5)	6 (6.1)	16 (16.3)

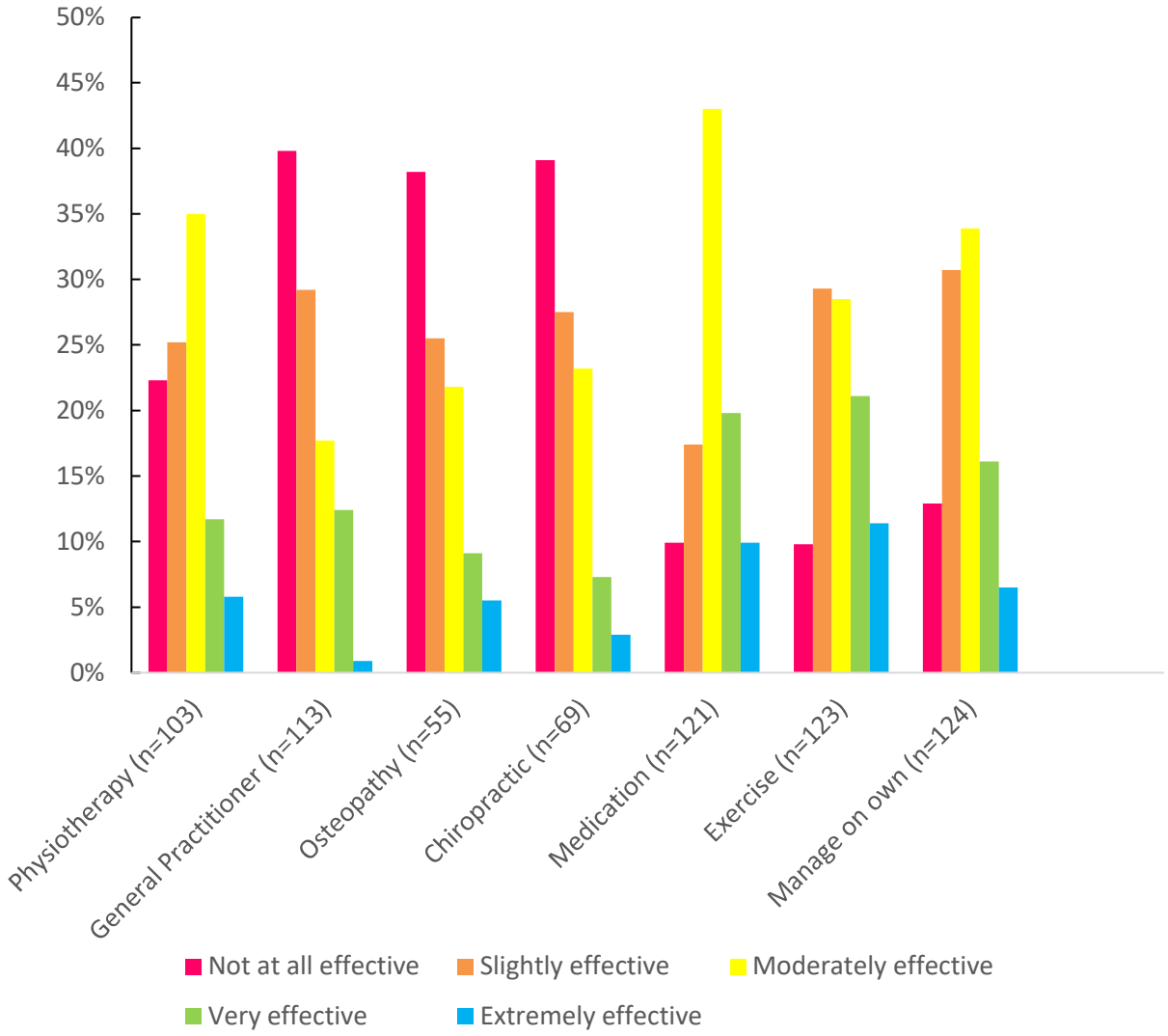
Note. **Bold** = most frequently used

Effectiveness

Effectiveness was self-reported and treatments perceived as extremely effective (19%, n=11) or very effective (29.3%, n=17) included passive treatments (e.g. massage, acupuncture/Traditional Chinese Medicine), psychological or mindfulness therapies (e.g. meditation), and a range of low impact exercise (e.g. Pilates, yoga, swimming). In terms of perceived effectiveness (Figure 4.1), most participants considered medication (73%, n=88), exercise (61%, n=75), managing on their own (57%, n=70) and physiotherapy (53%, n=54) to be at least moderately effective. Treatment options that were considered not at all effective were no treatment (57%, n=40) or consulting a General Practitioner (40%, n=45), Chiropractor (39%, n=27) or Osteopath (38%, n=21).

Figure 4. 1.

Use of Different LBP Self-management Treatment Options and Perceived Effectiveness



Self-efficacy and self-management scores

Most participants self-managed either moderately (35%, n=44) or fairly (32%, n=40) well, with a mean self-management score of 11.9 (±4.0, range 3 to 20) out of a maximum possible score of 20, and a self-efficacy score above mid-range of 2.5 (90%, n=122) (Median = 3.9, IQR 0.9).

Associations between participant characteristics and self-efficacy

Employment status, SES and maternal birth country were significantly associated with self-efficacy (Table 4.3). Lower SES (SEIFA and SEIFA Decile) was associated with higher self-efficacy, both with a small correlation (r=-0.190, p=0.027,and r=-0.195, p=0.023). All personality trait scores (conscientiousness, agreeableness, openness, emotional stability and extroversion) showed a statistically significant positive correlation with self-efficacy, with higher personality trait scores associated with higher self-efficacy. Both LBP duration (H(2)=9.043, p=0.0.11) and recurrence (H(2)=9.724, p=0.008) were inversely associated with self-efficacy, with longer durations and increased recurrence of LBP associated with lower self-efficacy.

Associations between participant characteristics and self-management

Females had higher self-management scores than males (R^2 = 0.064, F(1, 124) = 8.486, p=0.004) and increasing age was associated with higher self-management scores (R^2 = 0.074, F(1, 124) = 9.846, p=0.002) (Table 3). Higher levels of extroversion, conscientiousness, emotional stability and openness were positively associated with higher self-management scores (Table 4.3). There was an inverse association between LBP severity and self-management (R^2 = 0.046, F(1, 125) = 6.077, p=0.029) (Table 4.3). People with higher self-management scores self-rated their ability to self-manage their LBP higher (r=0.529, n=127, p<0.001).

Table 4. 3.

Associations Between Demographic Factors and Self-efficacy and Self-management

	Self-efficacy (NGSE) (n=136)	**Self-management (SMST)** (n=127) Standardised Coef. (p-value) [95%CI]
Gender (n=126)	Z = -1.716, p=0.086[a] *Average rank:* 58.27 Male 71.41 Female	0.253 **(p=0.004)** [0.745, 3.641]
Age (n=135) (years)	0.030 (p=0.726) [-0.144, 0.203][b]	0.271 **(p=0.002)** [0.027, 0.112]
English 1st Language (n=127)	Z = -1.898, p=0.058[a] *Average rank:* 67.01 Yes 95.93 No	0.081 (p=0.367) [-0.297, 3.123]
Aboriginal or Torres Strait Islander (n=125)	Z = -0.925, p=0.355[a] *Average rank:* 51.80 Yes 68.11 No	0.086 (p=0.340) [-0.518,4.269]
Birth country (n=127)	Z = -1.155, p=0.248[a] *Average rank:* 67.24 Western 80.46 Eastern	-0.014 (p=0.876) [-2.293, 1.797]
Maternal birth country (n=127)	Z = -1.937, p=0.053[a] *Average rank:* 66.47 Western 89.46 Eastern	0.044 (p=0.622) [- 1.538, 2.363]
Paternal birth country (n=127)	Z = -1.826, p=0.068[a] *Average rank:* 66.68 Western 89.23 Eastern	0.023 (p=0.800) [-2.499, 3.234]
Highest education (n=127)	H(2)=0.72, p=0.699[c] *Mean rank:* 70.52 Bachelor / Graduate Certificate/Diploma/ Masters/Doctoral 64.44 TAFE or trade school / High school completed 70.44 High school not completed	-0.115 (p=0.218) [-2.501, 0.640] TAFE of trade school / High school completed -0.083 (p=0.258) [-2.821,0.847] High school not completed
Employment status (n=127)	Z = -1.950, p=0.051[a] *Average rank:* 75.78 Yes 62.58 No	0.091(p=0.309) [-0.744, 2.064]
SES **SEIFA total** (n=127)	-0.190 **(p=0.027)** [-0.351, -0.017][b]	0.025 (p=0.771) [-0.014, 0.10]
SEIFA Decile (n=127)	-0.195 **(p=0.023)** [-0.356, -0.022][b]	0.033 (p=0.723) [-0.259, 0.348]
Personality traits **Extroversion score** (n=126)	0.208 **(p=0.015)** [0.036, 0.368][b]	0.220 **(p=0.010)** [0.129, 1.031]
Agreeableness (n=127) (1 point)	0.269 **(p=0.002)** [0.101, 0.423][b]	0.051 (p=0.573) [-0.478,0.869]

	Self-efficacy (NGSE) (n=136)	Self-management (SMST) (n=127) Standardised Coef. (p-value) [95%CI]
Conscientiousness (n=127)	0.444 **(p<0.001)** [0.293, 0.573][b]	0.404 **(p<0.001)** [0.709, 1.574]
Emotional Stability (n=127)	0.383 (**p<0.001)** [0.225, 0.522][b]	0.462 **(p<0.001)** [0.779, 1.606]
Openness (n=127)	0.380 **(p<0.001)** [0.221, 0.519][b]	0.314 **(p=0.002)** [0.535, 1.652]
LBP Characteristics		
Current LBP (n=127)	Z = -0.329, p=0.742[a] *Average rank:* 68.20 Yes 72.67 No	-0.098 (p=0.396) [-6.167, 2.871]
Average LBP Severity (n=127)	-0.053 (p=0.539) [-0.224, 0.121][b]	-0.215 **(p=0.029)** [-0.892,-0.055]
Duration of LBP (n=127)	H(2)=9.043, **p=0.01**[c] *Mean rank:* 85.00 < 6 weeks 75.58 6-12 weeks 61.58 > 12 weeks	-0.123 (p=0.097) [-3.817, 0.269] 6-12 weeks -0.054 (p=0.600) [-2.277, 1.186] >12 weeks
Recurrence of LBP (n=112)	H(2)=9.724, **p=0.008**[c] *Mean rank:* 51.64 Constantly – Daily 71.05 < Daily – Monthly 71.87 < Monthly -Yearly/ Randomly/Activity Dependent	-0.061(p=0.458) [-2.557, 1.356] <daily-monthly 0.043 (p=0.658) [-1.445, 2.207] <monthly - yearly/Randomly/Activity dependent

Note. **BOLD =** significant p=0.05
SMST Score Reference categories for Gender – Males, English as a first language – Yes, Aboriginal/Torres Strait Islander – Yes, Country Born/ Mother born/Father born – Western, Highest Education – Bachelor or above, Employment status – Yes, Current LBP – Yes, Duration of LBP - <6weeks, Recurrence of LBP – constant/daily
[a]Denotes a non-parametric Mann-Whitney U test with the results reported as: Z, *p* value, average rank; [b]Denotes a non-parametric Spearman's rho test with results reported as: r, *p* value, 95%CI; [c]Denotes a nonparametric Kruskall-Wallis H test with the results reported as: H, *p* value, Mean rank.
NGSE = New General Self-Efficacy Score, SMST = Self-Management Self-Test Score

Use of smartphone apps by people with LBP

App user characteristics

Seventeen of the 136 participants (13%, n=17) reported using apps to manage their LBP (Table 4.1). The main reasons for not using apps were lack of knowledge (76%, n=73)

and deliberate choice (24%, n=23). All app users had access to a smartphone and 83% (n=14) to a tablet device. Most participants (65%, n=11) were very confident using smartphone/tablets. App users had a higher level of unemployed (65%, n=11), a lower socio-economic disadvantage, with a SEIFA score of 1015.4 (±41.9) (above the standardized mean of 1000) and median SEIFA decile score of 8 (IQR 4) (range 4-10) when compared to the whole sample. Most app users had below norm scores for extroversion (82%, n=14), agreeableness (77%, n=13), openness (65%, n=11) and conscientiousness (59%, n=10) and above norm emotional stability (53%, n=9).

All app users had LBP at the time of survey completion, with 71% (n=12) reporting constant or daily LBP and 82% (n=14) with pain lasting longer than 12 weeks (Table 4.1). Most app users reported self-managing their LBP moderately (35%, n=6) or fairly (35%, n=6) well, with a mean self-management score of 13.06 (±3.93, range 6-20) out of a maximum score of 20 and a self-efficacy score above mid-range of of 2.5 (94%, n=16) (Median=3.8, IQR 1.1).

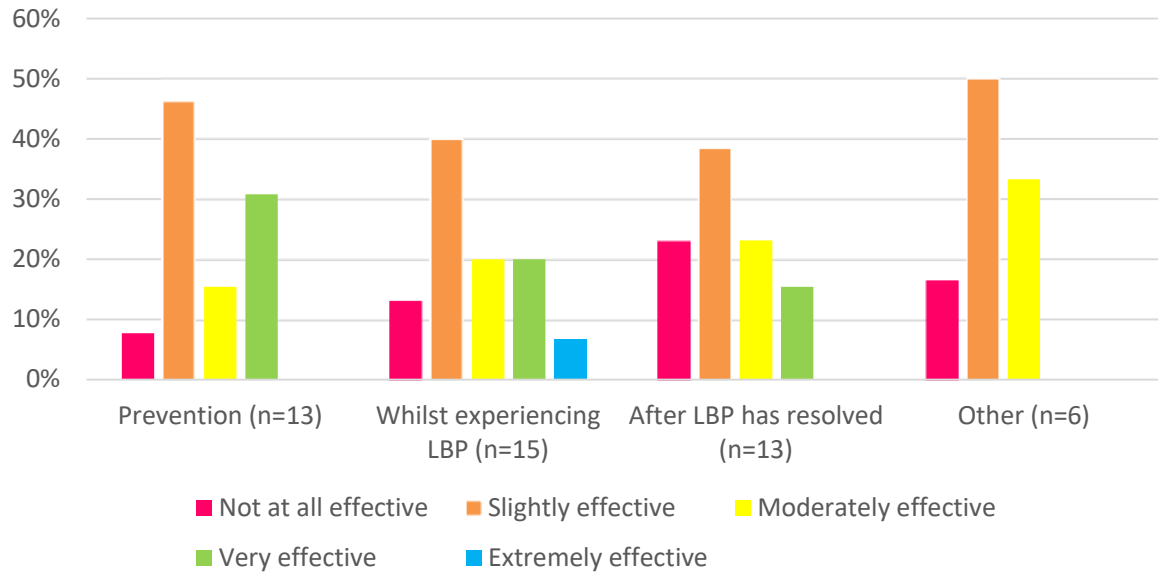
Self-management and app use

Apps were used whilst experiencing LBP (94%, n=16), for prevention (81%, n=13) and after LBP had resolved (81%, n=13) (Figure 4.2). Seventy-five per cent (n=6) of app users who responded, reported that apps were effective in improving LBP, and at least slightly effective during prevention (92%, n=13), whilst experiencing LBP (80%, n=15) and after it had resolved (77%, n=13). Three participants (30%) reported that they self-managed at least moderately well with LBP apps. Seven participants (70% of app users)

reported that there was no change in how often they sought treatment for LBP when using apps.

Figure 4. 2.

Phase of LBP Self-management App Use Most Effective



Apps used for LBP self-management

Apps used by participants included FlareDown (Logan Merriam), Microsoft OneNote (Microsoft), Youtube (Google), Back pain exercises at home (Vladimir Apps), Lower back pain exercises (Steveloper), Back pain relief yoga at home (Dr Zio), Notes (QR Scanner & QR Code Generator & Radio & Notes) and Insight Timer (Insight Network Inc). The app features most often used were meditation and relaxation (Insight Timer); tracking of symptoms, treatments, and management (FlareDown); exercises (Back pain exercises at home, Lower back pain exercises, Back pain relief yoga at home); and note taking and recording (Notes).

App users reported using their chosen app for months (33%, n=2) to years (67%, n=4). Five participants (63%) used their chosen app daily. The behaviour change features that helped to improve LBP were motivation (67%, n=4), healthy behaviour skills (67%, n=4), self-management prompts (50%, n=3) and example self-management behaviours (50%, n=3). Most participants (83%, n=5) reported that the behaviour change features that did not improve LBP were education, in-app rewards, fear of consequences, restriction of unhealthy behaviours and behavioural support options (67%, n=4).

Participants agreed or strongly agreed that their chosen app provided prompts to encourage self-management (60%, n=3), examples of self-management behaviours (50%, n=2) and motivational language (50%, n=2). Participants agreed that their chosen app provided information to promote self-management (80%, n=4), behavioural support options to reduce barriers to self-management (80%, n=4) and taught skills required to self-manage (50%, n=2). Over 57% (n=4) of the apps did not provide a reward system, consequences for not following self-management advice or behavioural restrictions.

While not all identified apps had all features that were rated, the monitoring feature of apps was reported to be important (80%, n=4). Advice, goal setting, prompts and alarms, and social support features were also rated as important (50%, n=2). Planning for flare-ups was the most used feature (100%, n=5), followed by education and information (75%, n=3), advice (67%, n=2), monitoring of progress and symptoms (60%, n=3), and goal setting and prompts and alarms (both 50%, n=2). The least used features were personalisation (75%, n=3) and social support (67%, n=2).

App features that were liked by all participants using apps with that feature included: interactivity (n=3), graphics (n=5) and quality of information (n=4). Navigation (86%, n=6), gestural design (86%, n=6), layout (83%, n=5), visual appeal (83%, n=6), accuracy of app description (83%, n=5) and interest (80%, n=4) were liked by over 80% of participants using apps with those features. The least liked features were entertainment (75%, n=3) and visual information (67%, n=4). The features that most commonly were not included in the identified apps were interactivity (57%, n=4), and customisation, goals, quality of information, and evidence base (43%, n=3).

Discussion

This study aimed to investigate the self-efficacy and self-management practises of people with LBP, as well as explore the use and preferences for smartphone app use for self-management. Most Australian adults reported daily, moderately severe LBP of at least three months duration. People with LBP had moderate self-efficacy, with lower SES, higher personality traits and lower LBP duration and recurrence associated with higher self-efficacy. In terms of self-management, most people with LBP self-managed moderately well, most commonly on their own, with effective self-management options including medication, exercise and physiotherapy. Females, lower pain severity, and extroversion, conscientiousness, emotional stability, and openness were associated with higher self-management scores. Only a small proportion of people reported using apps to self-manage their LBP, with popular behaviour change features including monitoring, advice, goal setting, prompts and social support options.

Self-efficacy is important for people with LBP (Costa Lda et al., 2011; de Moraes Vieira et al., 2014; Denison et al., 2004; Ferrari et al., 2019; Hampel & Neumann, 2023), impacting recovery and predicting progression to chronicity (de Moraes Vieira et al., 2014; Denison et al., 2004; Hampel & Neumann, 2023). Consistent with previous literature, we found that conscientiousness, extroversion, openness, emotional stability and agreeableness were associated with higher self-efficacy (Ambiel & Noronha, 2016; Brown & Cinamon, 2016; Delgado-Rodrguez et al., 2018; Hayat et al., 2020). It is possible that people with stronger personality traits may have improved coping mechanisms (Burgess et al., 2010) to better manage stress (Galindo-Domínguez & Bezanilla, 2021), resulting in higher self-efficacy and improved self-management. Interestingly, app users had below normal scores in the personality traits associated with higher self-efficacy. This apparent discrepancy may highlight that those with lower personality trait scores may be drawn to external self-management options to assist with self-management rather than relying on their own perceived ability to regulate behaviour. Previous studies have reported conflicting findings in relation to SES and self-efficacy in people with LBP (Whitley et al., 2021). This study found a significant inverse association between SES and self-efficacy, which may partially be explained by self-efficacy mediating possible impacts of low SES (Cerin & Leslie, 2008; Huang et al., 2019). It must also be noted that the average SES level in this study was very close to the standardised average in Australia (ABS, 2022b), with further exploration required of the low and high SES bands and self-efficacy in this population. Improving self-efficacy will likely improve health outcomes (Hampel & Neumann, 2023) and is integral to self-management interventions. Early intervention is particularly important for people with LBP due to relationships between LBP duration, recurrence and lower self-efficacy. Da Silva et al. (2019) found that approximately 40% of people who experienced LBP recurrence within a year, experienced moderate activity limitation and sought healthcare related treatment. Early intervention and self-management

targeted toward maintaining and improving self-efficacy is indicated to decrease the likelihood of progression to chronicity.

Self-management is a key recommendation in LBP guidelines (Meroni et al., 2021) to enhance a person's ability to manage day-to-day and improve quality of life (Lorig & Holman, 2003). People with stronger traits in conscientiousness, openness, extroversion and emotional stability self-manage better and are more likely to undertake health promoting activities (Dietmaier et al., 2022; Hampson et al., 2016; Mendoza-Catalán et al., 2022). Those who are open to new experiences (openness), thoughtful and with good impulse control (conscientiousness), sociable and assertive (extroversion), deal better with stress and are emotionally resilient (emotional stability) (Power & Pluess, 2015), and may be more likely to effectively self-manage. Although not found in this sample, high levels of agreeableness have been shown to improve self-management (Sirois & Hirsch, 2015; Zhang et al., 2019). In this study, people with LBP self-managed moderately well, however, in contrast with previous literature (Banerjee et al., 2022; Kawi, 2014), lower age and higher LBP severity were associated with lower self-management. The contrasting results may be due to the differing methods used for data collection in these studies. As the survey was undertaken online, it may have been biased toward those that were younger (mean age in this sample was 55.5 years (working age)) and comfortable using technology, as it is well documented that older adults can have poorer self-management abilities (Scheffer, Menting & Boeije, 2021; Simpson & Xu, 2020). However, in agreement with Banjeree et al. (Banerjee et al., 2022), pain duration did not predict self-management and it's change.

Despite most people with LBP in this study reporting self-managing their LBP effectively on their own, the number of participants using apps to aid self-management approaches was lower than anticipated. Interestingly, those who used apps to self-manage

their LBP had below norm personality traits aside from emotional stability, which contrasts with the finding that higher personality traits are associated with improved self-management and self-efficacy in the whole sample. Higher levels of some personality traits have been shown in the general population to be associated with increased use of physical activity apps such as Strava or Fitbit (Petersen et al., 2020). Many general physical activity apps emphasise the importance of social support features, such as sharing on social media platforms, to encourage adherence to app use and increase physical activity (Petersen et al., 2020). Interestingly, most of the app users in this study did not place importance on social support features, and few used them if they were available. It is likely that people with LBP have different goals and priorities when accessing apps to the general population.

Low back pain interventions should encourage behaviours that improve health outcomes by encouraging self-management (Araújo-Soares et al., 2019). In this study, self-management and behaviour change features (NICE, 2016; Araújo-Soares et al., 2019; Devan et al., 2019; McKay et al., 2019) were often not provided in the identified apps which aligns with current literature (Didyk et al., 2022a). In this sample, those that used apps had higher mean self-management scores than the whole sample but slightly lower median self-efficacy scores. It is possible that those with higher personality trait scores, self-efficacy and self-management who did not use apps, self-managed well without the need for adjunct self-management options such as apps. In contrast, those with lower personality trait scores and associated lower self-efficacy, may require apps as an adjunct self-management option to assist with improving self-management.

Apps appear to be used by a small proportion of people with LBP as an adjunct to other management options such as exercise, medication and physiotherapy. App users in this study placed importance on the monitoring of progress and planning for flare-ups in

apps, and liked app quality functionality (navigation, gestural design, layout) and aesthetic (layout, graphics, visual appeal) features. App developers should include these features to encourage app use for LBP self-management. There is also a clear need for health professionals such as physiotherapists, to understand the importance of self-efficacy and self-management for people with LBP. We currently do not know how health professionals use apps for clients with LBP, or their understanding of the role of apps in self-management. Assessment of app quality and self-management and behaviour change potential is important to guide appropriate app choice for consumers and health professionals. There is an urgent need for a quick and easy to use tool to evaluate apps, which may increase LBP self-management app recommendation by health professionals and uptake by people with LBP.

Strengths and limitations

This study has numerous methodological strengths. The survey was disseminated nationally, using a variety of paid and free online methods. The tools used in the survey were reliable and valid, allowing for a high level of confidence in the results. Large amounts of data were collected and analysed to explore possible relationships and those that might influence app use. Although the number of app users was small, it aligns with current trends (Accenture, 2020). There were also some limitations. The small sample size of app users meant that it was not possible to explore associations between participant characteristics and app use variables. However, we were able to descriptively explore participant preferences and perceptions of smartphone apps for the self-management of LBP. The findings of this study are generalisable to the Australian context, however, given the similarities in results with other developed countries, it is likely the findings may be applied to similar contexts and regions.

Most Australian adults with LBP have above average self-efficacy and self-manage moderately well. Early intervention is important for people with LBP due to the relationship between duration and recurrence of LBP and lower self-efficacy. Smartphone apps were only used by a small proportion of people with LBP as an adjunct to other management options such as exercise, medication and physiotherapy. App users self-managed moderately well with apps with popular behaviour changes features including monitoring, advice, goal setting, prompts and social support options. Assessment of app quality and self-management and behaviour change potential is an important future direction for research to guide optimal app selection for people with LBP and health professionals. Adoption of informed and appropriate app use by health professionals in primary healthcare, has the potential to improve current LBP management and improve outcomes.

Chapter Five – Study 3 (Health professionals)

Health professionals' use of smartphone apps for clients with low back pain: an observational study

This chapter answers the aim "to explore health professionals' use, barriers, confidence and preferences for technology and smartphone apps to assist clients with self-managing low back pain (LBP)". This chapter describes the findings of an online health professional survey. The survey was completed to explore health professionals' choice of self-management options for low back pain and use of smartphone apps for the self-management of low back pain. The systematic assessment (study 2, chapter 3) found that commercially available apps are of average to good quality, but few were designed to specifically incorporate self-management support and behaviour change potential. As such, commercially available apps have questionable potential for self-management and behaviour change. This made it difficult to transfer this knowledge to practice to encourage app use. To gain a better understanding of the landscape around app use and LBP management an understanding of the use of apps by first point of contact health professionals for LBP management was required.

Statement of co-authorship:

All authors were involved in formulating the concept and design of the study. Claudia Didyk completed the initial version of the survey. All authors contributed to create the final version of the survey. Claudia Didyk conducted the data analysis and completed the initial

draft of the manuscript. All authors edited multiple revisions of the manuscript. See Appendix 1 for the signed co-authorship approval form. No conflict of interest was reported by the authors and funding for participation voucher purchases was provided by the Flinders University Research Student Maintenance (RSM) support. Ethical approval was gained from the Flinders University Human Research Ethics Committee (HREC) (no. 2818). Prior to undertaking the survey, online informed consent was gained from all participants. The authors are grateful to the survey participants who contributed information about LBP management.

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Abstract

Aim: This study aimed to explore health professionals' use, barriers, confidence and preferences for technology and smartphone apps to assist clients with self-managing low back pain (LBP).

Methods: Prospective observational cross-sectional survey of registered Australian health professionals that managed clients with low back pain.

Results: 52 survey responses were included (mean age 43 ±13.8 years). Most did not personally use healthy lifestyle apps (60%) and did not recommend apps due to a lack of knowledge of app effectiveness (93%). The largest barrier to recommending apps was the potential for apps to be misused as a substitute to health professional diagnosis. Fifteen recommended smartphone apps (mean age 36 ±10.6 years) and were at least moderately confident in choosing/recommending apps (94%) and assessing app quality (80%). Those more likely to recommend apps personally used apps for healthy lifestyle behaviours (OR 5.1 (p=0.009)), were Physiotherapists (OR 0.13 (p=0.035) c/f Chiropractors, in their profession for <10 years (OR 8.6 (p=0.015)) c/f >30 years. Increasing age decreased the odds (OR 0.94 (p=0.013)) of recommending apps.

Conclusions: Health professionals do not recommend LBP self-management apps due to a lack of knowledge of their effectiveness. Those that do recommend apps for LBP self-management are confident with app choice, recommendation and app quality assessment. Physiotherapists with <10 years' experience were most likely to recommend apps.

Keywords: smartphone apps; low back pain; self-management; behaviour change; health professional; barriers

Introduction

Prior to 2020, the use of digital tools in health management and mobile app use was declining globally (Accenture, 2020). The Covid-19 pandemic and subsequent restrictions caused increased reliance on digital health options for consumers and health professionals, due to both the lack of face-to-face options, and an increase in availability of modalities such as telehealth. This shift toward broader acceptance and access to digital health options for consumers and health professionals has shown no sign of slowing down, with digital options now integrated into sustainable models of health care. There are opportunities for increased adoption of a broader scope of digital health options such as smartphone apps that may assist in the management of conditions that are a global burden, such as low back pain (LBP) (Vos et al., 2017).

Low back pain is the leading cause of disability globally and poses a significant economic challenge, with one in every three people requiring rehabilitation during the course of their injury (Cieza et al., 2020; Vos et al., 2017). Digital tools, such as smartphone apps, offer an easily accessible and cost-effective option for scalable health management (Murray et al., 2016). Smartphones are ubiquitous and apps have the potential to address health inequities in low to middle income countries, rural and remote communities (Murray et al., 2016). While smartphone apps can be used as a useful adjunct to face to face management (Wang et al., 2018), recent data shows that uptake for musculoskeletal conditions that make up a large component of visits to health professionals is low (Gordon et al., 2020; Gupta et al., 2023). Musculoskeletal conditions make up 18 per cent of visits to general practitioners (GPs) in Australia (AIHW, 2022b). With the current shortage of GPs (Australia Medical Association [AMA], 2022), timely access to medical care can be impeded

by appointment utilisation for musculoskeletal complaints (AMA, 2022). In Australia, back problems account for nearly a quarter of health system expenditure (AIHW, 2022), resulting in unnecessary presentations to hospitals, with people with LBP occupying hospital beds required for medical clients (Coombs et al., 2021) and this trend is similar in other countries (Beyera et al., 2020; Edwards et al., 2017; Melman, 2023). Change in the management of LBP is required, with a need to move to increased self-management and consumer independence in their own care.

The NICE LBP guideline (2016) recommends self-management and exercise as the gold standard for LBP management. The self-management recommendations include advice and information tailored to the person's needs and capabilities; encouragement to continue with normal activities and active rehabilitation such as exercise. The rehabilitation should consider the individual's needs, preferences, and capabilities. Exercise could include biomechanical, mind-body or a combination as well as group exercise in conjunction with psychological therapies using a cognitive behavioural approach. Finally, programs are recommended that facilitate return to work and normal activities. Digital health management tools, such as smartphone apps, may offer an easily accessible, cost-effective, guideline informed (NICE, 2016) LBP self-management solution that may improve self-efficacy and encourage consumer independence in their care.

Recent data shows that over half of consumers from Australia, England, Finland, Norway, Singapore, Spain and the United States, who have used digital health care are willing to receive it from their usual healthcare providers, however, only 11 per cent of health care providers recommend digital tools for health management (Accenture, 2020). This mis-match may be due to data protection concerns, time constraints and medical

liability, which are identified barriers of in-clinic use of digital health management tools, such as smartphone apps (Sarradon-Eck et al., 2021). There is a clear need to explore and better understand smartphone LBP self-management app use by first point of contact health professionals for LBP management. This information may be applied to address the barriers to adoption of smartphone LBP self-management app use in clinical practice which could be applicable across different countries and health systems.

Therefore, the aim of this study was to explore first point of contact health professionals' use, barriers, confidence and preferences for technology and smartphone apps to assist clients with self-managing LBP. The secondary aim was to describe the characteristics of health professionals who use smartphone apps for client management of LBP, including app preferences.

Methods

Design

This prospective observational cross-sectional online survey (Qualtrics, Provo, UT) explored the use, barriers, confidence and preferences for technology and smartphone apps for people with LBP from a health professional perspective. Ethical approval was gained from the Flinders University Human Research Ethics Committee (HREC) (no. 2818). Prior to undertaking the survey, online informed consent was gained from all participants.

Participants

Participants were health professionals that were considered first point of contact for LBP management (Chinese medicine practitioners, Chiropractors, Exercise physiologists, General practitioners, Occupational therapists, Osteopaths, Physiotherapists, Podiatrists and Psychologists) (AIHW, 2019a; Arthritis Australia, 2016), registered in Australia and either currently or had previously managed clients with LBP of any duration. Health professionals were recruited between April and July 2022 through relevant professional associations (such as the Australian Physiotherapy Association and Royal Australian College of General Practitioners), social media (Facebook, Twitter) and the University webpage. Based on Peduzzi et al. (1996) a sample size of at least 100 was proposed.

Survey instrument

A comprehensive literature review did not identify existing validated surveys or instruments that measured health professionals' use of smartphone apps for client management of LBP. The research team (A.Prof, Prof and PhD candidate) developed a survey, incorporating pre-existing instruments relating to the self-management of LBP, that was reviewed by a statistician.

The final survey consisted of 27 items (24 closed, 3 open-ended) in five sections:

- *Personal information* was collected including age, gender, highest level of education, current profession and years of experience, work setting and location and access to technology.
- *Smartphone app use and preferences*- The survey included a question relating to smartphone app use to help clients self-manage LBP. For those that indicated that they did not use apps, a follow up question regarding *barriers to app* use was

included based on barriers identified in previous literature (Sarradon-Eck et al., 2021). For health professionals who indicated they used apps to assist clients with self-management of their LBP, follow up questionswere included about their *app preferences* (open-ended questions) and in terms of the features that they liked or disliked, relating to *app quality* and the potential of the apps for development of client *self-management and behaviour change.*

- *Self-management potential*- The items relating to the health professionals' perception of the self-management potential features of apps were developed using the Self-management Support Checklist (SMS-14), developed from the well-established Stanford Self-management Support Model (Devan et al., 2019). The checklist guided the development of survey questions using the six self-management skill categories (1) self-efficacy building, (2) self-tailoring, (3) self-monitoring of symptoms, (4) goal setting and planning, (5) problem solving, and (6) partnership between views of patient and clinicians.
- *Behaviour change potential* - The items relating to the health professionals' perception of the behaviour change potential features of apps were developed using the App Behaviour Change Scale (ABACUS), a reliable tool with high interrater reliability and internal consistency, evaluating four broad categories of behaviour change (knowledge and information, goals and planning, feedback and monitoring, and actions) (McKay et al., 2019). The Capability, Opportunity, and Motivation Behaviour system model (COM-B) (Michie et al., 2011) is considered a key theoretical framework for supporting behaviour change (NICE, 2014) and was also used to guide survey question development. Closed questions incorporated the COM-B relating to education, persuasion, incentivisation, coercion, training, restriction, environmental restructuring, modelling and enablement required in behaviour change interventions (Michie et al., 2011).

- App quality - Health professional perception of the quality of the apps they used was assessed using the Mobile App Rating Scale (MARS), a reliable tool with excellent interrater reliability and internal consistency, evaluating four quality categories (engagement, functionality, aesthetics and information) (Stoyanov et al., 2015) to guide question development.

The survey was pilot tested for usability (time taken to complete, flow of questions, clarity) on a group of adults (n=4). The survey was revised based on this feedback.

Data management and analysis

Data were exported into Microsoft Excel. Survey responses which included minimal information, only demographic details or were repeated bot responses were considered invalid and removed. The included survey responses with questions in which respondents answered the first component of a question and then did not answer the next component were treated as missing data. Missing data were omitted, and complete case analysis was used. The final complete data set was exported into the Statistical Package for Social Science (IBM SPSS) version 28.0.1.1 for Windows for analysis. Text responses were collated into similar groups and descriptive analyses were completed on all variables. Associations between health professional characteristics, technology use and recommendation of smartphone apps were explored using logistic regression analyses. Significance was set at 0.05.

Results

A total of 100 participants completed the survey, with 52 complete survey responses included in the final analyses. The survey took approximately 10 minutes to complete.

Participant characteristics and app use

Whole sample

Participants (n=52) had a mean age of 42.8 (±13.8) years (range 21 to 70 years) and 56% were male (Table 5.1). Most participants were Chiropractors (28%, n=14) and Physiotherapists (24%, n=12), had 0-9 years (44%, n=23), or over 30 years (27%, n=14) of experience, worked in a metropolitan area (56%, n=29), community (primary care, private practice) (75%, n=39) setting with a highest education level of Masters or Doctoral degree (48%, n=25). Of the 52 participants, 10 (19%) were aware of the NICE LBP guidelines and one participant correctly outlined all the guideline recommended areas of self-management with the exception of return-to-work facilitation.

Most participants (76%, n=40) had access to an iPhone (67%, n=35) or Android phone (48%, n=25) and 75% (n=39) had access to a tablet device. One participant did not have access to any smartphone or tablet device. Over 39% (n=20) of participants reported personally using apps to promote healthy lifestyle behaviours. Technology for client-related care was used by 60% (n=31) of participants. Thirty-seven per cent (n=19) of participants recommended apps to clients and 31% (n=16) reported that clients requested them to recommend LBP apps.

Health professionals who recommend apps

Of the 19 participants who reported recommending apps to clients, 15 completed follow up survey items relating to apps (Table 4.1). Sixty-four per cent (n=9) recommended apps to clients on a weekly basis, mostly for self-management (100%, n=15), health education (87%, n=13) and health promotion (87%, n=13). Health professionals who reported recommending apps to clients were aged 35.7 years (±9.7, range 21 to 60 years), and predominantly male (74%, n=14). The highest proportion of health professionals using apps for clients were Physiotherapists (37%, n=7), followed by General Practitioners (26%, n=5), had 0-9 years (74%, n=14) of experience, and worked in a metropolitan (58%, n=11) or community (primary care, private practice) (58%, n=11) setting.

Ten health professionals (67%) who used apps for clients also reported personally using apps to promote a healthy lifestyle. Most health professionals who recommended apps reported moderate to high confidence in choosing and recommending apps (93%, n=14) and assessing LBP app quality (79%, n=11).

Barriers and facilitators to health professionals recommending apps

For the health professionals who did not recommend apps for clients with LBP (n=36), the most common reason cited was a lack of knowledge of app effectiveness (93%, n=27), followed by lack of perceived client digital technology literacy (79%, n=23).

For the health professionals who recommended apps and responded to follow up questions (n=13), 77% (n=10) reported barriers to recommending apps including: the

potential for apps to be misused as a substitute to health professional diagnosis, too time consuming, not independently certified, clinically valid or not backed by evidence and the potential for medical liability.

Table 5. 1.

Participant Characteristics of Whole Sample and Health Professionals that Recommend Apps for Low Back Pain

	Whole sample (n=52)	**Recommend apps (n=19)**
Gender n (%)		
Female	21 (40.4%)	5 (26.3 %)
Male	29 (55.8%)	14 (73.7%)
Other	2 (3.8%)	-
Age (years) mean ± SD (range)	42.8 ± 13.82 (21-70)	35.67 ± 9.71 (21-60)
Highest education n (%)		
High school completed	1 (1.9%)	1 (5.3%)
TAFE or trade school	3 (5.8%)	2 (10.5%)
Bachelor degree	15 (28.8%)	7 (36.8%)
Graduate Certificate or Diploma	8 (15.4%)	4 (21.2%)
Masters or Doctoral degree	25 (48.1%)	5 (26.3%)
Occupation n (%)		
Chiropractors	14 (28.0%)	2 (10.5%)
Physiotherapists	12 (24.0%)	7 (36.8%)
Eastern Medicine – TCM/Acupuncture	8 (16.0%)	3 (15.8%)
General Practitioners	6 (12.0%)	5 (26.3%)
Exercise physiology/Occupational Rehabilitation	4 (8.0%)	2 (10.5%)
Psychologist/Mental health	3 (6.0%)	-
Osteopaths	2 (4.0%)	-
Massage/Myotherapist	1 (2.0%)	-
Did not specify	2 (4.0%)	-
Years in current profession n (%)		
0-9 years	23 (44.2%)	14 (73.7%)
10-19 years	11 (21.2%)	2 (10.5%)
20-29 years	4 (7.7%)	1 (5.3%)
over 30 years	14 (26.9%)	2 (10.5%)
Work setting n (%)		
Community (primary care, private practice)	39 (75%)	11 (57.9%)
Hospital	6 (11.5%)	4 (21.1%)
Combination of hospital and community	7 (13.5%)	4 (21.1%)
also worked in other settings:	6 (11.5%)	
Community (not primary care or private practice)	3 (5.8%)	-
Education	2 (3.8%)	-
Sporting team	1 (1.9%)	-
Work location n (%)		
Metro	29 (55.8%)	11 (57.9%)
Non-metro	15 (28.8%)	6 (31.6%)
Combination Metro/Non-metro	8 (15.4%)	2 (10.5%)

Data protection concerns or not being sure of what value apps would add to improve outcomes were not considered barriers to app recommendation by 46% (n=6) of participants. Nine participants suggested that additional elements such as ease of use of apps, better control and customisation options, more targeted and/or specific content, and additional education in self-management would encourage health professional recommendation of apps for clients with LBP.

Health professionals' preferences for apps for the self-management of LBP

Fifteen health professionals reported recommending a range of apps to clients for their LBP, including: Curable (Curable Inc), Tapping solution (The Tapping Solution, LLC), Keep (Google, LLC), Physitrack (Physitrack PLC), Insight timer (Insight Network Inc), SelfBack (SelfBack), Kaia (Kaia Health) and activity monitors (specific apps not mentioned).

Features included and reported as most liked by participants in the apps they recommended (Figure 5.1) were in the following categories: 'information' (visual information (100%, n=15), quality of information (93 %, n=14) and evidence base (93%, n=13)) and 'functionality' (ease of use (100%, n=15)). Features that were disliked by participants were in the 'functionality' (gestural design (39%, n=5) category as well as the 'engagement' (entertainment (36%, n=4) and customisation (33%, n=5)) categories. The features that were most often not included in their chosen apps were in the categories of 'engagement' (entertainment (25%, n=4)) and 'functionality' (performance (19%, n=3)).

Features considered by health professionals when investigating LBP self-management apps included goal setting (100%, n=15), prompts and alarms (93%, n=14),

advice (93%, n=13), education (87%, n=13), monitoring (87%, n=13), planning (88%, n=12), and social support (80%, n=12). The least sought-after feature was personalisation (73%, n=11). For the apps that had these features, health professionals rated the following as very or extremely important for LBP self-management apps: teaching skills required to self-manage (86%, n=12), providing information to promote self-management (71%, n=10), using motivating language to encourage self-management (71%, n=10), providing examples of self-management behaviours to follow (69%, n=9) and prompts to encourage self-management (54%, n=7) (Figure 5.2). A small number of participants considered consequences for not following self-management advice (17%, n=2) and behavioural restrictions (15%, n=2) not at all important.

Figure 5. 1.

Low Back Pain Self-management App Features Liked by Health Professionals

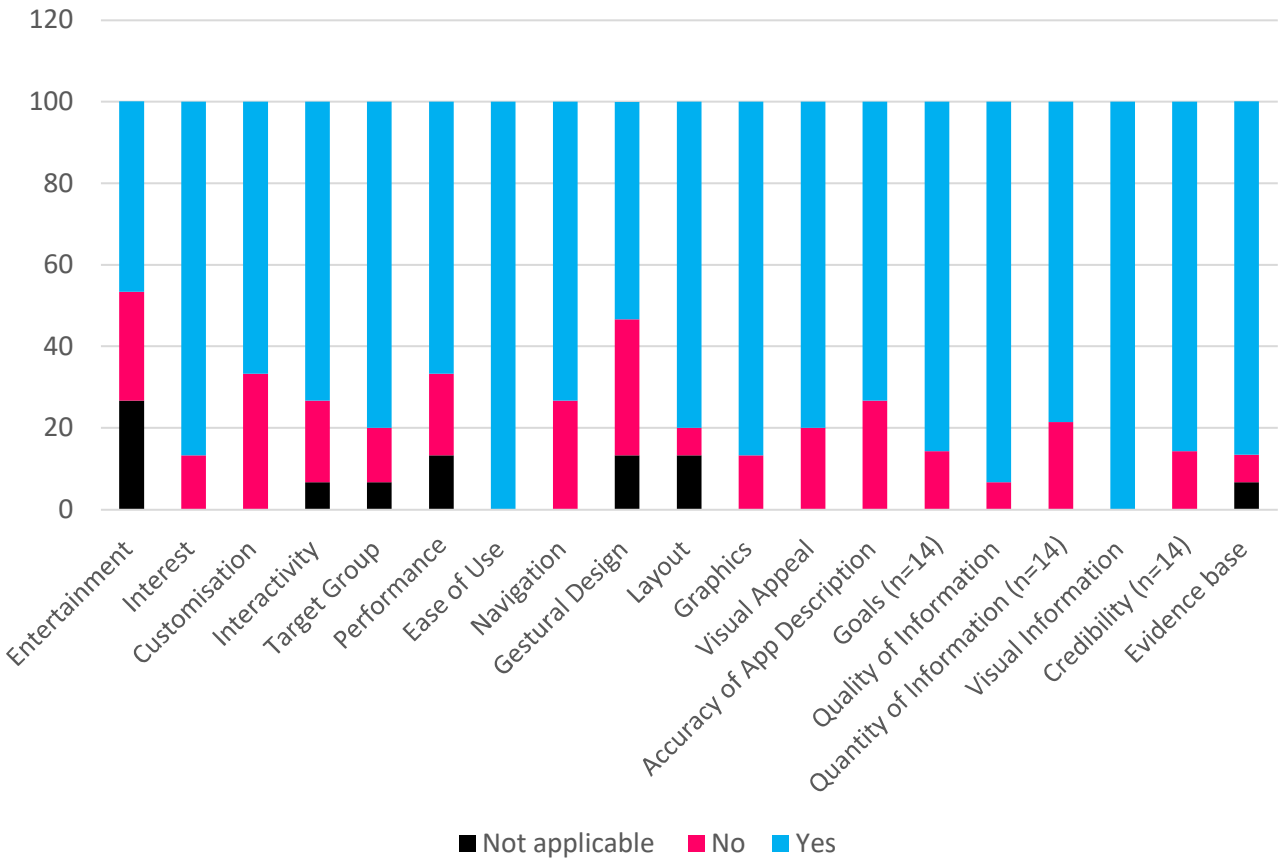
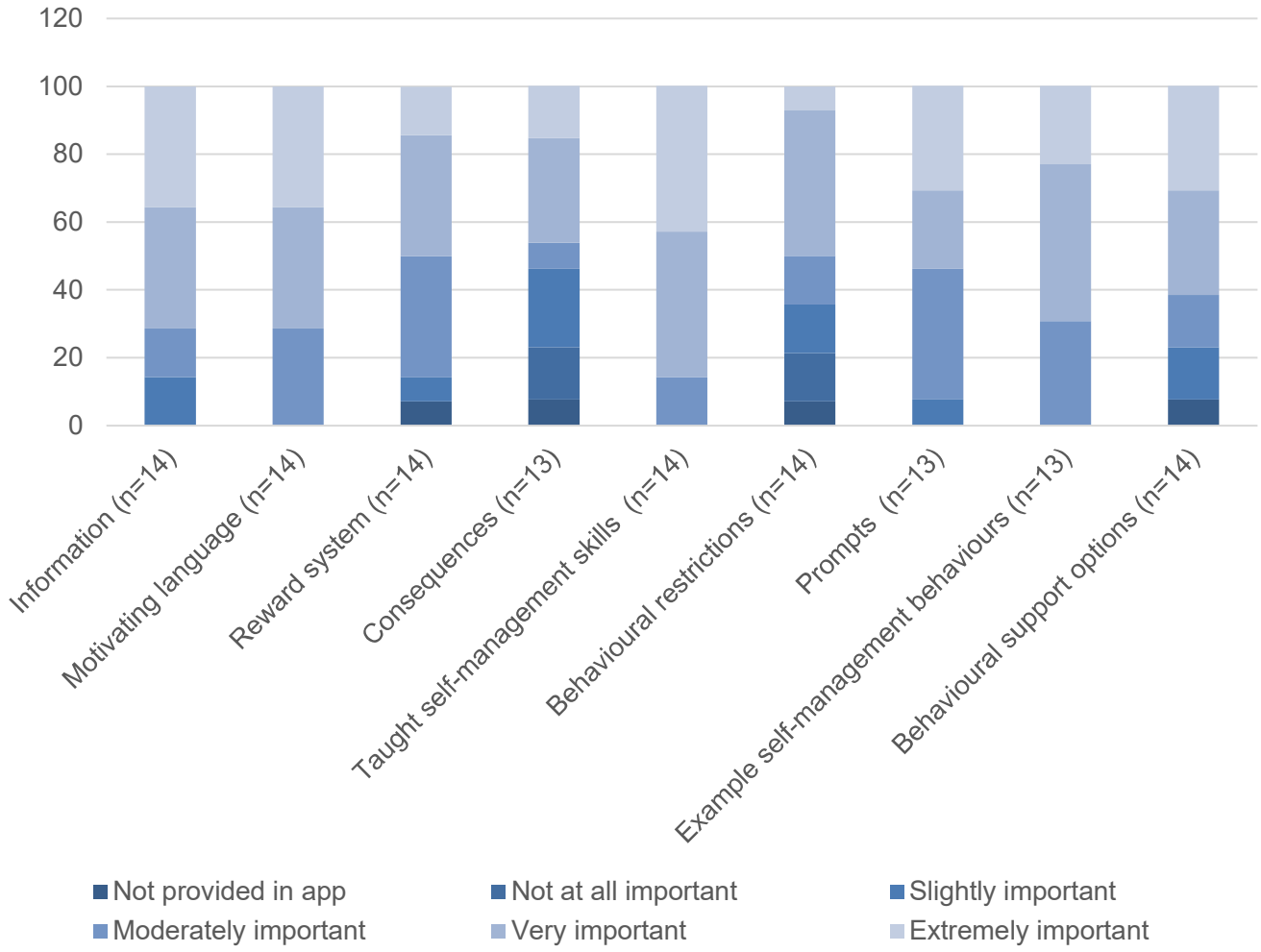


Figure 5. 2.

Behaviour Change Features and Perceived Importance of Apps Recommended by Health Professionals



Associations between health professional characteristics, technology use and recommendation of smartphone apps

Age, current profession, and years of experience were significantly associated with app recommendation. With every year increase in age the odds of recommending apps was 0.94 times less (OR 0.94; p=0.013). Chiropractors were 0.13 times less likely to recommend apps than Physiotherapists (OR 0.13, p=0.035) and those in their profession

with less than 10 years of experience were 8.6 (OR 8.6, p=0.015) times more likely to recommend apps than those with over 30 years of experience.

Table 5. 2.

Associations Between Demographic Factors, Technology Use and App Recommendation

	App Recommendation (n=19) O/R (p value) [95% CI]
Gender (n=50) (Male)	3.2 (p=0.068) [0.919, 11.145]
Age (n=50) (years)	0.94 **(p=0.013)** [0.886, 0.986]
Highest education (n=51) (TAFE or below)	5.8 (p=0.141) [0.559, 60.475] Bachelor or above
Current profession (n=51) (Physiotherapist)	3.6 (p=0.305) [0.313, 40.751] GP 0.0 (p=0.999) [0.000, .] Osteopath * 0.13 **(p=0.035)** [0.020, 0.863] Chiropractors 0.3 (p=0.101) [0.059, 1.285] Other professions
Years in current profession (n=51) (Over 30 years)	8.6 **(p=0.015)** [1.526, 47.956] 0-9 years 1.2 (p=0.855) [0.143, 10.480] 10-19 years 1.8 (p=0.662) [0.121, 27.797] 20-29 years
Work setting (n=51) (Community)	4.9 (p=0.089) [0.782, 30.801] hospital 3.3 (p=0.160) [0.627, 17.092] combined settings
Work location (n=51) (Metro)	1.2 (p=0.757) [0.335, 4.491] non-metro 0.6 (p=0.501) [0.093, 3.194] combined locations
Access to Smartphone – Iphone (Yes)	1.8 **(p=0.008)** [2.140, 151.402]
Access to smartphone – Android (No)	1.6 (p=0.448) [0.496, 4.898]
Access to smartphone – Windows (Yes)	4.9 **(p=0.012)** [1.424, 16.930]
Access to Tablet – Ipad (Yes)	3.1 (p=0.079) [0.879, 10.829]
Access to Tablet – Android (Yes)	2.6 (p=0.131) [0.753, 8.995]
Access to Tablet – Windows (Yes)	3.0 (p=0.066) [0.931, 9.827]
Access to Other (No)	6.9 (p=0.081) [0.786, 59.814]
Personally use apps (Yes)	5.1 **(p=0.009)** [1.506, 17.568]

Note. **BOLD =** significant p=0.05
* = None in this sample

Access to a smartphone was statistically associated with app recommendation, with health professionals with access to an iPhone being 1.8 times more (OR 1.8, p=0.008) likely to recommend apps and those with a Windows smartphone 4.9 times more likely (OR 4.9, p=0.012). Participants were also 5.1 times more (OR 5.1, p=0.009) likely to recommend apps if they personally used apps to promote their own healthy lifestyle behaviours (Table 5.2).

Discussion

This study aimed to investigate health professionals' use, barriers, confidence and preferences for technology and smartphone apps to assist clients with self-managing LBP. Most Australian health professionals were at least moderately confident in choosing or recommending apps and assessing their quality, almost one third had clients request recommendation of LBP self-management apps, and over a third recommended LBP self-management apps to clients. Most health professionals who recommended apps did so on a weekly basis for LBP self-management, health education and health promotion. Physiotherapists, higher levels of education, decreasing age, less than 10 years' experience and personally using healthy lifestyle apps were associated with greater app recommendation to clients, and a lack of knowledge of app effectiveness and perceived lack of client digital technology literacy were identified barriers to app recommendation.

Previous literature has shown that 11 per cent of health professionals in Australia, England, Finland, Norway, Singapore, Spain and the United States, recommend general digital health options to their clients, and over 50% of clients look to trusted health

professionals for guidance in more actively managing their health (Accenture, 2020; Deloitte, 2018). Interestingly, in this study, we found much higher rates of app recommendation by health professionals, over three times higher than published trends (Accenture, 2020). It is possible that the online recruitment method used in this study was biased toward recruiting health professionals comfortable in an online digital environment and potentially more likely to recommend apps to their clients. It is also possible that there has been a large increase in the number of health professionals using and recommending digital options to clients in the last three years, aligned with the global move to telehealth and virtual options in developed countries during the Covid-19 pandemic (University of Queensland [UQ], 2022; Thomas et al., 2020; Webster, 2020). In this study, Physiotherapists with less than 10 years' experience were more likely to recommend apps. Incorporating technology into client care may be easier for those newer to the workforce, due to greater technology literacy and an increased likelihood that these professionals were exposed to these technologies during their health professional training (Martin et al., 2022). We also found that approximately one third of clients requested LBP self-management apps to be recommended by their health professional, suggesting that clients may take the lead from their health professional regarding possible digital options for their LBP self-management.

Clients trust health professional guidance in managing their health (Accenture, 2020; Deloitte, 2018) and guideline-based recommendations are considered best practice to improve outcomes for people with LBP (Foster et al., 2018). Not adhering to these recommendations could result in poorer outcomes and greater personal and health system costs. Despite the high prevalence of LBP and the high levels of health care usage and presentation to health care providers, less than two per cent of health professionals in this

study were able to correctly identify most of the NICE (2016) LBP guideline self-management recommendations. This lack of knowledge could be due to health professionals considering guidelines to be restrictive on professional autonomy, clinical reasoning and patient empowerment (Slade et al., 2016). Although evidence-based practice is part of the physiotherapist education framework (World Physiotherapy [WP], 2021), it is also possible that health professionals are not exposed to these guidelines throughout their entry-level training, or ongoing professional development (Derghazarian & Simmonds, 2011; Synnott et al., 2015). This lack of knowledge of best practice guidelines is concerning and warrants further investigation. Of further concern is that some health professionals reported using management options, such as electrotherapies, that are not currently recommended for LBP (NICE, 2016; Zadro et al., 2019). Return to work facilitation was the least identified recommendation, which is surprising as LBP presents mostly in working age and is a leading cause for early retirement in Australia (Schofield et al., 2012). International guideline-based self-management recommendations, particularly in the facilitation of return to work, could improve patient outcomes, allow people to remain at work, and reduce the chance of decreased wealth in later life due to early work cessation. The lack of knowledge of guidelines and use of guideline-based recommendation should be addressed in continuing education for health professionals involved in the management of people with LBP (Hush & Alison, 2011).

Behaviour change techniques can encourage people with LBP to adopt health behaviours to self-manage their condition (Mansell et al., 2016) and LBP self-management interventions may improve health outcomes by including features that encourage behaviour change (Araújo-Soares et al., 2019). In contradiction to current literature (Didyk et al., 2022a), this study found that the apps recommended by health professionals included many

features to promote behaviour change. However, most of the recommended apps were not specific for LBP self-management and did not address the required behaviour change and self-management support criteria for LBP self-management interventions (Didyk et al., 2022a; Michie et al., 2011). Health professionals placed importance on example self-management behaviours and skills, behavioural restrictions and sought goal setting and prompts and alarms as self-management features. Health professionals also liked features relating to app quality functionality (ease of use), information (visual information, quality of information, evidence base, goals and credibility), aesthetics (layout, graphics) and engagement (interest, target group). Functionality and aesthetic features have been previously found to rate highly, and although highly liked by health professionals, the information and engagement features were rated the lowest quality in a previous systematic app assessment (Didyk et al., 2022a). This could be due to health professionals recommending different apps to those formally assessed in previous research. Simple app assessment methods or tools for health professionals to assess app quality may assist with future recommendation of apps for clients (Gordon et al., 2020).

Recommendation of smartphone apps needs to be part of workflows nested into current health care delivery models (Accenture, 2020). Barriers to implementation of app use into clinical practice, such as lack of time, exist and sustainable adoption of smartphone app use for the self-management of LBP will need to address the health professional time constraints. One of the largest barriers for health professionals recommending apps was the potential for apps to be misused as a substitute to health professional diagnosis. To minimise this, oversight should be provided by trusted health professionals (Bernhardsson et al., 2019). Whilst many commercially available apps in the app stores are not independently certified, clinically valid or backed by evidence, some guidance from health

care providers could ensure better app choices aligned with client needs. Further education on the value of recommending apps to suitable clients to improve outcomes, may assist with greater app recommendation (Gordon et al., 2020). Health professional app recommendation would also need to be client specific and take into consideration levels of digital technology literacy (Kloek et al., 2020). Potential for medical liability could be avoided by recommending important features that should be present in apps to assist in self-management and behaviour change. Educating health professionals about app features for self-management and behaviour change potential (Gordon et al., 2020), could increase health professional confidence in app effectiveness and increase use. This could assist both health professionals and consumers to determine suitable LBP self-management apps, reduce liability and increase confidence. There is a clear need for an app evaluation tool (Gordon et al., 2020) that is quick and easy to use, which may increase LBP self-management app use by people with LBP and recommendation by health professionals.

Strengths and limitations

This study has numerous methodological strengths. Dissemination occurred nationally, using free and paid and online methods. Reliable and validated tools were used in the survey for a high level of confidence in survey results. Data were collected from over 50 health professionals, representing different first point of contact disciplines and of relevance to a range of primary care health professionals. Although the number of health professionals who recommended apps was small, it was over three times higher than expected. To the best of our knowledge, this is the first study to investigate health professionals' recommendation of smartphone apps for the self-management of LBP. Future research should explore entry-level training and professional development

opportunities for health professionals in digital health, smartphone apps and self-management of LBP. There is also scope for the development of a user-friendly app quality rating tool to guide health professional decision making when recommending apps in clinical practice.

Few health professionals were able to correctly identify LBP guideline self-management recommendations. Greater knowledge and use of guideline-based recommendations to facilitate LBP self-management, particularly in return-to-work facilitation, is required. LBP self-management apps are cost effective, scalable and accessible and can be used as an adjunct to current modes of LBP management but are underutilised. Apps that were recommended were not specific for LBP self-management. Reasons for not recommending apps included lack of knowledge of app effectiveness and assumptions about digital literacy level of clients. However, those that did recommend apps were confident in choosing and recommending apps and assessing LBP app quality and placed importance on self-management features. Clients sought advice from health professionals about apps, highlighting the need for an easy-to-use app assessment method that can assist health professionals and guide consumers in choosing high quality LBP specific apps from those currently available. This could reduce barriers to recommendation, encourage uptake and reduce the personal and economic burden of LBP. Promoting digital health tools, such as apps, for self-care may improve self-management and self-efficacy.

Chapter Six – Study 4

Co-design of the Low Back Pain Self-Management App Review Tool (LBP-SMART) for consumers to assess the quality, behaviour change and self-management potential of LBP smartphone apps

This chapter answers the aim “to co-design and pilot test a tool for consumers to assess the quality, behaviour change and self-management potential of LBP self-management apps”. This chapter describes the four co-design workshops conducted to co-design a tool for use by consumers to assess LBP self-management apps. The co-design process involved both consumer and health professional input, as well as input from the research team. The consumer and health professional surveys (study 3 (consumers) (health professionals), chapters 4 and 5), few health professionals and consumers used apps due to lack of knowledge. All consumer app users had LBP and most found that app use helped improve their LBP. The small percentage of both consumer and health professional app users outlines the underutilisation of this self-management tool. The app assessment tool was developed to allow for quick and easy evaluation of currently available LBP self-management apps by consumers and health professionals to increase adoption of app use.

Statement of co-authorship:

All authors were involved in formulating the concept and design of the study. Claudia Didyk managed the study, conducting recruitment, undertaking the workshops and pilot study as well as data collection. Claudia Didyk conducted the data analysis and consulted with co-authors on the categories arising from the qualitative data analysis. Claudia Didyk completed the initial draft of the manuscript. All authors edited multiple revisions of the manuscript. See Appendix 1 for the signed co-authorship approval form. No conflict of interest was reported by the authors and funding for participation voucher purchases was provided by the Flinders University Research Student Maintenance (RSM) support. Ethical approval was gained from the Flinders University Human Research Ethics Committee (HREC) (no. 5568). Prior to undertaking the workshops or pilot testing, online informed consent was gained from all participants. The authors are grateful to the workshop and pilot study participants who contributed to the design of the LBP self-management app assessment tool.

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Abstract

Introduction: Low back pain poses global health management and economic challenges. Self-management of LBP is critical, and smartphone apps have great potential to facilitate LBP self-management. This study aimed to co-design a LBP Self-Management App Review Tool (LBP-SMART) for consumers to assess the quality, behaviour change and self-management potential of LBP self-management apps.

Methods: A two-phase prospective cross-sectional design was used. First, a consumer-level assessment tool for LBP self-management smartphone apps was co-designed and developed. Consumers and health professionals were invited to participate in four online co-design workshops, underpinned by the Co-KT framework, a five-step knowledge translation framework aimed at co-creating, refining, implementing and evaluating the impact of new knowledge. The second phase pilot tested the tool (LBP-SMART).

Results: Four stakeholders (consumers n=2, health professionals n=2) with the guidance of researchers (n=3) participated in the workshops. The LBP-SMART was developed, consisting of seven categories: 1) Safety; 2) Download process; 3) Look, function and feel; 4) Customisation; 5) Goals and self-monitoring; 6) Enabling sharing and 7) Additional features. Five additional participants pilot tested the LBP-SMART, with all reporting via telephone interview, that the tool was easy to use and understand, and the order and sequencing was appropriate. The LBP-SMART has content validity based on evidence and stakeholder views.

Conclusion: The LBP-SMART guides consumers to choose apps with appropriate quality, and self-management and behaviour change potential features that may improve their LBP outcomes. The tool also may provide a guide for health professionals working with people with LBP.

Keywords: app assessment; low back pain; self-management; behaviour change; consumers; co-design.

Introduction

Low back pain is the leading worldwide cause of disability, posing global health management and economic challenges (Vos et al., 2017). In developed countries, LBP is the largest contributor to the burden of disease (Arora et al., 2016). Current management models are unsustainable in already stretched health systems (AIHW, 2022b; AMA, 2022; Coombs et al., 2021). New accessible and cost-effective modes of LBP management, such as smartphone apps, could address these challenges.

Guideline-based recommendations for LBP self-management can be delivered via digital platforms/apps (Didyk et al., 2022a; Moller et al., 2017). Limited homogeneous high-quality research exists (Didyk et al., 2022b), however, LBP self-management apps have shown improvements in health-related outcomes (Thurnheer et al., 2018) such as pain (Cavanagh et al., 2019) and disability (Shebib et al., 2019). Commercially available apps for LBP self-management are of average to good quality, with few apps designed to specifically incorporate features for LBP self-management support and behaviour change (Didyk et al., 2022a).

Self-management and behaviour change may increase adherence to health behaviours to manage LBP (Soderlund & von Heideken Wagert, 2021). Adherence to physical activity and exercise leads to positive pain management outcomes (Soderlund & von Heideken Wagert, 2021). Poor quality app content may adversely impact outcomes (AOV, 2013) and confidence in provision of evidence-based recommendations (Cortez et al., 2014). Knowledge of app quality, prior to download, would allow for greater consumer and health professional (Sarradon-Eck et al., 2021) confidence in self-management and

behaviour change outcomes. This may improve health professional recommendation of apps and consumer uptake and adoption (Accenture, 2020).

Regulatory changes (NICE, 2022; WHO, 2018) may improve app quality at the development stage, however, impact to clinical practice will be slower. The Australian Government and Australian Digital Health Agency (ADHA, 2022) have created an assessment framework for mHealth apps, due to be implemented late 2023. The framework provides app developers with guidance on requirements for developing mHealth apps. This voluntary paid four-stage app assessment will result in scores uploaded to a library providing endorsement and star ratings for consumers and health professionals to search and compare apps to aid with choosing credible mHealth apps and encourage use in clinical practice (ADHA, 2022). The rapidly growing field of apps and voluntary nature of assessment does not allow for the timely, informed use of apps. App will continue to be underutilised in healthcare until a more efficient and intuitive app assessment process is in place (Gordon et al., 2020).

Current app assessment tools are designed to be used by researchers or experts, require training to use, (Azad-Khaneghah et al., 2021; Stoyanov et al., 2016; Stoyanov et al., 2015) and do not combine all the required components to establish app quality and potential to improve behaviour change and self-management (Azad-Khaneghah et al., 2021; Didyk et al., 2022a). The need for multiple tools is time consuming and impractical for consumers and may lead to over reliance on other less accurate subjective measures such as app ‘star’ ratings (Didyk et al., 2022a). A consumer-level assessment tool (Wicks & Chiauzzi, 2015) could provide quick and easy assessment of app quality and potential to improve self-management and behaviour change. Such a tool would provide rapid

recommendation process and a checklist of required features (Lewis, 2013). This may also minimise liability concerns of health professionals in recommending specific apps (Sarradon-Eck et al., 2021). The development of such a tool should consider the views and opinions of all stakeholders in a co-design process, enabling meaningful consultation and engagement (Slattery et al., 2020) and increasing relevance to end users (Ioannidis, 2016). This process may improve confidence in app quality, potentially increase the recommendation and use of apps, and may result in decreased personal and economic burden.

This study aimed to co-design and pilot test a tool for consumers to assess the quality, behaviour change and self-management potential of LBP self-management apps.

Methods

Design

A two-phase prospective cross-sectional design was used. The first phase involved the co-design and development of a consumer-level assessment tool for LBP self-management apps. The second phase pilot tested the tool. Ethical approval was gained from the Flinders University Human Research Ethics Committee (no. 5568). Informed consent was gained from all participants.

Phase 1: Development and co-design of the tool

Participants

Consumers and health professionals were invited to participate in the co-design process. Consumers were recruited through social media (Facebook, LinkedIn), online advertising (Flinders University) and national consumer recruitment groups (South Australian Health and Medical Research Institute Health Translation SA Group and the Consumer and Community Involvement Program WA Health Translation Network). Consumers were eligible if they had lived experience of LBP or as a carer of a person with LBP, and/or used LBP self-management apps, lived in Australia, were aged over 18 years, and had internet access.

Health professionals were recruited through social media, online advertising and musculoskeletal national groups and large multidisciplinary clinics. Health professionals were eligible if they were first point of contact practitioners (Chinese Medicine practitioners, Chiropractors, Exercise Physiologists, General Practitioners, Occupational Therapists, Osteopaths, Physiotherapists, Podiatrists and Psychologists) (AIHW, 2019e; Arthritis Australia, 2016) who had experience in treating people with LBP, lived in Australia, aged over 18 years, and had internet access.

Procedure

Four online co-design workshops were undertaken, underpinned by the first three steps of the Co-KT (Co-creating Knowledge Translation) framework (Kitson et al., 2013) (Figure 1). The co-KT framework is a five step (initial contact and framing the issue; refining and testing knowledge; interpreting, contextualising and adapting knowledge to the local context; implementing and evaluating; embedding and translating of new knowledge into practice) knowledge framework aimed at co-creating, refining, implementing and evaluating

the impact of new knowledge (Kitson et al. 2013). This framework was chosen as it aligned with the goals and structure of process undertaken for this study. Consumer and health professional workshops were facilitated online, once per week for four weeks (approx. 1.5 hours each). Separate workshops were undertaken for health professionals and consumers to minimise concern about the perceived power imbalance with health professionals as 'experts' in LBP (Busetto et al., 2020; Femdal & Solbjør, 2018).

Workshop 1: Initial contact and framing the issue

Consistent with Step 1 of the Co-KT framework (Kitson et al., 2013), The code of conduct and expected behaviour for the workshops, the goal of the study and timeframes were outlined. Participants downloaded and used an example target app, TrackActive Me: Virtual Physio (Didyk et al., 2022a), prior to the first workshop. This app is a highly rated example LBP self-management app (Didyk et al., 2022a). Discussion was undertaken in an open and semi-structured format to collect opinions free from bias. Responses were collated under 12 features that incorporated app quality (MARS) (Stoyanov et al., 2015), behaviour change (ABACUS) (McKay et al., 2019) and self-management (SMS-14) (Devan et al., 2019) (Table 1). Outcomes from this workshop formed the outline for the first version of the tool.

Workshops 2 and 3: Knowledge refining and testing

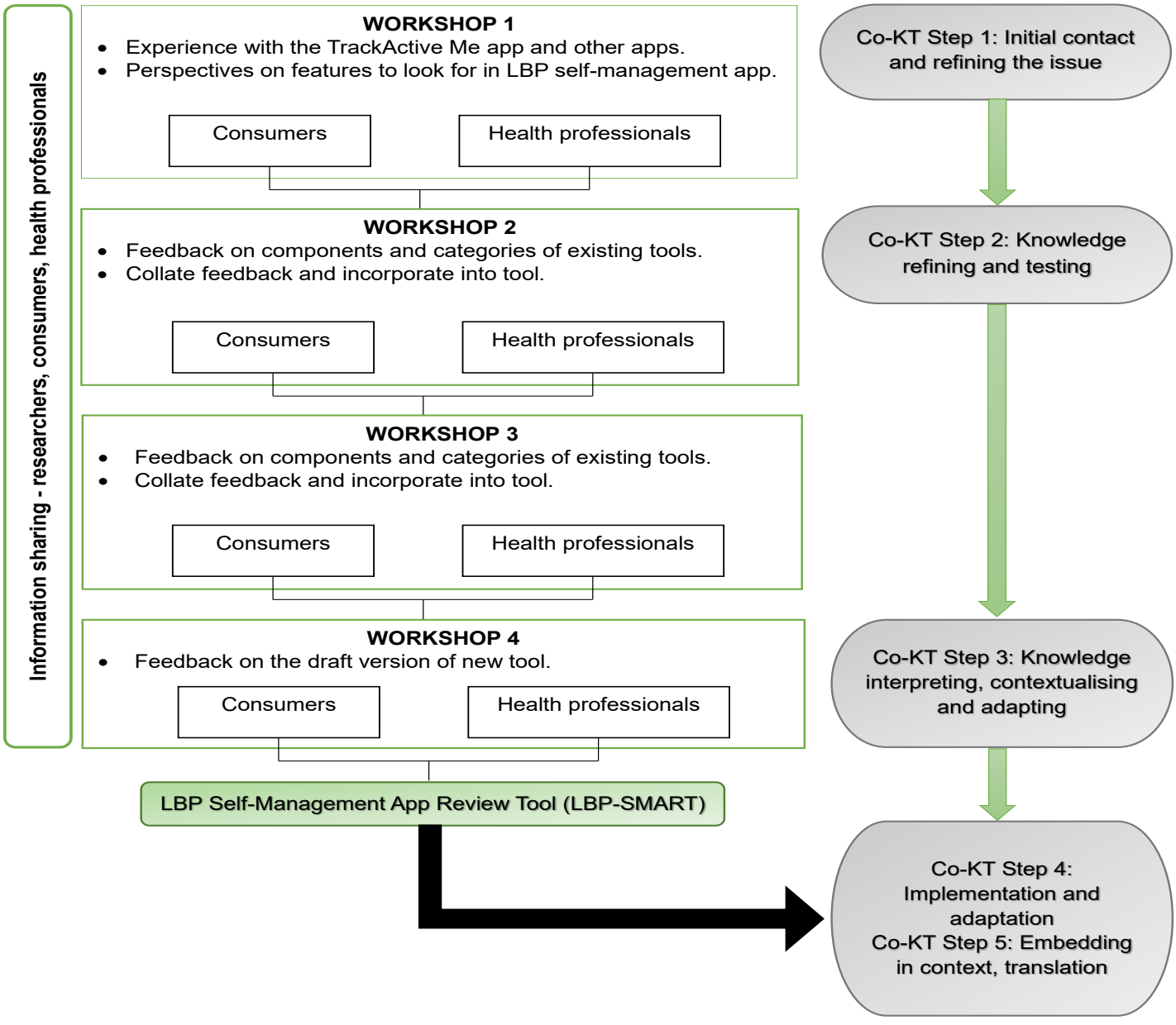
Knowledge refining and testing occurred in workshops 2 and 3, consistent with step two of the Co-KT framework (Kitson et al., 2013). Summaries of previous workshop/s were provided to participants for subsequent workshop/s. Knowledge from the research team, incorporating domains of three tools (MARS, SMS-14, ABACUS) previously used for app assessment (Didyk et al., 2022a), was integrated into workshops 2 and 3. The results of the collated responses were discussed, together with evidence from the literature.

Workshop 4: Knowledge Interpreting, contextualising and adapting

Participants were encouraged to interpret, contextualise and adapt their knowledge base (Co-KT Step 3) (Kitson et al., 2013) in the final workshop. At the end of the fourth workshop, a version of the LBP Self-management App Review Tool (LBP-SMART) was finalised.

Figure 6. 1.

App Assessment Tool Development Process and Co-design Groups (Based on the Co-KT Framework)



Data analysis

Workshops were audio recorded and transcribed. Participant responses from the structured workshop questions, which aligned with 12 features that incorporated app quality (MARS), behaviour change (ABACUS) and self-management (SMS-14), were collated using inductive coding. The collated responses formed the outline for the first version of the tool and were emailed to participants to inform subsequent workshops. At the completion of each workshop, the information from both consumer and health professional groups was collated to feed back into subsequent workshops, allowing sharing of ideas between groups.

Phase 2: Pilot testing

The co-designed LBP-SMART for consumers to assess app quality and potential for behaviour change and self-management for LBP was pilot tested for usability, clarity and sequencing using specific questions on usability, clarity and sequencing that were asked in semi-structured interviews and self-reported by the participants. Pilot study reporting is based on the consolidated criteria for reporting qualitative research (COREQ-32) (Tong et al. 2007). One member of the research team (Female, PhD Candidate/physiotherapist) was guided and educated by the research team on interview techniques and conducted the telephone interviews which were audio recorded. No previous relationship was established with the participants. The purpose of the study and reasons for the study were presented in the information and consent form. No methodological framework was stated but useability of the tool was the outlined requirement. A convenience sample was used and participants were recruited through social media (Facebook, LinkedIn), online advertising (Flinders University). Data was collected online and via telephone at a convenient time for the participants. Presence of non-participants was not monitored, and demographic data was collected in an online survey. The questions and prompts were guided by the author but not

pilot tested, and no repeat interviews were carried out. Handwritten notes were also taken at the time of the interview as a safeguard for the audio recording but were not required. Transcripts were not provided to participants for review. The interview questions were designed to be answered simply or with either a ‘yes’ or ‘no’. No coding was required, and participants did not provide feedback on the results. Microsoft Excell was used to collate the data. Quotations were not provided, but data and findings were consistent, and themes were not required.

Participants

Participants were eligible to participate in the pilot testing if they had not been involved in Phase 1, lived in Australia, were aged ≥18 years and had internet access. Participants were recruited through social media and online advertising.

Procedure

Participants completed an online demographic survey (LBP experience, access to, and confidence with technology and LBP app use) and downloaded the TrackActive Me: Virtual Physio app on their smartphone or tablet device for the evaluation. Participants assessed the app using the LBP-SMART and shared their thoughts on the app and tool (usability, clarity, sequencing) via individual telephone interviews.

Data analysis

Participant demographics, evaluation and interview responses were collated in Microsoft Excel and analysed descriptively. Feedback on the app assessment tool was incorporated into the tool as appropriate.

Results

Phase 1: Development and co-design of the tool

Participant characteristics

Two consumers and two health professionals consented to participate in Phase 1. Consumer participants (aged 26 and 69 years) had experienced LBP (n=1) and had experience as a carer for someone with LBP (n=1). Health professional participants were physiotherapists with experience (9 years, 22 years) in private, public and education settings.

Consumer participants reported using apps for social media, communication, planning, exercise, mindfulness, wellbeing, spirituality, reading, online banking and booking social activities. Health professional participants used apps for planning, communication, tracking and monitoring, entertainment, and exercise.

Workshop 1:

Participant experiences using the TrackActive Me: Virtual Physio (V1.14.0) app and other apps were collated under the 12 features (from MARS, ABACUS, SMS-14) they

considered important to include in a LBP self-management app. The responses were collated to develop a preliminary outline of required features for an app assessment tool (Table 1).

Table 6. 1.

Workshop 1 Findings

Domain	Description	Workshop 1 findings
Engagement	Fun, interesting, customisable, interactive (e.g., sends alerts, messages, reminders, feedback, enables sharing), well-targeted to audience.	• Consumer and Health professional participants liked engagement features such as customisation of notifications and reminders, but disliked pop-ups and signup requirements, as well as overly challenging apps or difficult language. • Both consumers and health professionals mentioned data concerns and health professionals disliked regular notification and content heavy apps.
Functionality	App functioning, easy to learn, navigation, flow logic, and gestural design of app.	• Functionality was important to both health professional and consumer participants, particularly ease of use and download speed. • Consumers disliked functionality features that were time consuming or added to the mental load of using the app, whilst health professionals disliked features that were not intuitive or apps with too many functions.
Aesthetics	Graphic design, overall visual appeal, colour scheme, and stylistic consistency.	• Consumer participants liked aesthetics features that were appealing to look at, fit the screen, both health professionals and consumers liked apps that were not crowded but health professionals also preferred a mixture of text and visual aesthetic features. • Consumers reported disliking aesthetic features that contained overpowering graphics or unappealing app logos, whilst health professionals disliked features that were time consuming and not necessary to the main requirements of the app.
Information	Contains high quality information (e.g. text, feedback, measures, references) from a credible source.	• Evidence based information that aligned with what had been provided by trusted health professionals and that was presented in a variety of ways was liked by consumer participants and health professionals also liked information that was evidence based and consolidated.

Domain	Description	Workshop 1 findings
		• Both consumer and health professional participants disliked information that was overly basic, and consumers also disliked a large amount of text whilst health professionals disliked a low threshold to remove exercises based on pain.
Self-efficacy building	Provision of information on self-management or active coping strategies to improve the ability to control one's behavior—Cognitive Behavioral Therapy (CBT) approaches.	• *Self-efficacy features were not commented on by consumer or health professional participants in the first workshop.*
Self-tailoring	Provision of structured information and self-management support based on the individual symptoms/needs.	• The ability to self-tailor pain thresholds for exercise and physical activity recommendation linking to triage questions was liked by health professionals . • Health professionals did not mention any features that they disliked in workshop 1. • *Consumers did not comment on self-tailoring in workshop 1.*
Self-monitoring of symptoms	Capacity to help people to monitor their symptoms (e.g., mood, thoughts, and pain intensity).	• Consumer participants liked self-monitoring of symptoms features that allowed for pain monitoring that was quick and easy to use but that presents the inputted data in greater detail and shows progression to towards set goals, whilst health professionals were not keen on pain monitoring and preferred less focus on pain. • However, health professionals liked features that allowed for red flags to be triggered based on medications entered. • Neither consumers nor health professionals mentioned any features that they disliked in workshop 1.
Goal setting and planning	Capacity to identify and log meaningful goals (e.g., physical, emotional, social) and track goals.	• Goal setting and planning that included instructions and guidance on goal setting, allowed for goal achievement and provided rewards, was liked by consumers and health professionals. • Consumers disliked a lack of rewards for achieving the set goal.
Problem solving	A systematic approach to be aware of and developing a plan for dealing with stressful or challenging situations.	• *Problem solving features were not commented on by consumer or health professional participants.*
Partnership between views of patient and clinicians	Opportunity to interact with health care provider and involve people with persistent pain in decision making.	• Partnership with clinicians was liked by both consumers and health professionals.

Domain	Description	Workshop 1 findings
		• Consumers liked features that allowed for low technological sharing of recorded monitoring, that was not stored or sent electronically, such as screenshots and both consumers and health professionals liked features that allowed for initial consultation either via the app although a trusted health professionals was preferred. • Health professionals also liked diagnostic triage or chat features within the app to trigger the need to be reviewed by, or connect to, a health professional. • Neither consumers nor health professionals mentioned any features that they disliked.
Social support	Access to a community of persons living with persistent pain.	• Social support options were not considered a necessary requirement for consumers or health professionals. • Consumers liked social support options that were opt in rather than opt out, and with strict privacy features and disliked sharing health-based information with an app-based community and competition in health care.
Cultural relevance	Reporting of culturally tailored information applicable for diverse ethnic groups.	• Consumers and health professionals both liked cultural relevance features that showed relatable body types, and apps that had the capacity to change language, whilst a lack of cultural diversity was disliked by consumers.

Workshop 2

Workshop two allowed for consolidating and repositioning of categories and the included features, and language modification or simplification. The 12 categories were consolidated into 10 that were identified by participants as requirements in a LBP app assessment tool, including: partnership with health professionals; safety; download process; look, feel, and function; customisation; goals; information; self-monitoring of symptoms; enabling sharing and self-tailoring. Neither consumer or health professional participants had any additions to the summary of the first workshop. Scaling of the categories was briefly discussed. At the completion of the second workshop, eight categories for the app assessment tool had been developed (Table 2).

Table 6. 2.

Workshop 2 Findings

Domain	Description	Workshop 2 findings
Introductory Statement	Initial statement outlining recommendations at the beginning of the tool rather than an app requirement	The 'Partnership with health professionals' evolved into recommendations at the beginning of the tool rather than a requirement of the app. As a result of discussions, an initial question 'Is the app right for you?' was added to the tool. This point directs users to question if app use if appropriate for them and seek oversight from a trusted health professional if they are unsure. *It is recommended that, prior to using an app, you seek advice and oversight from a trusted health professional on:* • *If the app suits your needs and initial setup* • *Managing possible risks to your health e.g., situations to* • *avoid/aggravating factors* • *Guidance and planning for changes to your symptoms* • *Consequences of participation/using the app* • *Recommendations and suggestions to achieve your goals* *Particularly if you have other conditions that may affect your ability to exercise or use the app.*
Safety	Questions that help to tailor the app to the individual's health needs. Privacy – comply with information security and data protection standards	• Safety was discussed. • Health professional participants shared concerns about patient safety, with privacy considered to be important by both consumers and health professionals. • Consumer participants reported the importance of having trusted health professional guidance or oversight.
Download process	Quick and easy to download	-
Look, feel and function	Look nice, functions well, easy to use, layout	-
Customisation	Exercises and activities, scheduling of notifications, connection and ability to sync, spam, advertising and emails, look of app – relatable representation	• Customisation of features such as exercises, flare-ups and notifications was reported as important by both consumers and health professionals. • Self-tailoring was incorporated into the customisation, information self-monitoring of symptoms categories
Goals	Option to set goals and pause goals, option to track goals and progress, option for in app chat function	• The ability to set and pause goals was also considered an important feature by both consumers and health professionals.
Information	Options for amount and type of information, week by week plan of how activities can change over time	• High quality information presented in various formats was valued by both consumers and health professionals. • The self-tailoring category was incorporated into the safety and information categories.

Domain	Description	Workshop 2 findings
Self-monitoring of symptoms	Pain scale, feedback and guidance when red flags are triggered	• Although self-monitoring of pain symptoms was considered important by consumers, health professionals were concerned about the potential for pain to be a main focus.
Enabling sharing	Ability to interact with a community	• Both consumers and health professionals agreed that an option to share with a community was appropriate with the ability to decide how much data was shared.

Workshop 3

The third workshop incorporated discussion around the initial stages of creating a scale with differing levels for each category. At the completion of the third workshop the tool had been refined, wording had been simplified and reduced to minimise user fatigue and a scale had been developed (Table 3).

Table 6. 3.

Workshop 3 Findings

Domain	Description	Workshop 3 findings
Introductory statement	Initial statement outlining recommendations at the beginning of the tool rather than an app requirement	Consumers suggested that the suitability and set-up of the app should be in the same section, whilst both consumers and health professionals discussed the wording of the recommendations.
Safety	• Questions that help to tailor the app to the individual's health needs • Feedback and guidance when specific symptoms that require medical follow-up are triggered • Safety warning • Privacy	• The wording and layout of the safety category was discussed by both consumers and health professionals to better refine the category. • Consumers and health professionals had differing opinions on the Privacy category. • Consumers valued an opt in approach rather than opt out, whilst health professionals decided that the privacy category should be driven by consumers not health professionals.
Download process	• Quick and easy to download	• The download section was considered appropriate by both consumers and health professionals.
Look, feel and function	• Looks nice • Functions well, easy to use • Layout • Spam, advertising	• This category was considered acceptable, but greater refinement, detail and scale ideas were added.

Domain	Description	Workshop 3 findings
Customisation	• Exercises and activities • Tailoring of notifications and emails • Look of app – representation of people in the app • Optional extras: Option for feedback • Yes/No Option to opt out – • Yes/No Connection and ability to sync to other devices or programs	• This category was considered acceptable, but greater refinement, detail and scale ideas were added.
Goals and self-monitoring of symptoms	• Option to set goals • Option to pause goals • Option to track progress and symptoms • Feedback and guidance when specific symptoms that require medical follow-up are triggered Scale – may be binary Yes/No on features	• The goals and self-monitoring of symptoms categories were combined. Greater refinement, detail and scale ideas were added.
Information	• Options for amount and type of information	• This category was considered acceptable, but greater refinement, detail and scale ideas were added.
Enabling sharing	• Ability to interact with others via the app	• This category was considered acceptable, but greater refinement, detail and scale ideas were added.

Workshop 4

Minor changes were made to the tool, concentrating on simplifying wording. Participants collectively agreed to remove ‘initial setup’ from the recommendation section, left the remaining categories the same and the level of detail in the tool was collectively considered appropriate. The ‘optional extras’ category was changed to ‘additional features’ and scaled as either ‘yes’ or ‘no’. Scale options were refined to simplify wording and scale differentiation, and consumers considered symbols to be quicker and easier to understand

than text options. A ‘thumb up, neutral, down’ system replaced the scale options of ‘very good, acceptable, not good’. Overall, participants reported they enjoyed the co-design experience, felt that they contributed and were happy with the final product.

An initial version of the LBP Self-Management App Review Tool (LBP-SMART) was developed (Table 4). The tool consisted of 31 items, assessed self-management, behaviour change, quality and additional features, and used a simple ‘thumb up, neutral, down’ system for rating each item.

Table 6. 4.

LBP Self-Management App Review Tool (LBP-SMART)

Flinders University

It is recommended that, prior to using an app, you seek advice and oversight from a trusted health professional on:

- **If the app suits your needs**
- **Managing possible risks to your health eg. situations to avoid/ aggravating factors**
- **Guidance and planning for changes to your symptoms**
- **Benefits and cautions of using the app**
- **Recommendations and suggestions to achieve your goals**

Particularly if you have other conditions that may affect your ability to exercise or use the app.

Safety		
1. Questions that help to tailor the app to the individual's health needs		
1.1. Thorough, relevant personalised health analysis questions 	Somewhat personalised - Some standard non-specific health questions 	Not personalised at all - limited, general or irrelevant health questions 
1.2. Information collected is used to customise effective and safe exercise prescription 	Exercises somewhat customised 	Exercises not customised 

1.3. Information is continually used to update the exercises according to the person's needs 	General progressions - some data used but not tailored to the person 	General exercises without tailoring the person 
2. Feedback and guidance when specific symptoms that require medical follow-up are triggered		
Lists specific symptoms that require further health professional follow-up 	Outlines general symptoms and provides limited guidance for follow-up 	No specific symptoms or guidance provided 
3. Safety warning		
Specific safety warning and checklist to clear that you are safe to exercise 	General safety warning before exercising 	No safety warning 
4. Additional features: A registered medical device	Yes 	No 
5. Privacy		
Range of control and customisation of your own data 	Limited control and customisation of your own data 	No customisation 
6. Additional features: Comply with information security and data protection standards • Privacy policy	Yes 	No 
Download process		
7. Download process		
Quick and easy to download without issues 	Slow to download and/ or with minor issues 	Slow to download and/or major issues 
Look, function and feel		
8. Looks nice		
Appealing- modern, colourful and professional. App logo is related, colourful and easy to identify 	**Somewhat appealing** - somewhat **modern, somewhat** professional **looking, app logo** is related to **content** 	Not appealing - not modern, professional or colourful, logo is hard to identify 
9. Functions well, easy to use		
Guidance on app gestures for use when required, know where you need to go next 	Limited guidance 	No guidance 

10. Layout		
Range of layout features eg. essential content on initial screen, easy to navigate menus, not overcrowded, fit the layout of screen 	A few features but not all 	Not many features 
11. Spam, advertising		
Ability to be turned off 	Limited ability to be turned off 	No ability to be turned off 
Customisation		
12. Exercises and activities		
12.1. Range of appropriate exercises and ability to pick and choose 	Limited range of exercise and/or options to adapt 	Fixed set of exercises and/ or limited options to adapt 
12.2. Range of activities and ability to pick and choose eg. emotional wellness, mindfulness, relaxation, breathing 	Limited range of activities and/ or limited options to adapt 	No activities and/ or limited options to adapt 
12.3. Ability to modify the activities/ exercises according to the individual's needs eg. type, amount and frequency 	Limited ability to modify the activities/ exercises 	No ability to modify the activities/ exercises 
12.4. Range of formats available - video, written, verbal, pictorial 	limited range of formats available 	Only one format available 
13. Tailoring of notifications and emails		
Ability to customise the type and amount of information provided 	Able to have notifications but can't customise 	No option to turn off notifications or customise 
14. Look of app - representation of people in the app		
Range of options to customise avatar and or images eg. age, gender, level of fitness, body shape, clothing, culture, language 	Limited options to customise the look 	No options to customise the look 
15. Additional features: Option for feedback	Yes 	No 

16. Additional features: Option for feedback • Option to opt out	Yes 	No 
Additional features:		
17. Connection and ability to sync to other devices or programs		
Range of options for connections and syncing 	Limited options 	No options 
Goals and self-monitoring		
18. Option to set goals		
Set goals with guidance 	Set goals but no guidance 	No option to set goals 
19. Option to pause goals		
Without resetting to baseline 	Option to pause goals but resets to baseline 	No option to pause goals 
20. Option to track progress and symptoms		
20.1. Progress reports - with simple visual representation of progress eg. graph, interactive, targets, rewards or gamification 	Progress reports - no or complex and difficult to understand visual Representation 	No progress reports 
20.2. Tracking of different measures eg. pain, exercise tolerance, wellbeing, function, sleep, stress, readiness for change 	One or more outcomes measured but not tracked over time 	Not measured 
20.3. Tracking with scale and text description 	Tracking with scale only 	No scale 
21. Options for amount and type of information Topics • Pain education – mild pain and exercise Activity pacing • Medication use • Problem solving – dealing with changes to your symptoms • Thought and behavioural management • Wellbeing • Distraction techniques **Types** • blog, video, written		

Levels • basics • evidence summary • links to research		
Self-tailoring of relevant, general information supported by research with different topics, types and levels 	Limited generic information supported by research – not specific or tailored 	No information or information not supported by research 
Enabling sharing		
22. Additional features: Option for in app data sharing • Option to switch off	Yes 	No 
23. Additional features: Option for progress sharing with app community • Option to switch off	Yes 	No 
24. Additional features: Option to connect to social support group (blog) • Option to switch off personal data sharing	Yes 	No 
Features: Self-management – Items 2,3,18, 20.2, 20.3, 21, 24 Behaviour change – Items 1.1, 1.2, 1.3, 12-15, 17, 19, 20, 23 Quality – Items 5, 7-11 Additional features – Items 4, 6, 16, 22		

Phase 2 – Pilot study

Thirteen people consented to participate in the pilot study. Of these, seven completed the app assessment using the tool, and five underwent the interview process. Interviews took less than 10 minutes on average and saturation was reached with the five interviews. The results in this section are therefore reported as a percentage of the total number who completed each individual item or completed the section of the app assessment.

Participant characteristics

Participants (n=7) were aged 33.7 (±16.2) years (18 to 60 years), 86% were female and most had university level education (86%). Most had access to an android phone (86%, n=6) and most (71%, n=5) rated themselves very confident using smartphone/tablet devices and had used smartphone/tablet apps (100%, n=7). All participants had experienced LBP (100%, n=7), 14% (n=1) had used apps to self-manage LBP and reported self-managing their LBP moderately well. The main reasons for not using apps were lack of knowledge (100%, n=6).

Usability, clarity and sequencing of the LBP-SMART

All participants (100%, n=5) reported that the app assessment tool was easy to use, had no difficulties understanding any areas of the tool, felt the order and sequencing was appropriate, and no areas required modification. Most (60%, n=3) reported that the wording was clear and easy to understand, and all (100%, n=5) agreed on the meaning of the thumb icons.

TrackActive Me: Virtual Physio app assessment using the LBP-SMART

All participants (100%, n=5) reported the app was ‘good’ and rated it at least 7/10 overall. The quality features were rated most highly by participants. Behaviour change features were rated the second highest, followed by self-management and additional features. All participants (100%, n=7) reported a thumbs up for the download process and layout category. The lowest rated quality feature was the ‘looks nice’ category (look, function and feel) where 71% (n=5) of participants felt the app was appealing, modern,

colourful and professional. The lowest rated behaviour change feature was the safety category with 43% (n=3) of participants reporting the questions asked within the app helped tailor to the individual's health needs and that the information collected was used to customise effective and safe exercises prescription. All participants (100%, n=7) reported that the app had the behaviour change feature of customisation of exercises and activities, with a range of activities and the ability to pick and choose. Most (86%, n=6) reported that the self-management feature of goals and self-monitoring, with the option to track progress and symptoms with progress reports such as simple visual representation, were available through the app. The lowest rated self-management feature where only 50% (n=3) reported that the additional feature of enabling sharing, that allowed connection to a social support group but with the option to switch off personal data sharing, was available. All participants (100%, n=6) reported additional features of privacy policy and complies with information security and data protection standards. However, 71% (n=5) of participants reported that the option for feedback with the option to opt-out was available.

As a result of the pilot testing no further modifications were made to the LBP-SMART content, however, suggestions were made regarding the formatting for clarity.

Discussion

Self-management is a key component of LBP management, allowing people to take control of their condition. Smartphone apps have great potential to assist with the self-management of LBP. However, this potential can only be realised if apps are accessed and used. Choosing an appropriate app with the required quality, self-management and

behaviour change features, can be challenging (Azad-Khaneghah et al., 2021; Didyk et al., 2022a; Nouri et al., 2018; Stoyanov et al., 2016; Wicks & Chiauzzi, 2015). To date, efforts to regulate the quality of available apps have focused on developers, researchers and regulators (ADHA, 2022; Stoyanov et al., 2015). Although some consumer level app assessment tools exist (Azad-Khaneghah et al., 2021; Levine et al., 2020; Stoyanov et al., 2016), there is currently no single tool available for consumers that assesses quality, self-management and behaviour change potential (Azad-Khaneghah et al., 2021). Recent systematic reviews reported most available rating tools assess app usability, intended for developer use, or quality, intended for health professional use, and few provided guidance on assessing self-management or behaviour change potential (Azad-Khaneghah et al., 2021; Nouri et al., 2018). The need for consumer and health professional app assessment education has been highlighted (Lewis, 2013; Wicks & Chiauzzi, 2015) and the creation of a tool (Azad-Khaneghah et al., 2021; Lewis, 2013; Nouri et al., 2018) based on frameworks and classifications of app evaluation and consumer experience has been suggested as a solution (Azad-Khaneghah et al., 2021; Nouri et al., 2018).

Many research tools exist for app quality assessment for a range of conditions (Azad-Khaneghah et al., 2021; Baumel et al. 2017; Nouri et al., 2018), as well as separate assessment tools for app behaviour change (McKay et al., 2019; McMillan et al., 2016) and self-management potential (Devan et al., 2019). However, to the best of our knowledge, the LBP-SMART is the first co-designed consumer-level app assessment tool that does not require specific training to use such as the research-level MARS (Azad-Khaneghah et al., 2021; Stoyanov et al., 2016). Although reliable (Didyk et al., 2022a; Stoyanov et al., 2015), the MARS has a training package (Stoyanov, 2016) and is time consuming, complex (Didyk et al., 2022a) and not easy for consumers to use. The codesigned LBP-SMART assesses app quality, self-management and behaviour change potential and is divided into seven

main categories: 1) Safety; 2) Download process; 3) Look, function and feel; 4) Customisation; 5) Goals and self-monitoring; 6) Enabling sharing and 7) Additional features. The findings from the pilot study suggest the LBP-SMART is clear, well organised and easy to use and understand. The tool fills the need identified for consumer and health professional app assessment education (Lewis, 2013; Wicks & Chiauzzi, 2015) with a consumer-level tool based on frameworks and classifications of app evaluation and consumer experience (Azad-Khaneghah et al., 2021; Lewis, 2013; Nouri et al., 2018).

The benefits of using a co-design process to develop the tool is the ability to guide the inclusion of each category for assessment based on what the consumers and health professionals considered important. Additionally, it was based in knowledge of the literature, supplied by the contribution of the research team and previous work completed in this area (Devan et al., 2019; Didyk et al., 2022a; McKay et al., 2019; Stoyanov et al., 2015).

Future research is required to complete the final two steps of the Co-KT framework (step 4) implementation and evaluation and embedding in context, translating to other contexts (step 5), to determine the most appropriate method of dissemination, and the usability of the tool in this and other communities. This is of particular interest in primary care, with first point of contact health professionals for LBP management, where uptake could impact clinical care. The use of the COnsensus-based Standards for the selection of health Measurement Instruments (COSMIN) guidelines could potentially be used in the future for content validity.

Strengths and limitations

This study had numerous methodological strengths. A robust co-design process was used and based on the Co-KT theoretical framework (Kitson et al., 2013). Previous literature and the research team's preliminary work (Didyk et al., 2022a, 2022b) were used to guide the workshops, allowing for a high level of confidence in the results. Recruitment was undertaken nationally, and the included workshop participants enabled coverage of both consumer and heath professional views. Co-design stakeholders completed all workshops, and an appropriate number of participants was recruited for initial pilot testing. The LBP-SMART has content validity based on evidence and confirmed with co-design participant views that represented key stakeholders. However, it is unable to be evaluated against a 'gold-standard' tool. Reliability needs to be explored in future work. There were also some limitations. Despite extensive recruitment efforts for Phase 1, the number of participants involved was small. This was mitigated by the highly engaged participants and the use of the online pilot study participants to provide more demographically diverse additional feedback and experience. The initial version of the LBP-SMART did not allow users to de-select a response in the pilot testing, resulting in multiple responses for some categories. The tool was designed for LBP apps and may not be transferrable to other conditions, communities or countries. However, it is likely that all sections are generalisable to pain related apps. Aside from section 1.2 and 12.1, that are exercise specific, it is likely that all other sections are transferable to many health apps, however, this requires further exploration.

This study co-designed and pilot tested LBP-SMART, a tool for consumers to assess app quality, behaviour change and self-management potential. The tool has great potential to improve app uptake by consumers and confidence of health professionals in recommending apps. Further work is required to implement and evaluate the tool for people with LBP, and, if successful, translate the findings broadly at a population-level.

Chapter Seven – Discussion

This program of research was conducted across four studies. The first study (study 1, chapter 2) aimed to report on the current evidence of effectiveness of smartphone apps for the self-management of LBP. A systematic review of the literature found that the evidence for the effectiveness of smartphone apps in the self-management of LBP is limited, with methodological biases in selection, performance, detection and attrition and mixed results and provides inconclusive evidence for the use of apps for the self-management of LBP. The second study (study 2, chapter 3) aimed to systematically assess the availability, content, and quality of commercially available, self-contained smartphone apps for the self-management of LBP in adults, and explore the associations between quality, in-app user ratings and cost. A systematic assessment found that smartphone apps for the self-management of LBP, that function with or without health professional input were numerous, of average to good quality, with poor engagement ratings and marginal levels of self-management and behaviour change support. The third study (study 3 (consumers), chapter 4) aimed to investigate the self-efficacy and self-management practises of people with LBP, as well as explore the use and preferences for smartphone app use for self-management. An on online consumer survey found that overall, most Australian adults with LBP have above average self-efficacy and self-manage moderately well. Early intervention is important due to the relationship between duration and recurrence of LBP and lower self-efficacy. Smartphone apps were only used by a small proportion of people with LBP as an adjunct to other management options, with lack of knowledge as a perceived barrier. All consumer app users had LBP and most found that app use helped improve their LBP. The third study (study 3 (health professionals), chapter 5) aimed to investigate health

professionals' use, barriers, confidence and preferences for technology and smartphone apps to assist clients with self-managing LBP. An online health professional survey found that health professionals have limited knowledge of LBP guidelines, do not recommend LBP self-management apps due to a lack of knowledge of their effectiveness and those that do recommend apps are confident with app choice, recommendation and app quality assessment. The final study in this program of research (study 4, chapter 6) aimed to co-design and pilot test a tool to assess the quality of low back pain self-management apps and behaviour change and self-management potential, with a group of health professionals and consumers. A co-designed app assessment tool was developed that allows for quick and easy evaluation of currently available LBP self-management apps by consumers and health professionals to increase adoption of app use.

The overall aim of this program of research was to evaluate the use of commercially available LBP self-management smartphone apps, by consumers and health professionals, to better guide implementation and adoption of app use into LBP management. This discussion will step back from the program of research and consider the bigger picture. It will reflect on what is currently known, what was found through this research, what is still not known and what the next steps might be. The areas of self-management and the co-designed app assessment tool, apps for LBP self-management, the evidence underpinning apps, and finally, health professional and consumer education, will be discussed to explain the current landscape around LBP management and app use. Finally, recommendations for researchers, app developers, government, education providers, consumers and health professionals are presented.

Self-management

Self-management is considered best practice to improve outcomes for people with LBP (Foster et al., 2018) and the overarching non-invasive recommendation in LBP clinical guidelines (NICE, 2016; Bernstein et al., 2017; Meroni et al., 2021). Self-management has been shown to reduce pain intensity and disability in people with LBP (Du et al., 2017) and aims to develop a person's ability to manage day-to-day and improve quality of life (Lorig & Holman, 2003). Many studies have explored interventions for people with LBP that incorporate principles of self-management, exercise and active rehabilitation (Baena-Beato et al., 2014; Du et al., 2017; Elbers et al., 2018; Kim et al., 2015; Monro et al., 2015; Moon et al., 2015; Zhang et al., 2014). Self-management interventions should provide encouragement to continue with normal activities, information on the nature of LBP and tailored advice to guide self-management (NICE, 2016). Self-management recommendations may differ for each person with LBP and are dependent on the person's capabilities and preferences (NICE, 2016).

Consumer self-management differs for everyone. Self-management is impacted by biopsychosocial factors (Banerjee et al., 2022) and individual self-management and self-efficacy capacity, preferences, needs and personality traits, also require consideration in behaviour change interventions (Stieger et al., 2020). This program of research found that most Australian adults with LBP self-managed moderately well and had above average self-efficacy (Study 3, chapter 4). Those with higher self-management were female, with increasing age, lower severity of LBP and higher traits in personality domains aside from agreeableness. Conscientiousness, emotional stability and openness personality traits, play a role in self-management and self-efficacy. Although apps may not be appropriate for

everyone experiencing LBP, recent data shows that over half of consumers are willing to receive digital health care from their usual healthcare providers (Accenture, 2020). Despite this, smartphone apps were only used by a small number of people with LBP, as an adjunct to other management options such as exercise, medication and physiotherapy. Those with lower personality trait scores had associated lower self-efficacy, consistent with previous studies (Ambiel & Noronha, 2016; Brown & Cinamon, 2016; Delgado-Rodríguez et al., 2018; Hayat et al., 2020), and apps may provide an adjunct to assist with improving self-management. However, in line with previous research, those with higher personality trait scores, self-efficacy and self-management, self-managed well (Burgess et al., 2010) perhaps without the need for adjunct self-management options such as apps. This research highlighted the importance of assessing the individual personality traits of people with LBP, to identify those who may benefit most from LBP self-management apps.

Health professional recommendation for use of self-management options in LBP is imperative to improving outcomes (Foster et al., 2018). International studies have explored self-management of LBP to address current clinical practice and increase self-management (Adam et al., 2020; Banerjee et al., 2022; Chala et al., 2022; Kongsted et al., 2021). Apps offer a novel self-management option that may address the personal and economic burden of LBP, increase accessibility to health management guidance and decrease health inequality. Health professionals are in a position of power and their opinions and recommendations are valued by consumers (Accenture, 2020; Deloitte, 2018). Surprisingly, very few health professionals were able to correctly identify LBP guideline self-management recommendations, however, this is consistent with previous research (Slade et al., 2016). This lack of knowledge of current guidelines presents a challenge for health professionals to effectively manage people with LBP. This is of particular importance in return-to-work

facilitation as LBP is a leading cause of early retirement in Australia and impacts retirement wealth levels (Schofield et al., 2012). Although health professionals may choose not to follow LBP self-management clinical guideline recommendations, they should be aware of them.

Interventions for self-management

The most beneficial self-management interventions are targeted and personalised to specific groups of people (Banerjee et al., 2022). Demonstrating this, the World Health Organisation (2022) encouraged the research development of self-management toolkits for health and well-being and launched a guideline for self-care interventions (WHO, 2022). One of the greatest Australian success public health self-care campaigns was undertaken to prevent skin cancer (Public Health Association Australia [PHAA], 2018). The ‘slip, slop, slap’ campaign was successful in targeting consumer education, from schools to workplaces, with a variety of educational resources, including sun awareness packs, to decrease sun exposure and seek medical checks (PHAA, 2018). The consumer education campaign successfully reduced melanoma incidence rates in Australia (AIHW, 2022c). Due to the prevalence of LBP, a tool kit specific for LBP supplied in primary care, could provide self-management advice. The tool kit could include evidence-based information and guidance on the nature of LBP, when to seek health professional assistance, pain education, and options for self-management, such as activity maintenance and LBP self-management apps. Such a toolkit could be a valuable population based public health self-management education option. This may require changes in health policy but could provide large scale LBP self-management education to both health professionals and consumers. The toolkit could provide an efficient, low burden, evidence based clinical care process for

LBP management. Although LBP toolkits are available to educate primary care providers (NSW Agency for Clinical Innovation [NSWACI], 2016; Royal Australian College of General Practitioners [RACGP], 2013), mainly GPs, practice nurse and physiotherapists, they are not designed to be supplied to consumers for consumer education. Although the toolkits encourage provision of patient education which may include electronic education packs, what is included in the education packs is at the discretion of each primary care practice (NSWACI, 2016). Placing the onus on individual primary care practices to sift through the dearth of available information and choose consumer appropriate education materials may result in the provision of non-comprehensive consumer education and an increased workload for practices. People experiencing LBP would be provided with the toolkit if they presented to their primary care health professional for LBP management. This type of large-scale public health option could effectively educate the population on LBP self-management and encourage implementation of low cost, scalable self-management options such as apps. Although guidance and LBP management education exists for primary care providers (RACGP, 2013) to the best of our knowledge, no such guidance and education toolkit for people with LBP currently exists in Australia. Future work is needed to co-design, test and implement such a toolkit.

Apps

This program of research demonstrated that both health professionals and consumers lacked knowledge about apps for the self-management of LBP, and this was a barrier for recommendation by health professionals (Study 3, chapters 4-5). The apps used by health professionals and consumers differed, were not condition-specific apps for LBP self-management and did not align with those assessed in this program of research as they

did not meet the inclusion criteria (Studies 1-2, chapters 2-3). Considering health professional lack of knowledge of clinical guidelines, it is understandable that consumers and health professionals may not have chosen apps based on the clinical guideline recommendations that made up the inclusion criteria for the systematic review and assessment (Studies 1-2, chapters 2-3). This program of research has provided a greater understanding on consumer and health professional behaviour around app choice and use. Consumers and health professionals both valued behaviour change app features that included monitoring, advice, goal setting, prompts and social support options (Studies 3-4, chapters 4-6). However, consumer app choice seemed based around specific personal requirements from the apps, such as exercise, information or tracking. In contrast, health professionals chose non-specific apps with a broader reach that could be tailored to the consumers' specific management requirements, such as exercise and education. The reasons why health professionals and consumers do not choose condition-specific apps remains unclear and requires further investigation. It is possible that factors such as the cost or the capacity to be tailored across a range of conditions influence these decisions.

Inconsistent with previous literature recommendations, consumers in this research chose apps to self-manage LBP that were not condition specific (Elbers et al., 2018) (Study 3, chapter 4). Despite this lack of app specificity for LBP, and in contrast to previous literature (Elbers et al., 2018), users self-managed moderately well with apps, and found them to be at least moderately effective in all phases of LBP management but extremely effective whilst experiencing LBP. Consumers also reported that their chosen apps contained multiple self-management and behaviour change features. These results suggest that generalised apps with appropriate self-management and behaviour change features may be sufficient for consumers to perceive app effectiveness for LBP self-management.

Health professionals lacked knowledge of LBP self-management apps (Study 3, chapter 5). It is probable that the lack of knowledge around apps for the self-management of LBP impeded recommendation by health professionals. However, a higher number of Australian health professionals recommended apps compared to current trends (Accenture, 2020). Physiotherapists with less than 10 years experience, who personally used healthy lifestyle apps were most likely to recommend apps. Perhaps those newer to the workforce may have greater technology literacy (Keep et al., 2021) and a combination of technology literacy and clinical practical skills and knowledge to incorporate technology more easily into client care (Konttila et al., 2019). Aligned with generational trends, it is also likely that the younger generation are more comfortable with using (Keep et al., 2021) and recommending technology in the workplace (Byambasuren et al., 2020). Those who recommended apps did so for health education, health promotion and LBP self-management and were confident in choosing/recommending apps and assessing app quality. Guideline-based recommendations for LBP self-management can be delivered via digital platforms such as apps (Didyk et al., 2022a, 2022b; Moller et al., 2017). LBP self-management apps have shown improvements in health-related outcomes (Thurnheer et al., 2018) such as pain (Cavanagh et al., 2019) and disability (Shebib et al., 2019). However, limited homogeneous high-quality research exists (Didyk et al., 2022b).

Evidence for app use

Health professionals required evidence of effectiveness to recommend apps to their clients with LBP (Study 3, chapter 5). This program of research demonstrated that evidence regarding app effectiveness is limited and challenging to find. In Study 1, we found only a

small number of studies including apps which met our inclusion criteria (Study 1, chapter 2). In addition, the majority of these apps were developed and used specifically for the research studies, rather than being publicly available, making the evidence difficult to translate into everyday clinical practice and management of LBP in the general population. While we concluded that there is limited evidence for app use for the self-management of LBP, this is mainly due to the lack of research, and heterogeneity of studies, rather than a lack of app effectiveness. There is also a clear need for studies to investigate the effectiveness of commercially available apps for the self-management of LBP. When we explored commercially available apps for the self-management of LBP, we found that none of the identified commercially available apps had been tested (aside from the Selfback app, where consumers could still only access the guest version) (Study 2, chapter 3). This lack of rigorous testing may result in poor health professional confidence in recommending such apps to consumers. There may also be a perceived lack of control from health professionals in recommending commercially available apps, with developers able to make updates and changes to apps without health professionals' knowledge.

There is a clear need for rigorous RCTs exploring the effectiveness of commercially available apps for the self-management of LBP. However, it is acknowledged that the time and cost associated with undertaking RCTs for each available app, or even specific apps, makes this level of evidence challenging to obtain (Patrick et al., 2016; Murray et al., 2016). This is also particularly challenging given the fast rate that apps are added, updated or removed from app stores (IQVIA Institute for Human Data Science (IQVIA), 2021; Larsen et al., 2016; Patrick et al., 2016). Perhaps alternative testing methods may be more appropriate, such as collecting outcome data from app use in real-time, as part of the care model, which would contribute to knowledge of app effectiveness. Unfortunately, this places

the burden on already overburdened health professionals. Alternatively, opportunities to influence app development could result in apps that contain guideline based self-management and behaviour change features that can improve self-management. Conversely, this also raises the question of whether evidence is required for specific apps. Evidence based clinical guidelines also recommend self-management for LBP and perhaps this level of evidence may be enough evidence for their use and potential to improve outcomes. Apps have shown capacity to improve pain (Bailey et al., 2020; Cavanagh et al., 2019; Thurnheer et al., 2018) and disability outcomes (Shebib et al., 2019) or at least provide similar pain outcomes compared to physiotherapy, for people with LBP (Lara-Palomo et al., 2022; Stark et al., 2022). Perhaps evidence of effectiveness of the healthy lifestyle behaviour that the app promotes, such as exercise for LBP, is sufficient to promote app use. Additionally, if health professionals are confident that consumer use of these apps is low risk, then the potential benefits of use far outweigh the risks to recommendation.

The role of education for self-management

This program of research has demonstrated that health professionals lack knowledge of evidence based self-management options for LBP and may use options that are low quality or not recommended (Study 3, chapter 5). Additionally, both health professionals and consumers lacked knowledge of apps for the self-management of LBP which limits the uptake of a self-management option that is easy to access, cost effective and scalable (Study 3, chapters 4-5).

Consumer education regarding self-management options for LBP is required to improve outcomes (ACSQHC, 2022b; Foster et al., 2018). As consumers look to trusted

health professionals for guidance (Accenture, 2020) it is important to educate health professionals on options for LBP self-management (ACSQHC, 2022b) such as apps so that they can best guide consumers. Additionally, providing consumers with evidence-based guidance for LBP self-management may improve LBP outcomes (ACSQHC, 2022b). Sixteen percent of Australians experience LBP and consumer education may assist in reducing the fear associated with LBP, fear avoidance behaviour, pain, disability and progression to chronicity that can result from incorrect beliefs and conflicting advice (Bunzli et al., 2017). Health professionals are also required to follow codes of conduct that require the use of evidence-based practice (Australian Health Practitioner Regulation Agency [AHPRA], 2023). There may be potential insurance implications where verification of evidence-based care, consistent with clinical guidelines may be required to be provided to health insurers.

Health professionals may consider guidelines to be restrictive on clinical reasoning, professional autonomy and patient empowerment (Slade et al., 2016). However, guideline-based recommendations are considered best practice to improve outcomes for people with LBP (Foster et al., 2018) and should be embedded into clinical practice. The lack of knowledge around LBP self-management guideline recommendations is concerning considering the prevalence and impact of LBP globally. The reasons why health professionals are unaware of LBP clinical guideline self-management recommendations are not clear (Slade et al., 2016). The limited implementation of guidelines is generic across health care (Foster et al., 2018; Qumseya et al., 2021), and guideline-based LBP management is also complicated by the range of attitudes and beliefs of the many different primary care health professionals that manage LBP (Slade et al., 2016).

It is possible that primary care health professionals are not exposed to guidelines throughout their entry-level training, or ongoing professional development (Derghazarian & Simmonds, 2011; Qumseya et al., 2021; Synnott et al., 2015) and this should be addressed in entry-level and continuing education for health professionals involved in the management of people with LBP (Hush & Alison, 2011). Changes in accreditation for health professions may be required to ensure entry level programs of study are providing the required knowledge and skills that align with guidelines and that accredited continuing education programs of study are also meeting these competencies. Additionally, education around apps could be provided at entry-level training level, or as part of continuing education for those that have graduated. Exposing health professionals to technologies such as apps could encourage use and make incorporating them into client care easier.

How can consumers choose and assess apps for LBP self-management?

Apps have been shown to improve pain (Bailey et al., 2020; Cavanagh et al., 2019; Thurnheer et al., 2018) and disability outcomes for people with LBP (Shebib et al., 2019). The Australian government has implemented an app assessment framework (ADHA, 2022), placing the onus on app developers to nominate their apps for assessment and cover the costs for this service. The process can be lengthy and costly and may impact the number of apps that are assessed. These factors may limit the transferability to practice and usefulness for consumers and health professionals.

Many research tools exist for app quality assessment (Azad-Khaneghah et al., 2021; Lewis, 2013), as well as some separate tools for app behaviour change (McKay et al.,

2019; McMillan et al., 2016) and self-management potential assessment (Devan et al., 2019). The MARS is a widely used reliable app quality assessment tool (Azad-Khaneghah et al., 2021; Didyk et al., 2022a; Stoyanov et al., 2016; Stoyanov et al., 2015). However, the MARS is a research level tool that has a training package (Stoyanov, 2016), is time consuming, complex (Didyk et al., 2022a) and is not easy for consumers to access or use. Although apps currently available in the app stores have not been tested, some apps contain self-management and behaviour change features that may improve LBP outcomes (Study 2, chapter 3). Interestingly, consumers and health professionals have different criteria and place importance on different features when choosing apps (Studies 3-4, chapters 4-6). The app assessment tool (Study 5, chapter 6) that was co-designed and created as part of this program of research collated consumer and health professional views (Study 5, chapter 6), to educate and guide both consumers and health professionals in appropriate app choices for LBP self-management. The tool contains quality, self-management and behaviour change feature categories to assist health professionals to provide guidance to consumers on appropriate app choice that may improve LBP outcomes. The pilot testing confirmed ease of use and showed the tools capacity to highlight similar app features as app assessment tools designed for researchers (Didyk et al., 2022a).

Improving LBP self-management knowledge and self-management behaviours is crucial to improving outcomes for people with LBP. The tool offers both consumers and health professionals a quick and easy option to address barriers to apps use, fill the gaps in LBP self-management knowledge, and encourages app use and recommendation. To effectively disseminate the app assessment tool to people with LBP, it could be added to a LBP toolkit to guide app choice as an additional self-management option for those that

might benefit from the use of apps to manage LBP. Although the tool was designed specifically for LBP apps, the categories of quality, self-management and behaviour change content are not specific to LBP and there are implications and possible uses for other conditions requiring self-management and behaviour change. However, further research would be required to explore generalisability of the tool to other populations and conditions. Additionally, although the app assessment tool has a simple rating system, further research would be required to create a measurable scale. It is also possible the tool could be converted to an app itself, or made available online, to widen reach and increase ease of use.

Strengths and limitations

This program of research had many strengths. A range of research methodologies and study designs were used, including primary and secondary study designs. The studies included a systematic review, systematic assessment, consumer and primary health professional observational studies and a co-design study which engaged key stakeholders to deliver an app assessment tool for consumers. There were also some limitations. In the final co-design study (Study 4, chapter 6), the views of some health professional disciplines were not well represented due to the low number of participants. The focus on LBP was a strength of this program of research as the data collected were specific to LBP as was the app assessment tool. While this limits the generalisability of the results, recommendations and use of the app assessment tool to other conditions, this focus also provides valuable evidence for people with LBP, a large proportion of the population and a predominant health problem globally. It is acknowledged that the data obtained in Studies 3 and 4 was from Australia, meaning that these results may not be transferrable to other countries,

especially less developed countries with significantly different health care systems. Further research is required in different countries and contexts.

Future directions and recommendations

This program of research considered and collected perspectives from key stakeholders, including consumers, health professionals and researchers. There are many directions for future research and recommendations arising from this body of work across these stakeholder groups (Figure 7.1).

Figure 7. 1.

Recommendations

Researchers

1. Explore entry-level training and professional development opportunities for health professionals in digital health, smartphone apps and self-management of LBP, focusing on guideline-based recommendations.
2. Explore benefits of using condition specific versus generic apps to justify the use of one over the other.
3. Develop a database of assessed apps, however, research is required to better understand how to maintain the database and verify app assessments.
4. Explore, co-design, test and implement LBP toolkits, for both health professional and consumer use to assist people with LBP to improve self-management.
5. Explore dissemination and scale or rating options for the app assessment tool to enable wider use and to better rate and test effectiveness of consumer levels apps.
6. Develop and test a digital version of the app assessment tool, to enable greater scalability and reach in further research and implementation studies.

Education providers

1. Ensure that primary health care professionals are exposed to guidelines in their entry-level training. Changes in accreditation and current standards in education programs and the addition of competency assessments may be required.
2. Guidelines should be addressed in continuing education for health professionals involved in the management of people with LBP.
3. Provide digital technology education, including apps, during entry-level training, or as part of continuing education, for those already in the workforce, to encourage use.

App developers

1. Work with researchers to develop apps that contain evidence-based features that may assist in improving LBP outcomes.
2. Explore the generalisability of these app features with other conditions.

Government

1. Consider incentivising app developers to nominate their apps for assessment, especially health apps which have potential to positively impact the health and wellbeing of Australians.
2. Consider a cost waiver for health apps which meet guideline recommendations.

Consumers

1. Use app assessment tools to assess quality, self-management and behaviour change features of an app to ensure the app has the required features to improve outcomes.
2. Use LBP self-management apps in conjunction with other LBP management options such as exercise, medication and physiotherapy.

Health professionals

1. Follow LBP guidelines as they offer evidence based self-management recommendations that can improve LBP outcomes.
2. Consider the role of individual personality traits (conscientiousness, emotional stability and openness) of people with LBP in self-management and self-efficacy.
3. Offer early self-management guidance as those with lower severity of LBP had higher self-management.
4. Offer consumers digital health options as consumers are keen to use them and look to health professionals for guidance.
5. Consider the suitability of app recommendation for the person and incorporate personal preferences.
6. Recommend LBP self-management apps in all phases of LBP self-management but particularly when experiencing LBP as apps can assist people with LBP to self-manage in all phases of LBP.
7. Use an app assessment tool to guide consumer app choice and assist app recommendation by ensuring the inclusion of self-management and behaviour change features.
8. Use apps as an adjunct to exercise, medication and physiotherapy rather than a stand-alone management option.

Conclusion

This program of research aimed to evaluate the use of commercially available LBP self-management smartphone apps, by consumers and health professionals to better guide implementation and adoption of app use into LBP management. This research has shown that commercially available LBP self-management smartphone apps can assist with LBP self-management. This program of research has significantly contributed to the body of evidence about the use of smartphone apps for the self-management of LBP, by contributing novel data from key stakeholder perspectives, and culminating in a co-designed consumer-focused app assessment tool. This app assessment tool may help to address the personal and economic burden of LBP using a cost-effective, easily accessible, scalable self-management option and guiding implementation and adoption of app use into LBP management.

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Appendices

Appendix 1

Signed co-authorship approval form

Office of Graduate Research
Room 003, Registry Building
Bedford Park, SA 5042
GPO Box 2100, Adelaide 5001 Australia
Email: hdrexams@flinders.edu.au
Phone: (08) 8201 5961
Website: https://students.flinders.edu.au/my-course/hdr
CRICOS Provider: 00114A

CO-AUTHORSHIP APPROVALS
FOR HDR THESIS FOR EXAMINATIONS

In accordance with Clause 5, 7 and 8 in the HDR Thesis Rules, a student must sign a declaration that the thesis does not contain any material previously published or written by another person except where due reference is made in the text or footnotes. There can be no exception to this rule.

a. Publications or significant sections of publications (whether accepted, submitted or in manuscript form) arising out of work conducted during candidature may be included in the body of the thesis, or submitted as additional evidence as an appendix, on the following conditions:
   I. they contribute to the overall theme of the work, are conceptually linked to the chapters before and after, and follow a logical sequence
   II. they are formatted in the same way as the other chapters (i.e. not presented as reprints unless as an appendix), whether included as separate chapters or integrated into chapters
   III. they are in the same typeface as the rest of the thesis (except for reprints included as an appendix)
   IV. published and unpublished sections of a chapter are clearly differentiated with appropriate referencing or footnotes, and
   V. unnecessary repetition in the general introduction and conclusion, and the introductions and conclusions of each published chapter, is avoided.

b. Multi-author papers may be included within a thesis, provided:
   I. the student is the primary author
   II. there is a clear statement in prose for each publication at the front of each chapter, recording the percentage contribution of each author to the paper, from conceptualisation to realisation and documentation.
   III. The publication adheres to Flinders Research Publication, Authorship and Peer Review Policy, and
   IV. each of the other authors provides permission for use of their work to be included in the thesis on the Submission of Thesis Form below.

c. Papers where the student is not the primary author may be included within a thesis if a clear justification for the paper's inclusion is provided, including the circumstances relating to production of the paper and the student's position in the list of authors. However, it is preferable to include such papers as appendices, rather than in the main body of the thesis.

STUDENT DETAILS

Student Name	Claudia Didyk
Student ID	9504699
College	Choose an item. CNHS
Degree	Doctor of Philosophy
Title of Thesis	Smartphone Applications for the Self-management of Low Back Pain

PUBLICATION 1

This section is to be completed by the student and co-authors. If there are more than four co-authors (student plus 3 others), only the three co-authors with the most significant contributions are required to sign below.

Please note: A copy of this page will be provided to the Examiners.

Full Publication Details	Effectiveness of smartphone apps for the self-management of low back pain in adults: a systematic review.
Section of thesis where publication is referred to	Chapter 2

Student's contribution to the publication

70	%	Research design
80	%	Data collection and analysis
80	%	Writing and editing

Outline your (the student's) contribution to the publication:

Claudia Didyk contributed to the conceptualisation of the research questions and research design with input form the supervisory team. Claudia Didyk conducted the literature search and data extraction. Claudia Didyk and Belinda Lange conducted the data analysis, and Claudia Didyk completed the initial draft of the manuscript. All authors edited multiple revisions of the manuscript.

APPROVALS

By signing the section below, you confirm that the details above are an accurate record of the students contribution to the work.

Name of Co-Author 1	Associate Professor Belinda Lange	Signed		Date	18/07/2023
Name of Co-Author 2	Professor Lucy Lewis	Signed		Date	18/07/2023
Name of Co-Author 3		Signed		Date	

PUBLICATION 2

This section is to be completed by the student and co-authors. If there are more than four co-authors (student plus 3 others), only the three co-authors with the most significant contributions are required to sign below.

Please note: A copy of this page will be provided to the Examiners.

Full Publication Details	Availability, content and quality of commercially available smartphone applications for the self-management of low back pain: a systematic assessment.
Section of thesis where publication is referred to	Chapter 3

Student's contribution to the publication

70	%	Research design
80	%	Data collection and analysis
80	%	Writing and editing

Outline your (the student's) contribution to the publication:

All authors were involved in formulating the concept and design of the review. Claudia Didyk and Belinda Lange conducted the systematic app search. Claudia Didyk and Belinda Lange conducted the data analysis, and Claudia Didyk completed the initial draft of the manuscript. All authors edited multiple revisions of the manuscript.

APPROVALS

By signing the section below, you confirm that the details above are an accurate record of the students contribution to the work.

Name of Co-Author 1	Associate Professor Belinda Lange	Signed		Date	18/07/2023
Name of Co-Author 2	Professor Lucy Lewis	Signed		Date	18/07/2023
Name of Co-Author 3		Signed		Date	

PUBLICATION 3

This section is to be completed by the student and co-authors. If there are more than four co-authors (student plus 3 others), only the three co-authors with the most significant contributions are required to sign below.

Please note: A copy of this page will be provided to the Examiners.

Full Publication Details	Self-efficacy, self-management and use of smartphone apps for low back pain: an observational study.
Section of thesis where publication is referred to	Chapter 4

Student's contribution to the publication

80	%	Research design
90	%	Data collection and analysis
70	%	Writing and editing

Outline your (the student's) contribution to the publication:

All authors were involved in formulating the concept and design of the study. Claudia Didyk completed the initial version of the survey. All authors contributed to create the final version of the survey. Claudia Didyk conducted the data analysis and completed the initial draft of the manuscript. All authors edited multiple revisions of the manuscript.

APPROVALS

By signing the section below, you confirm that the details above are an accurate record of the students contribution to the work.

Name of Co-Author 1	Professor Lucy Lewis	Signed		Date	18/07/2023
Name of Co-Author 2	Associate Professor Belinda Lange	Signed		Date	18/07/2023
Name of Co-Author 3		Signed		Date	

PUBLICATION 4

This section is to be completed by the student and co-authors. If there are more than four co-authors (student plus 3 others), only the three co-authors with the most significant contributions are required to sign below.

Please note: A copy of this page will be provided to the Examiners.

Full Publication Details	Health professionals' use of smartphone apps for clients with low back pain: an observational study.
Section of thesis where publication is referred to	Chapter 5

Student's contribution to the publication

80	%	Research design
90	%	Data collection and analysis
70	%	Writing and editing

Outline your (the student's) contribution to the publication:

All authors were involved in formulating the concept and design of the study. Claudia Didyk completed the initial version of the survey. All authors contributed to create the final version of the survey. Claudia Didyk conducted the data analysis and completed the initial draft of the manuscript. All authors edited multiple revisions of the manuscript.

APPROVALS

By signing the section below, you confirm that the details above are an accurate record of the students contribution to the work.

Name of Co-Author 1	Associate Professor Belinda Lange	Signed		Date	18/07/2023
Name of Co-Author 2	Professor Lucy Lewis	Signed		Date	18/07/2023
Name of Co-Author 3		Signed		Date	

PUBLICATION 5

This section is to be completed by the student and co-authors. If there are more than four co-authors (student plus 3 others), only the three co-authors with the most significant contributions are required to sign below.

Please note: A copy of this page will be provided to the Examiners.

Full Publication Details	Co-design of a consumer-level tool to assess the quality of smartphone apps for the self-management of low back pain
Section of thesis where publication is referred to	Chapter 6

Student's contribution to the publication

80	%	Research design
95	%	Data collection and analysis
75	%	Writing and editing

Outline your (the student's) contribution to the publication:

All authors were involved in formulating the concept and design of the study. Claudia Didyk managed the study, conducting recruitment, undertaking the workshops and pilot study as well as data collection. Claudia Didyk conducted the data analysis and consulted with co-authors on the categories arising from the qualitative data analysis. Claudia Didyk completed the initial draft of the manuscript. All authors edited multiple revisions of the manuscript.

APPROVALS

By signing the section below, you confirm that the details above are an accurate record of the students contribution to the work.

Name of Co-Author 1	Professor Lucy Lewis	Signed		Date	18/07/2023
Name of Co-Author 2	Associate Professor Belinda Lange	Signed		Date	18/07/2023
Name of Co-Author 3		Signed		Date	

Appendix 2

Ethics Approval – Study 3 & 4, chapter 4-5

26 November 2021

HUMAN ETHICS LOW RISK PANEL

APPROVAL NOTICE

Dear Mrs Claudia Didyk,

The below proposed project has been **approved** on the basis of the information contained in the application and its attachments.

Project No:	2818
Project Title:	Self-management of low back pain.
Primary Researcher:	Mrs Claudia Didyk
Approval Date:	26/11/2021
Expiry Date:	31/01/2023

Please note: *Due to the current COVID-19 situation, researchers are strongly advised to develop a research design that aligns with the University's COVID-19 research protocol involving human studies. Where possible, avoid face-to-face testing and consider rescheduling face-to-face testing or undertaking alternative distance/online data or interview collection means. For further information, please go to https://staff.flinders.edu.au/coronavirus-information/research-updates.*

RESPONSIBILITIES OF RESEARCHERS AND SUPERVISORS

1. **Participant Documentation**

   Please note that it is the responsibility of researchers and supervisors, in the case of student projects, to ensure that:

   - all participant documents are checked for spelling, grammatical, numbering and formatting errors. The Committee does not accept any responsibility for the above mentioned errors.
   - the Flinders University logo is included on all participant documentation (e.g., letters of Introduction, information Sheets, consent forms, debriefing information and questionnaires – with the exception of purchased research tools) and the current Flinders University letterhead is included in the header of all letters of introduction. The Flinders University international logo/letterhead should be used and documentation should contain international dialing codes for all telephone and fax numbers listed for all research to be conducted overseas.

2. **Annual Progress / Final Reports**

   In order to comply with the monitoring requirements of the *National Statement on Ethical Conduct in Human Research 2007 (updated 2018)* an annual progress report must be submitted each year on the approval anniversary date for the duration of the ethics approval using the HREC Annual/Final Report Form available online via the ResearchNow Ethics & Biosafety system.

   Please note that no data collection can be undertaken after the ethics approval expiry date listed at the top of this notice. If data is collected after expiry, it will not be covered in terms of ethics. It is the responsibility of the researcher to ensure that annual progress reports are submitted on time; and that no data is collected after ethics has expired.

   If the project is completed *before* ethics approval has expired please ensure a final report is submitted immediately. If ethics approval for your project expires please either submit (1) a final report; or (2) an extension of time request (using the HREC Modification Form).

   For student projects, the Low Risk Panel recommends that current ethics approval is maintained until a student's thesis has been submitted, assessed and finalised. This is to protect the student in the event that reviewers recommend that additional data be collected from participants.

3. **Modifications to Project**

   Modifications to the project must not proceed until approval has been obtained from the Ethics Committee. Such proposed changes / modifications include:

- change of project title;
- change to research team (e.g., additions, removals, researchers and supervisors)
- changes to research objectives;
- changes to research protocol;
- changes to participant recruitment methods;
- changes / additions to source(s) of participants;
- changes of procedures used to seek informed consent;
- changes to reimbursements provided to participants;
- changes to information / documents to be given to potential participants;
- changes to research tools (e.g., survey, interview questions, focus group questions etc);
- extensions of time (i.e. to extend the period of ethics approval past current expiry date).

To notify the Committee of any proposed modifications to the project please submit a Modification Request Form available online via the ResearchNow Ethics & Biosafety system. Please note that extension of time requests should be submitted prior to the Ethics Approval Expiry Date listed on this notice.

1. Adverse Events and/or Complaints

Researchers should advise the Executive Officer of the Human Research Ethics Committee on at human.researchethics@flinders.edu.au immediately if:

- any complaints regarding the research are received;
- a serious or unexpected adverse event occurs that effects participants;
- an unforeseen event occurs that may affect the ethical acceptability of the project.

Yours sincerely,

Hendryk Flaegel

on behalf of

Human Ethics Low Risk Panel
Research Development and Support
human.researchethics@flinders.edu.au

Flinders University
Sturt Road, Bedford Park, South Australia, 5042
GPO Box 2100, Adelaide, South Australia, 5001

http://www.flinders.edu.au/research/researcher-support/ebi/human-ethics/human-ethics_home.cfm

Appendix 3

Ethics Approval – Study 5, chapter 6

29 July 2022

HUMAN ETHICS LOW RISK PANEL

APPROVAL NOTICE

Dear Mrs Claudia Didyk,

The below proposed project has been **approved** on the basis of the information contained in the application and its attachments.

Project No:	5568
Project Title:	Co-design of low back pain self-management app assessment tool
Primary Researcher:	Mrs Claudia Didyk
Approval Date:	29/07/2022
Expiry Date:	20/05/2023
Conditions of Approval:	None

Please note: *Due to COVID-19, researchers should try to avoid face-to-face testing where possible and consider undertaking alternative distance/online data or interview collection means. For further information, please go to https://staff.flinders.edu.au/coronavirus-information.*

Please note: *For all research projects wishing to recruit Flinders University students as participants, approval needs to be sought from the Office to the Deputy Vice-Chancellor (Students). To seek approval, please provide a copy of the Ethics approval for the project and a copy of the project application to the Office of the Deputy Vice-Chancellor (Students) via dvcsoffice@dl.flinders.edu.au.*

RESPONSIBILITIES OF RESEARCHERS AND SUPERVISORS

1. **Participant Documentation**

   Please note that it is the responsibility of researchers and supervisors, in the case of student projects, to ensure that:

   - all participant documents are checked for spelling, grammatical, numbering and formatting errors. The Committee does not accept any responsibility for the above mentioned errors.
   - the Flinders University logo is included on all participant documentation (e.g., letters of Introduction, information Sheets, consent forms, debriefing information and questionnaires – with the exception of purchased research tools) and the current Flinders University letterhead is included in the header of all letters of introduction. The Flinders University international logo/letterhead should be used and documentation should contain international dialing codes for all telephone and fax numbers listed for all research to be conducted overseas.

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If the project is completed *before* ethics approval has expired please ensure a final report is submitted immediately. If ethics approval for your project expires please either submit (1) a final report; or (2) an extension of time request (using the HREC Modification Form).

For student projects, the Low Risk Panel recommends that current ethics approval is maintained until a student's thesis has been submitted, assessed and finalised. This is to protect the student in the event that reviewers recommend that additional data be collected from participants.

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- change to research team (e.g., additions, removals, researchers and supervisors)
- changes to research objectives;
- changes to research protocol;
- changes to participant recruitment methods;
- changes / additions to source(s) of participants;
- changes of procedures used to seek informed consent;
- changes to reimbursements provided to participants;
- changes to information / documents to be given to potential participants;
- changes to research tools (e.g., survey, interview questions, focus group questions etc);
- extensions of time (i.e. to extend the period of ethics approval past current expiry date).

To notify the Committee of any proposed modifications to the project please submit a Modification Request Form available online via the ResearchNow Ethics & Biosafety system. Please note that extension of time requests should be submitted prior to the Ethics Approval Expiry Date listed on this notice.

2. Adverse Events and/or Complaints

Researchers should advise the Executive Officer of the Human Research Ethics Committee on at human.researchethics@flinders.edu.au immediately if:

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- a serious or unexpected adverse event occurs that effects participants;
- an unforeseen event occurs that may affect the ethical acceptability of the project.

Yours sincerely,

Hendryk Flaegel

on behalf of

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human.researchethics@flinders.edu.au

Flinders University
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GPO Box 2100, Adelaide, South Australia, 5001

http://www.flinders.edu.au/research/researcher-support/ebi/human-ethics/human-ethics_home.cfm

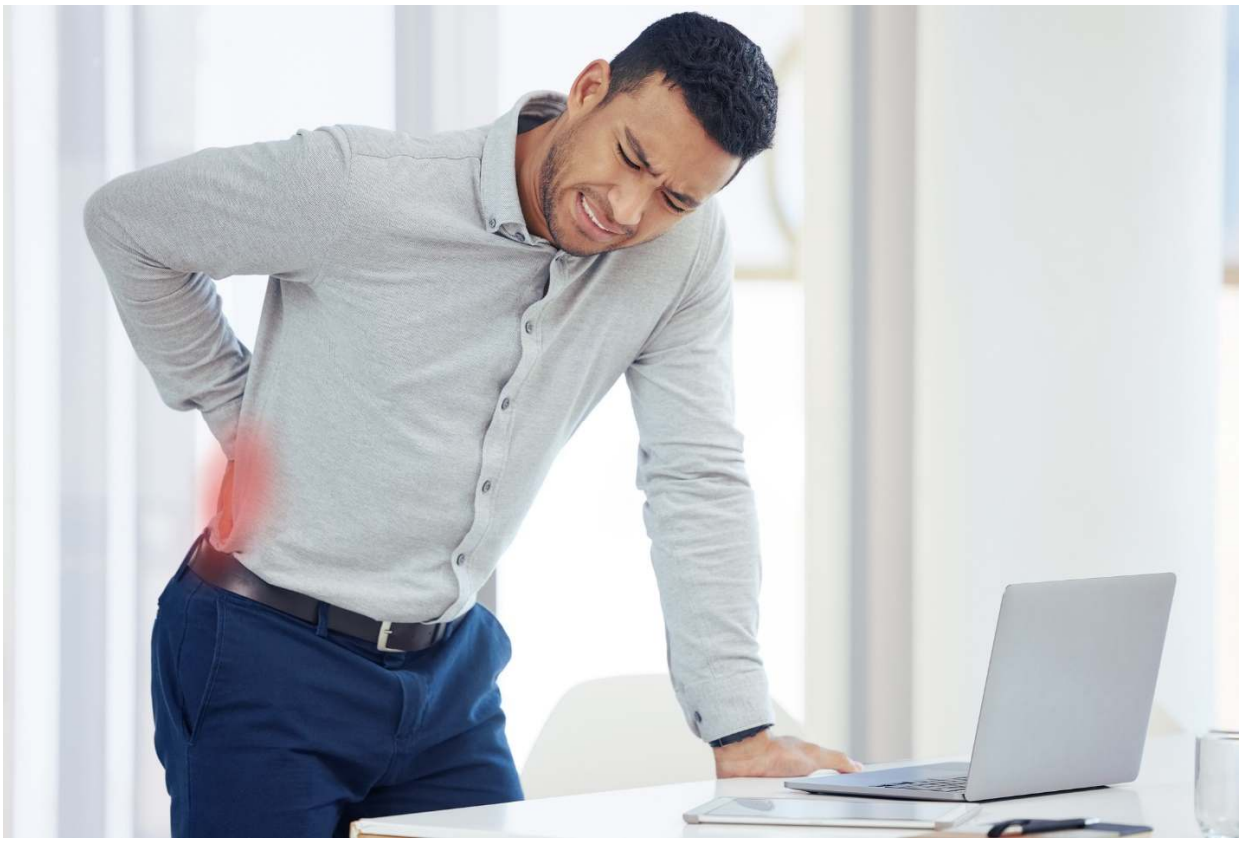
ResearchNow
Ethics & Biosafety

Flinders Proactively supporting our Research

Appendix 4

Smartphone apps and back pain treatments

Posted on November 11, 2021 by newsdesk



Australians hoping to reduce medical and physiotherapy costs by using smartphone apps to self-manage lower back pain could be setting themselves up for failure – with a new study outlining the lacklustre quality and lack of individualised medical advice on the apps.

The study, published in open-access journal Disability and Rehabilitation, found 25 apps that are available for Apple and Android smartphones offer poor quality advice and information, instead recommending common aerobic exercises that fail to deliver important customised management tools for lower back pain.

Nine of the smartphone apps had to be purchased with some offering an initial one-month trial before monthly fees were introduced.

Flinders University PhD Candidate Claudia Didyk, in the College of Nursing and Health Sciences, says the results suggest apps have the potential to improve lower back pain outcomes, however they re not well regulated, and the quality of information and advice provided is often poor.

Smartphones apps can be a cost-effective option for health monitoring and advice, particularly for those who are time-poor, have financial constraints, have transport difficulties or live-in rural areas with poor access to health care. But the rapid rate that

health and wellbeing apps are developed makes it difficult to monitor and effectively regulate content quality," says Ms Didyk.

"Many of the apps were not developed by individuals with a clear health-related background. None of the apps have been tested to determine if they can improve lower back pain outcomes, self-management, and behaviour change. This limits consumer confidence in the product."

"There is a clear need for higher-quality apps that have been evaluated and are from reliable sources. Only one of the apps, the SelfBack app, had been trialled and evaluated in randomised controlled trials."

With back and neck pain effecting millions of Australians at some point in their lives and consistently ranked as a common reason for GP and hospital visits, technology could offer effective alternatives that don't clog up the health system.

But the researchers say the poorly regulated industry reduces product quality and the health benefits are unproven as a result.

Associate Professor Belinda Lange, in the College of Nursing & Health Sciences.

"There is a need for low-cost, easily accessible, reliable, tailored interventions that can address health inequities by enabling the immediate delivery of high-level public health services to address the economic and personal costs of LBP," says Associate Professor Belinda Lange, in the College of Nursing & Health Sciences.

Academic Lead Physiotherapy, Associate Professor Lucy Lewis, in College of Nursing & Health Sciences.

Associate Professor Lucy Lewis says that the variable quality and lack of testing of most apps shows it's important for consumers to consult with a health professional to find out how using an appropriate app may supplement their care.

"There is great potential for apps for low back pain to further encompass behaviour change principles by including features such as sharing behaviours with others, similar to popular exercise app Strava.

Social support has been shown to improve exercise adherence and longevity with behaviour change – this is an important future area for app developers working in the area of low back pain self-management apps."

Funding for app purchases was provided by the Flinders University Research Student Maintenance (RSM) support.

Posted in
College of Nursing and Health Sciences News Research

Appendix 5

Smartphone apps and back pain treatments

11 November 2021

Credit: Pixabay/CC0 Public Domain

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"There is a need for low-cost, easily accessible, reliable, tailored interventions that can address health inequities by enabling the immediate delivery of high-level public health services to address the economic and personal costs of LBP," says Associate Professor Belinda Lange, in the College of Nursing & Health Sciences.

"Clinical recommendations of current smartphone apps for LBP should take into consideration that although apps are of acceptable quality, they are not specifically designed with self-management support and behavior change principles."

The results suggest developers need to work together with consumers and health professionals to incorporate increased self-management and behavior change content and subsequently trial apps to test their effectiveness.

More information: Claudia Didyk et al, Availability, content and quality of commercially available smartphone applications for the self- management of low back pain: a systematic assessment, *Disability and Rehabilitation* (2021). DOI: 10.1080/09638288.2021.1979664