Towards obesity resistance in children: Assessing the predictors of healthy behaviours within the family environment

Gillian Hendrie

BSc (Nut & Diet)

BSc (H Movement – Hons)

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Discipline of Public Health, School of Medicine,

Flinders University, South Australia

CSIRO Food and Nutritional Sciences

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SUMMARY

Understanding the determinants of behaviour in children is crucial to curb the current population obesity trends. Children's behaviour develops within the home, making it a target for obesity prevention efforts. Previous research has identified a network of parental factors that are thought to influence children's health-related behaviour including weight, health-related knowledge and behaviour, parenting styles and practices, to name but a few. This complexity makes it important to use theory or models to guide research and to determine the relative importance of factors within the home environment to improve the effectiveness of future obesity prevention interventions.

Embedded in psychological theory and nutrition education principles is the concept that knowledge is required for behaviour change. This thesis provides much-needed support for the theoretical foundation that nutrition knowledge is a determinant of dietary intake behaviour. The measurement of knowledge and the collection and interpretation of intake data are often cited as limitations to research – issues this thesis aimed to address. Modifications were made to an existing measure of nutrition knowledge, and a validation exercise conducted within a heterogeneous Australian community setting provided a valid and reliable assessment tool to measure knowledge.

Single nutrient or food group analysis omits the synergistic nature of whole diet. A key component of this thesis was the modification of the United States Department of Agriculture's Healthy Eating Index to be consistent with Australian dietary guidelines and its application to the interpretation of dietary intake. An exploratory study, using the validated knowledge tool and modified diet quality index, revealed that some of the basic nutrition guidelines, such as eat more vegetables and less fatty foods, are reaching the community, but detailed knowledge of the nutrient content of foods, diet-disease relationships and making healthier food choices is poor. Indeed, knowledge was shown to be a significant independent predictor of dietary intake and diet quality. Knowledge was shown to be a stronger predictor of overall diet quality than of any single nutrient or food group.

The second aim of this thesis was to disentangle the relative importance of family environmental factors in the context of obesity resistance in children. A 12-month longitudinal study involved 154 South Australian families with primary school-aged children, and used structural equation modelling and previous research to present a model of obesity resistance. The proposed model showed an acceptable fit (NFI=0.458; CFI=0.741; RMSEA=0.045). Parents' BMI (β=0.34*) and knowledge (β=-0.21*) had the strongest direct associations with children's obesity risk. Parents' intake and expenditure behaviours were indirectly associated with children's behaviours through the creation of the home environment. The physical activity environment was associated with children's sedentary (β=-0.44*) and activity habits (β=0.29*). The food environment was associated with fruit and vegetable intake (β=0.47*). General parenting styles (β=0.63*) and child feeding practices (β=-0.74*) were associated with the family environment. Parents' knowledge also had a direct influence on their parenting practices – parenting style (β=0.25*) and feeding practices (β=-0.50*). The proposed model provided a comprehensive insight into the potential avenues for intervention within the complex network of factors that make up the family home environment.

I certify that this thesis does not incorporate without acknowledgement 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 the reference is made in the text.

Signed:  Date: May 21st, 2010

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10th International Congress of Obesity: *Coping with the obesogenic environment: Development of a conceptual model to explain the family factors associated with children's healthy weight status*. Sydney 2006.

10th International Congress of Obesity: *Nutrition knowledge and dietary intake: What is the relationship within an Australian population?* Sydney 2006.

30th Nutrition Society of Australia Annual Scientific Meeting: *Nutrition knowledge and dietary intake: Exploring the differences and relationships within a South Australian Community Sample.* Sydney 2006.

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1 INTRODUCTION

The prevalence of obesity is increasing worldwide. Global increases in overweight and obesity are attributed to a number of factors, including a shift towards energy-dense foods and a trend towards decreased physical activity and increased sedentary behaviours (World Health Organisation, 2006). In Australia the indications are that overweight and obesity in adults (National Obesity Taskforce, 2003) and children are continuing to rise (A. M. Magarey, Daniels, & Boulton, 2001; National Obesity Taskforce, 2003). Rising rates of obesity in children is of concern as childhood obesity has been shown to track into adulthood (Power, Lake, & Cole, 1997a), with serious consequences for both the individual and society (K. Campbell, Waters, O'Meara, Kelly, & Summerbell, 2002).

The increasing trend in the prevalence of obesity suggests effective population-based prevention strategies are not yet known (K. Campbell et al., 2002). Preventive efforts in children have had limited success (K. Campbell et al., 2002), and children are recognised as an important target group to address this problem. Children are at a life stage where they are forming their personal identity and habits, including dietary and activity behaviours. For young children, the family home environment is one setting in which these behaviours are learnt, therefore the family home has been identified as one of the possible intervention points in obesity prevention programs.

Investigating the home environment or intervening within a family home is perceived to be difficult in a research context, thus there is currently relatively little information that informs us about the eating and physical activity environments in which children reside. Research shows parents play a key role in children's development as they are the main food providers within the home, and shape eating and physical activity patterns (Bosch, Stradmeijer, & Seidell, 2004). There is an opportunity to better understand the family environment and how the factors within a home interact to influence children's dietary and activity behaviours. The overarching rationale of this thesis is to contribute to the understanding of the relative importance of identified family environment factors in relation to children's dietary and activity habits, and obesity risk. This work will extend the knowledge in this area by exploring the interactions between family environment factors and the concept of obesity resistance or healthy weight maintenance in children. Having an improved understanding of the relationships between the home environment and children's energy balance behaviours will help to guide future interventions addressing the population problem of obesity.

The thesis comprises two parts. The first part addresses the methodology and some of the theoretical foundations, which underpin the study conducted in the second part that examines the family environmental influences on children's dietary and activity habits and obesity resistance. Many psychosocial theories support knowledge as a determinant of behaviour, however, in terms of nutrition knowledge and food intake behaviour, support from the literature is lacking. There was an identified need for a valid measure of nutrition knowledge to thoroughly explore this founding principle of nutrition education. Chapters 3 and 4 address the measurement of nutrition knowledge, and use the validated questionnaire to explore the nutrition knowledge levels in an Australian community setting. Chapters 5 and 6 explore the relationship between knowledge and food intake behaviour. One common problem in nutrition research is the interpretation of food intake data. Chapter 6 applies a measure of overall diet quality, the Healthy Eating Index, to further explore the role of knowledge in food intake behaviour.

Part two of the thesis presents a longitudinal study (Healthy Kids: The Family Way) of families of primary school-age children in Adelaide, South Australia. The study used the questionnaire and tools developed and trialled in the earlier work, and aimed to characterise the family food and physical activity environments, as well as parental characteristics thought to influence children's energy balance behaviours and obesity resistance. The methodology and justification for the study are presented in Chapter 7. Chapters 8 and 9 contain a description of the families involved in the study, the food and physical activity environments, and how these vary with markers of socioeconomic status. Chapter 10 proposes an exploratory model of the predictors of children's weight status and the interaction between factors within the family home. The proposed model is also applied to the notion of obesity resistance in children.

Finally, while this thesis discusses the implications of the research and possible areas of further research in this domain of obesity prevention in Australia, there are good reasons to believe that the findings may be useful in similar settings.

2 LITERATURE REVIEW OF FAMILY FACTORS ASSOCIATED WITH CHILDHOOD OBESITY

2.1 Introduction

Obesity is considered a modern epidemic and now affects all segments of the population. The fundamental cause of obesity is an energy imbalance where energy consumed is greater than energy expended (World Health Organisation, 2006). This relationship is made more complex by the interaction of factors influencing intake and expenditure behaviours. In children, the family environment plays a key role in shaping these behaviours.

This literature review examines the problem of childhood obesity and the risk factors for the development of obesity in children. It also provides an examination of current literature regarding the family home environment and its relationships with children's weight status, dietary intake, physical activity and sedentary behaviours. Until recently there has been limited research in the area of weight maintenance or protection against obesity in adults, and even less in children. The later parts of this review summarises the research findings in this area. The final part of this chapter presents the overall aims and objectives of this thesis.

2.2 Definition and Measurement of Obesity

The World Health Organisation (WHO) defines overweight and obesity as "abnormal or excessive fat accumulation that may impair health" (World Health Organisation, 2006). Overweight and obesity in adults is measured at the population level using the body mass index (BMI), which is calculated by dividing weight in kilograms (kg) by height in metres squared (m^2). A BMI greater than 25 is considered overweight, and 30 or above is considered obese. These cut-off points are derived from associations between disease and mortality (Department of Health and Ageing, 2004), and recommended for use internationally by the WHO. BMI is a measure of body weight relative to height, but fat distribution may also be worth considering in the assessment of obesity, as excessive abdominal adiposity has an associated disease risk. Thus in addition to BMI, waist circumference is commonly used as a measurement of obesity.

It is universally agreed that BMI is the best available tool to measure the weight status of adults at a population level (National Health & Medical Research Council, 2003a). While it may not be the most accurate assessment of body fat, it is easy to use, accessible in terms of simplicity and cost, reproducible, acceptable to the subject and well documented with published reference values (National Health & Medical Research Council, 2003a).

In children, the measurement of obesity is more complex, and the standard BMI calculation used in adults is not as accepted. Childhood is essentially a period of growth and development, and BMI will change with normal growth, age and gender during these years. To this point, the measurement of weight status in children has challenged researchers in this area. Various cut-off levels have been used to describe overweight or obesity, and criteria have been proposed based on reference populations and different statistical approaches.

Currently, the most accepted method to measure obesity in children is to compare BMI values with age and gender reference standards. In a tertiary setting, BMI can be compared with a referenced data set and reported in terms of a z-score. This allows more detailed statistical description of individuals, particularly at the extremes. In children, the BMI level at which adverse health risk factors increase is unknown. Cole and colleagues (2000) developed a reference population using international data, and identified age and gender specific cut-offs that correspond to adult cut-offs for overweight (BMI greater than 25) and obesity (BMI greater than 30) – points that are related to increased health risks (Cole, Bellizzi, Flegal, & Dietz, 2000). In an Australian research setting, it is recommended that the BMI curves reported by Cole and colleagues are used to interpret body weight information in children (National Health & Medical Research Council, 2003b).

Since the development of the BMI for age and gender, BMI has been adopted as the most appropriate measure of excessive weight in children (Batch & Baur, 2005). Similar to adult populations, some researchers suggest that measuring waist circumference in addition to BMI is worthwhile in the measurement of weight status in children (Lobstein, Baur, & Uauy, 2004).

2.3 The Population Problem of Obesity

Obesity, commonly labelled 'the modern day epidemic', is a population-level problem because it affects all age groups and both genders. Prevalence and trends in prevalence are somewhat difficult to ascertain because they require well-designed population surveys collecting data on body weight and height on a regular basis.

2.3.1 Adult Population Prevalence and Trends in Australia

The prevalence of overweight and obesity in Australia is among the highest in the world, and is thought to be increasing at an unprecedented rate (Jackson, Ball, & Crawford, 2001). Although longitudinal data on the Australian population are lacking, a number of cross-sectional studies have been conducted which suggests that prevalence is increasing. Serial cross-sectional surveys conducted by the National Heart Foundation during the 1980s suggested that the odds of being overweight or obese increased by 23% for men and 58% for women between 1980 and 1989 (Bennett & Magnus, 1994).

The National Health Survey has been conducted in Australia approximately every four years since 1989/90. Data collected in these surveys suggest the prevalence of overweight and obesity in Australian adults has increased gradually from about 38% in 1989/90, to 44% in 1995, to 50% in 2001, and most recent estimates in 2004/05 suggest 54% of Australian adults are overweight or obese (Australian Bureau of Statistics, 2008b). The increases have been greatest in the obese category, increasing from 9% to 18% (1989/90 through to 2004/05) (Australian Bureau of Statistics, 2008b).

The proportion of men classified as overweight or obese is significantly higher than women; recent estimates of 62% and 45% respectively have been reported (Australian Bureau of Statistics, 2008b). Other studies have suggested prevalence may be even higher – 67% in men and 52% in women (estimates for 1999/00) (Dietetic Association of Australia, 2005). While there are differences in the absolute prevalence, it is generally accepted that the majority of Australia's adult population is now classified as overweight or obese.

2.3.2 Childhood Obesity

The problem of obesity is not isolated to Australia's adult population. Recent estimates in children suggest the prevalence of overweight has almost doubled in the past decade, and the prevalence of obesity has almost tripled (Booth et al., 2001; A. M. Magarey et al., 2001). Unfortunately, the 'true' extent of the problem is difficult to define because in recent years, when obesity rates have thought to have increased, there has been limited national standardised monitoring.

In 1995, the National Nutrition Survey suggested about 20% of children were overweight or obese (McLennan & Podger, 1995). Between 1995 and 2007, estimates of obesity prevalence were based on smaller independent studies. For example, estimates from New South Wales (NSW) school children in 1997 suggested that the percentage classified as overweight or obese had increased to between 19% and 23% (Booth et al., 2001).

In 2007, 12 years after the previous national survey, the Australian National Children's Nutrition and Physical Activity Survey was conducted (Commonwealth Scientific Industrial Research Organisation (CSIRO), Preventative Health National Research Flagship, & University of South Australia, 2008). This survey collected physical measurements, food intake and physical activity levels in almost 4500 randomly selected Australian children (aged two to 16). One of the key findings of this survey was that 17% of children were classified as overweight and a further 6% as obese. Similar rates of overweight and obesity were reported for boys and girls.

Comparisons between cross-sectional studies need to be undertaken with caution due to methodological differences. While data from NSW in 1997 and the results of the Australian National Children's Nutrition and Physical Activity Survey reported a similar prevalence of obesity, approximately 23% of children overweight and obesity in both studies, a lot more longitudinal anthropometric data is needed to determine the changes in Australian children's body composition over time.

Comparisons of children within Australian states over time imply an upward shift in BMI, across all age groups and all BMI levels. The increase was particularly pronounced at the higher BMI percentiles (Lazarus, Wake, Hesketh, & Waters, 2000), suggesting that not only are more children becoming overweight, but the overweight children are getting heavier and moving towards obese.

Australia is not alone in this problem of obesity – the United States (US), United Kingdom (UK), Poland and China have all reported similar increases in childhood obesity rates (Lobstein et al., 2004). The WHO has recognised that childhood obesity is a global problem and "is already an epidemic in some areas" (World Health Organisation, 2006). To curb the increasing prevalence, preventive efforts are required for the population as a whole – that is both children and adults – but it could be argued the priority for prevention should be in children, as longer term this underpins the future health of Australia.

2.3.3 The Importance of Children as a Target Group

Childhood obesity is a known independent risk factor for adult obesity (Parsons, Power, & Manor, 2005; Whitaker, Wright, Pepe, Seidel, & Dietz, 1997), and has been described as an epidemic separate to adult obesity (Ebbeling, Pawlak, & Ludwig, 2002). Increasing trends in the prevalence of obesity in children is proof that effective population-based prevention strategies are not yet known (K. Campbell et al., 2002), and large-scale reviews show that no one particular program can prevent obesity in children (Summerbell et al., 2005). In light of rising prevalence in adults and the limited success of preventive efforts thus far in this population group, it is recognised that strategies to effectively manage this problem in children are vital. Australia's national action agenda to address the population problem of obesity, Healthy Weight 2008, focuses on children and their families, identifying this has the potential in the longer term to reduce overweight and obesity in the broader adult population (National Obesity Taskforce, 2003).

Children are an important target of intervention as they are at a life stage where they are forming their personal identity and developing a personal system of beliefs, morals and values (Bissonnette & Contento, 2001), both in general and specifically towards food and physical activity. Children are ready to become informed about health concepts. Studies have shown children as young as six are concerned about weight (O'Dea & Caputi, 2001), and food and nutrition issues are considered important even at this young age (O'Dea, 1999). More than 30% of adolescents in Australia currently report being concerned or worried about eating certain foods and drinks. Concerns most commonly refer to becoming overweight, wanting to be healthy, and other health-related consequences of eating certain foods (O'Dea, 1999).

Research has shown that children start to think about food choices and health behaviours at an early age. It is important to facilitate the learning of 'healthy' behaviours at this life stage while behaviours are malleable and habits are still forming.

2.4 The Impacts of Childhood Obesity

The impacts of obesity are of public health concern. These impacts include health and psychosocial and economic consequences, with both immediate and long-term effects (K. Campbell et al., 2002). The increasing prevalence of obesity in young children is particularly concerning because overweight children are at increased risk of being overweight adults (Power, Lake, & Cole, 1997b).

2.4.1 Health Consequences

Significant physical health problems associated with childhood overweight and obesity are well documented. Childhood obesity commonly leads to the development of serious and potentially life-threatening conditions, such as cardiovascular disease, type 2 diabetes, stroke, cancers, osteoarthritis, kidney and gall bladder disease, and respiratory and musculo-skeletal problems (Australian Institute of Health and Welfare 2002). Previously only seen in adults, type 2 diabetes and cardiovascular disease risk factors have now been reported in children (Lobstein et al., 2004). The increased risk of respiratory problems, such as asthma in obese children, can create a vicious circle by limiting their ability to participate and enjoy physical activity, thus putting them at risk of further weight gain (Ebbeling et al., 2002). The reported cases of such health issues will increase as prevalence of obesity rises and the onset comes earlier in childhood.

2.4.2 Psychosocial Consequences

Findings of many studies indicate that the psychosocial consequences of overweight and obesity are substantial and of serious concern. Australian data shows obesity has a measurable impact on children's self esteem (Franklin, Denyer, Steinbeck, Caterson, & Hills, 2006). Studies from the US and Australia suggest obese children are stigmatised and commonly report negative issues surrounding social acceptance, athletic incompetence and physical appearance (Franklin et al., 2006; Phillips & Hill, 1998; Waters & Baur, 2003). Other studies suggest that obese children are possibly stigmatised more than children with physical disabilities (French, Story, & Perry, 1995).

While some of the health consequences of obesity may be delayed, the social and emotional aspects can be more immediate and affect a child's wellbeing. Friendship is essential for social and psychological development in children, and research has shown that overweight adolescents are less likely to be selected as friends by their peers (Strauss & Pollack, 2003). Given the importance of peer acceptance for children's development, being overweight can have lasting implications for the emotional health of a child. Few other childhood conditions are believed to have a similar impact on emotional development as obesity.

2.4.3 Economic Consequences

The majority of the economic cost of obesity is attributed to disease burden born by the adult population. The economic consequences of childhood obesity are less immediate, but with the majority of obese children becoming obese adults, the long-term economic implications for the individual and the community need to be considered. It has been estimated that the total cost (direct and indirect) of obesity in Australia (in 2005) is about $1.7 billion (Kouris-Blazos & Wahlqvist, 2007). This represents approximately 7.5% of the overall burden of disease and injury (Begg et al., 2007). In addition, the intangible costs, which refer to the costs to the individual in terms of reduced quality of life and ill health, have been estimated to be about 10 times the estimated direct and indirect costs (Segal, Carter, & Zimmet, 1994).

It is, however, difficult to attribute a monetary cost to childhood obesity. Direct costs may be calculated in a similar way to the adult population, but the indirect costs would need to include time away from the workplace by parents to care for their obese children and those who are unemployable in the future due to their excessive weight (Lobstein et al., 2004). The costs of obesity are increasing, and as children continue to gain weight at a younger age and more of the adult population becomes obese, the future costs of obesity to society are going to be substantial.

2.4.4 Tracking of Weight Status

Assessing the relationship between childhood and adult obesity is difficult, partly because of the lack of longitudinal studies in Australia. Using international data and what is known about the Australian population, it is generally accepted that there is a positive association between being overweight as a child and being an overweight adult. While the strength of the correlation varies, this relationship increases with the increasing age and weight of the obese child (B. Livingstone, 2000).

Weight tracking refers to holding a particular weight status (eg underweight, normal weight, overweight or obese) during childhood and maintaining this status over an extended period of time. In a systematic review assessing the relationship between size and growth during the first two years of life, and subsequent obesity later in life, Baird and colleagues conclude that tracking is evident throughout the lifespan (Baird et al., 2005).

There is Australian evidence to support the idea of weight tracking. A study conducted in Busselton, Western Australia, collected the height and weight of individuals during an 11-year period. This study found that half of the children who were obese between the ages of nine and 14 were still obese when examined as a young adult (Kelly, Sullivan, Bartsch, Gracey, & Ridout, 1984). More recent South Australian data shows that of children classified as overweight at age two, 82% were still overweight at 20 (A. M. Magarey, Daniels, Boulton, & Cockington, 2003). Similar findings have been reported internationally. For example, the Bogalusa Heart Study tracked individuals from childhood to young adulthood and found the majority of participants remained in the same weight category across this time period (Deshmukh-Taskar et al., 2006).

The evidence is strong enough to suggest that without intervention, overweight children will become overweight adults. While an unknown proportion of this tracking can be attributed to a genetic predisposition, a considerable proportion is behavioural and is likely to be a consequence of environmental influences. An 'obesogenic environment' is obesity-promoting and includes all the influences that surroundings, opportunities and conditions of life have on promoting obesity in individuals or populations (Swinburn, Egger, & Raza, 1999). The current environment which encourages over-consumption of energy-dense foods and sedentary behaviour is often referred to as obesogenic. Within an obesogenic environment, there are many behavioural and environmental factors which need to be considered, and have been included in research as potential modifiable influences of obesity risk. Understanding these factors and the interrelationships between them is crucial in addressing the problem of obesity. Using theories and models can improve the understanding of these factors and the complex interactions between them. Complex behavioural interventions, such as obesity prevention interventions, need to be guided by theory or models (M. Campbell et al., 2000). Some obesity interventions have used theories or models, many borrowed from other disciplines, but too often an intervention is implemented without this theoretical underpinning, and when this occurs it can be problematic (M. Campbell et al., 2000).

2.5 Using Theory to Guide the Solution

The pathways influencing dietary and physical activity behaviours are complex and dynamic (Swinburn, Gill, & Kumanyika, 2005), and seem to have a number of psychosocial determinants (Knickman & Orleans, 2004). Health promotion research has recognised the importance of careful theory-based intervention planning for behaviour change (Green & Kreuter, 1999; Sallis, Patrick et al., 2000), including dietary behaviour change (Cerin, Barnett, & Baranowski, 2009), yet in relation to obesity prevention, the best possible theory or model is unknown.

Multiple approaches have been suggested to address obesity. Health promotion approaches have tended to focus on modifying an individual's behaviour whereas an ecological perspective, views health promotion in terms of the individual's specific health behaviour as well as the interaction many social factors and the environment (Stokols, 1992).

To date there is no single accepted theory or model to explain the multifaceted behaviours resulting in obesity (Knickman & Orleans, 2004; Swinburn et al., 2005), which may give rise to interventions being delivered without a theoretical basis. Possibly as a result, no country has developed and implemented a multifaceted, large-scale, coherent program to manage the increasing obesity burden (Batch & Baur, 2005; Swinburn et al., 2005), therefore the need for theoretically founded research is of utmost importance and may result in more effective interventions (Cerin et al., 2009).

2.5.1 Theory and Frameworks Used in Obesity Prevention Interventions

Traditionally, the gold standard of research-based interventions is the randomised control trial (RCT). The RCT requires a distinct outcome measure and a limited number of variables, which are too restrictive in population health where there are many influences interacting at a number of levels, and differently on each individual within a group. In an RCT, these would be viewed as confounding variables, however they are important to consider as they best reflect the 'true' or real life environment in which the obesogenic behaviour occurs.

A Cochrane Review has summarised the effectiveness of obesity prevention interventions in children including dietary, physical activity and lifestyle approaches (Summerbell et al., 2005). The inclusion criteria of this review resulted in 22 randomised controlled or clinical control trials of at least 12 weeks duration being reviewed. Almost all studies resulted in some improvement in dietary or physical activity behaviours. Some studies that focussed on dietary or physical activity approaches to obesity prevention showed a small positive impact on weight status, but those that combined dietary and activity approaches had no significant effect on children's weight status (Summerbell et al., 2005). Despite knowing that physical activity and dietary behaviours influence weight status, interventions that show significant impact on weight are scarce, as highlighted in this review. A Cochrane Review has strict criteria for inclusion, design and outcome measurements, which can limit the breadth of research included. It is virtually impossible in any community setting to undertake tightly controlled experiments where the precise effects of a single social influence can be measured (Mittelmark, 1999), and therefore RCTs or Cochrane Reviews are less appropriate for community problems, such as obesity, than in other bioscience disciplines, such as pharmaceutical trials. In the area of obesity prevention, evidence needs to accumulate from a range of sources and study designs.

Evidence of effectiveness is not always sufficient by itself to guide public health decisions, and therefore there is a move towards 'practice-based evidence'. Like the classic 'evidence-based practice', traditional theory and models can provide support for likely pathways of behaviour change, and supporting statistical models can provide estimates on the strength of relationships (Swinburn et al., 2005).

There is a need to increase the evidence base in complex lifestyle problems like obesity. The use of theories and modelling can improve our understanding of the complexity of obesity and the interactions between the many known and unknown influences, with the ultimate view of designing effective interventions (M. Campbell et al., 2000; Cerin et al., 2009).

2.5.2 Examples of Models Developed for Childhood Obesity

Because there is no single well accepted theory, model or approach to address obesity prevention, many different theories, models and approaches have been used or suggested in the literature. This section describes a few examples of models developed to understand obesity.

The WHO Collaborating Centre for Obesity Prevention and Related Research and Training, in Victoria, Australia, has focussed much of its research on understanding the environment and its influence on obesity. The 'obesogenicity' of the environment encompasses all the influences that promote obesity in individuals or populations (Swinburn et al., 1999). To help with conceptualising and prioritising the possible environmental influences, the centre has developed the Analysis Grid for Environments Linked to Obesity (ANGELO) model (Swinburn et al., 1999). Central to this framework is the classification of the environment into micro and macro environments. A microenvironment is a group of people who regularly gather for specific purposes involving food, physical activity or both; for example, the family. A macroenvironment relates to larger, more diverse groups of people, including services and supporting infrastructures such as schools or communities.

Within these two broad classifications are four types of environments – the physical, economic, political and socio-cultural. The physical environment refers to what is available, such as recreational facilities or food outlets, as well as less tangible factors, such as nutrition knowledge. The economic environment refers to costs related to eating and physical activity for an individual or family. The political environment refers to rules related to food and physical activity at the level of government or within a school – for example, school nutrition policy – and within the family, such as the rules or ethos within the home. The socio-cultural environment refers mainly to the family, community or society's attitudes, beliefs and values related to food and physical activity. These are the social and cultural norms which have a strong effect on the behaviour of individuals within a family or community group (Swinburn et al., 1999). The ANGELO model is a useful tool to conceptualise an obesogenic environment, and to prioritise environmental influences for research and identifying potential points for intervention.

Rosenkranz and Dzewaltowski (2008) use the ANGELO framework to conceptualise the home food environment. They describe this environment as "overlapping interactive domains composed of built and natural, sociocultural, political and economic, micro-level and macro-level environments" (Rosenkranz & Dzewaltowski, 2008). Using a comprehensive literature review, the authors describe how each type and level of the environment contributes to children's dietary behaviours and the development of obesity. Rosenkranz and Dzewaltowski's model limits itself to the home food environment. While the authors acknowledge the multifactorial nature of obesity, they state that their model represents "a substantial part of the full environmental context in which a child grows, develops, eat and behaves" (Rosenkranz & Dzewaltowski, 2008), emphasising the primary importance of the family home in the development of children obesity-related behaviours.

Kremers and colleagues (2006) also view the environment at a micro and macro-level, and consider the physical, political, economic and socio-cultural factors within the environment. In their Environmental Research framework for weight Gain prevention (EnRG framework), they suggest the environment influences behaviour both directly, through automatic or unconscious influences, and indirectly through mediation of behaviour-specific cognitions. These direct and indirect relationships between the environment and behaviour are moderated by personal factors and habitual behaviours. The EnRG framework is designed to guide research linking the environment with behaviour, and considers the interactions between the individual, their behaviour and the environment (Kremers et al., 2006).

Other researchers have also used diagrams to illuminate the many influences of obesogenic behaviours. One example is the ecological systems model developed by Davison and Birch (2001) (Figure 1). Like the ANGELO model, Davidson and Birch divide the influences into individual characteristics, the family and the community factors which potentially influence children's weight status (Davison & Birch, 2001a).

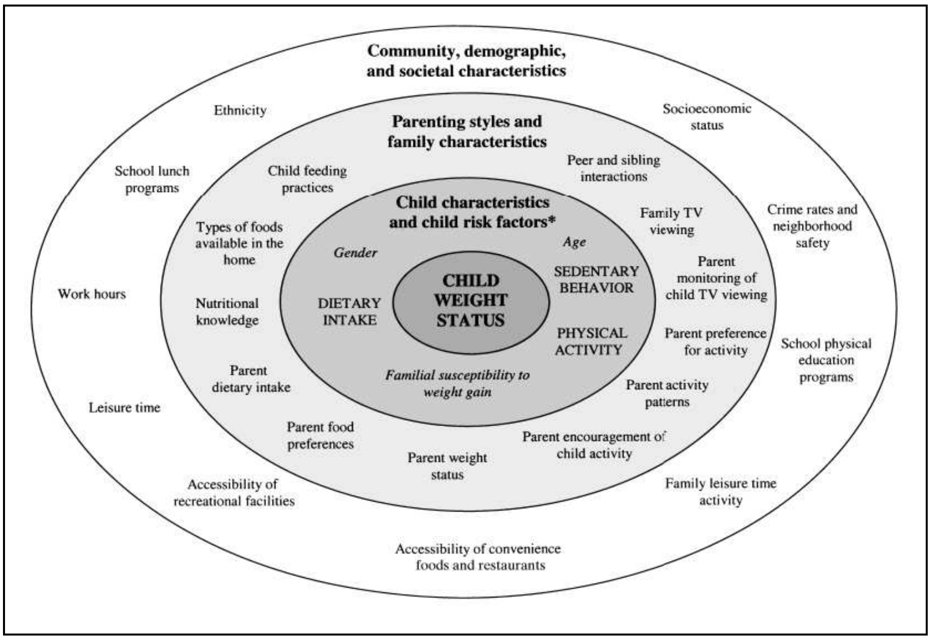

Figure 1 Ecological Model of Predictors of Childhood Overweight (Davison and Birch, 2001, pg 161)

An individual needs to be considered within their environmental context, and the models mentioned provide structure to the complex array of environmental influences of obesity and the related behaviours. However, in the 'real' setting, there are interactions between factors within a context, and also between contexts. For example, parents' food preferences may influence their weight status, which in turn influences their children's physical activity levels.

Most models do not show interactions between the environmental elements and their strengths, therefore missing additional yet potentially equally important influences of children's behaviours and obesity risk. Knowledge of these interactions may guide obesity prevention interventions. This thesis will contribute knowledge of interactions between factors within the family home, and examine the strength and relative importance of these relationships.

There is a belief that research should focus on the predictors of behaviour change rather than predictors of current behaviour (Baranowski, Weber Cullen, & Baranowski, 1999). The current theories that help to gain insight into determinants of current dietary and physical activity behaviours cannot be assumed to apply to behaviour change. There is a need to build better theories or models that guide research in the determinants of behaviour change, because behaviour change is usually the measurable outcome of interventions. The model proposed in this research will initially describe the family environmental factors relating to children's current behaviours and weight status, and will also be statistically tested as a model for predicting change – that is change in children's weight status.

The following section describes the primary risk factors for the development of obesity in children. These factors will be the key outcome behaviours measured and included in the proposed model.

2.6 Primary Risk Factors for the Development of Obesity in Children

The attributing factors in the development of obesity are complex, but ultimately weight gain is the result of a higher energy intake than energy expenditure. Adults make their own food and activity choices, however, in most cases, children rely heavily on parents for the provision of food and support for activity.

2.6.1 Increased Energy Consumption

Measuring dietary intake in any population has many well-documented limitations. Measurement in children is made more difficult for many reasons, such as rapid changes in food habits occurring during growth and development, difficulties with the reporting process, limited memories to recall foods eaten, unstructured eating patterns and consumption of snacks out of the home (B. Livingstone, 2000).

The 2007 Australian National Children's Nutrition and Physical Activity Survey provided estimates of children's food and nutrient intakes (Commonwealth Scientific Industrial Research Organisation (CSIRO) et al., 2008). In general, children surveyed consumed a diet in contrast to the *Dietary Guidelines for Children and Adolescents* (National Health & Medical Research Council, 2003c). Intakes of fruit and vegetables were lower than recommended and declined with age. At best, 61% of four to eight year-olds consumed adequate amounts of fruit (excluding juice), and 22% consumed adequate amounts of vegetables as recommended by the dietary guidelines. This decreased significantly (to 2-3% of all children surveyed) when potatoes were excluded from the vegetable category. This distinction is made because potatoes are frequently consumed with significant amounts of added fat, such as potato chips or wedges. Similar results have been reported internationally, with the majority of children failing to meet the recommended intakes of fruit, vegetables and dairy foods (Brady, Lindquist, Herd, & Goarn, 2000).

Fat is the most energy-dense macronutrient in food, and therefore is often used as a proxy for kilojoule intake. It has been suggested that children with high fat diets consume 15% more kilojoules each day than children consuming low fat diets (Gehling, Magarey, & Daniels, 2005), placing them at risk of weight gain. Data also suggests that Australian children consume fat including saturated fat in excess of the current dietary recommendations (Commonwealth Scientific Industrial Research Organisation (CSIRO) et al., 2008; Gehling et al., 2005).

Children's kilojoule requirements vary dependent on age, gender, body size and level of physical activity, making it difficult to compare intakes to a standard guideline. The estimated requirement for children aged four to eight ranges from 4800kJ to 9200kJ (National Health and Medical Research Council, 2006). An Adelaide study suggested that children consume approximately 5600kJ at age four, 6300kJ at age six, and by the time they are eight to 10, almost 7000kJ (A. Magarey & Boulton, 1987). It was also shown that the intake of children increased by 500-1500kJ during a 10-year period to 1995 (A. M. Magarey et al., 2001).

Australia has little longitudinal monitoring of children's intakes. It is difficult to make comparisons between studies, and any conclusions drawn from results of different studies need to be done with caution. Data suggests that Australian children's food consumption patterns are changing and the overall kilojoule intake may be gradually increasing. There is international research to support the changing food patterns, but an association with obesity risk is not as clear. The Bogalusa Heart Study has dietary intake data for American children over a 20-year period. This data suggests that dietary patterns are changing, but total energy intake has remained the same. Intake behaviours such as skipping breakfast, eating snacks and consuming dinner at home have decreased, while the frequency of eating at restaurants has increased (Nicklas et al., 2004).

Dietary intake and changes in food consumption patterns are complex and there is little information on the associations between food patterns and obesity. It is important to understand the underlying reasons of consumption and how they relate to obesity in children.

2.6.2 Decreased Physical Activity

Physical activity is the major modifiable component of energy balance and has health benefits beyond weight control (Deforche, Bourdeaudhuij, Tanghe, Hills, & Bode, 2004). The wide-ranging benefits of regular physical activity are well known, yet recent statistics suggest that most individuals are insufficiently active to obtain these health benefits (Rhodes & Plotnikoff, 2005). The evidence of the benefits has led the Australian Government to recommend that children participate in at least 60 minutes of moderate to vigorous activity per day (Department of Health and Ageing, 2004).

In the 2007 Australian National Children's Nutrition and Physical Activity Survey, 69% of boys and girls aged nine to 16 participated in adequate physical activity (as per the current recommendations). Girls were less likely to meet the recommendations than boys, and participation across both sexes decreased with age (Commonwealth Scientific Industrial Research Organisation (CSIRO) et al., 2008). Similar data has been reported using accelerometry, with boys spending significantly longer periods in vigorous or hard activities (Abbott & Davies, 2004).

It has been reported that many American children are inadequately vigorously active, and likewise girls in the US are less likely to meet activity recommendations than boys, particularly as they get older (Andersen, Crespo, Bartlett, Cheskin, & Pratt, 1998). Australian children are reported to be more active than American children (Vincent, Pangrazi, Raustorp, Tomson, & Cuddihy, 2003).

Like energy intake, the different methodologies make comparisons between studies into physical activity levels difficult, and therefore it is difficult to obtain trend data. Previous to the 2007 national survey, the last national physical activity survey was conducted in 1985, making the 2007 survey well overdue considering the significant changes in children's leisure pursuits, such as video games, and in changes to family structure, which have had the potential to influence children's physical and sedentary activities.

2.6.3 Increased Sedentary Behaviours

Most research into obesogenic behaviours are cross-sectional in nature, and therefore cause and effect cannot be assumed. However, there is growing evidence to suggest a positive association between increased sedentary behaviours and an increased risk of obesity.

Children participate in various sedentary behaviours, but to date most research has focussed on television viewing. There are two main health-related concerns with television viewing. Firstly, time spent watching television may replace time spent being more physically active, and secondly, children often consume snack foods while watching television. Parents tend to underestimate the amount of food children consume in front of the television (Moag-Stahlberg, Miles, & Marcello, 2003), and it is thought that the influences of television may overshadow any positive family influences on children's food-related behaviours (Fitzpatrick, Edmunds, & Dennison, 2007; J. P. Taylor, Evers, & McKenna, 2005).

Cross-sectional data suggests overweight or obese children watch more television than healthy weight children (van Zutphen, Bell, Kremer, & Swinburn, 2007). Longitudinal data further supports this, with increases in BMI more common in children who report watching more television (Hancox & Poulton, 2005; Jago, Baranowski, Baranowski, Thompson, & Greaves, 2005) or play more computer games (Berkey et al., 2000), and this relationship may strengthen as children get older (Jago, Baranowski et al., 2005). Children watching television for more than four hours per day appear to be at greatest risk of obesity (Caroli, Argentieri, Cardone, & Masi, 2004). It is estimated that for each additional hour of television, the risk of obesity may triple (Gable & Lutz, 2000).

The Australian Government recommends children limit their television and screen time to two hours per day (Department of Health and Ageing, 2004). A number of Australian state-based cross-sectional studies have been conducted, examining children's sedentary behaviours, and their findings vary. A Victorian study (van Zutphen et al., 2007) collected parent-reported television viewing data of 1926 children aged between four and 12. The mean viewing time was 83±1.5 minutes per day. Overweight children had more television time and were more likely to have a television in their room than healthy weight children (van Zutphen et al., 2007). A South Australian study of 11-year olds collected similar information however the data was self-reported, and results suggested that time spent watching television may be higher. These children reported watching between 97 minutes and 109 minutes per day (girls and boys respectively) (Dollman, Ridley, Magarey, Martin, & Hemphill, 2007). Reported time differences between the states may reflect an actual difference in viewing behaviours or the measurement differences – one was parent-reported and the other child-reported. Self-reported data, whether parent or child reported, are influenced by factors such as social desirability and lack of awareness. Parents may not be aware of exactly how much television their children watch, or how much time is spent on the computer or playing electronic games.

More recently, the focus of inactivity research has included television and computer time, and is commonly referred to as screen time. Many studies show that while physical activity decreases with age, screen time increases (Deforche et al., 2004). Hesketh and colleagues (2007) conducted a prospective cohort examining changes in screen time during a three-year period. Results suggest that less than half the children met the Australian screen time guidelines (two hours per day) (Hesketh, Wake, Graham, & Waters, 2007). Boys reported more screen time than girls, and screen time increased with age and body weight (Hesketh et al., 2007). Similar findings were reported in the recent Australian National Nutrition and Physical Activity Survey. This nationally representative survey reported that generally the compliance with the screen time guidelines was low, with only about one-third of children reporting no more than two hours of screen time per day (Commonwealth Scientific Industrial Research Organisation (CSIRO) et al., 2008).

2.7 Family Influences on Children's Energy Balance Behaviours

There is consensus that a family approach increases the likelihood of effective childhood obesity prevention interventions (K. Campbell & Hesketh, 2007). Parents need to be receptive to behaviour change intervention (K. Campbell & Hesketh, 2007) as they are the main food providers within the home, and shape children's eating and physical activity patterns (Bosch et al., 2004). The importance of the family in developing eating and activity habits has been reported in a number of studies and highlighted in proposed research models, however, specific interventions focusing just on families are scarce. Relative to schools, which are in a unique position to access children (Eisenmann et al., 2008; Peterson & Fox, 2007), investigating the home environment or intervening within a family home is perceived to be difficult, therefore families are commonly accessed through school-based interventions.

This section reviews the literature of family environmental influences of children's dietary and physical activity behaviours and obesity risk.

2.7.1 Socioeconomic Status and the Development of Obesity

One family factor which is out of children's control but may impact on their dietary and physical activity behaviours and weight status is the socioeconomic status (SES) of the household. There are various measures of economic status, such as household income and parents' education and occupation, as well as secondary measures, such as suburb of residence. There is some evidence in adults to suggest that weight gain over time varies by socioeconomic status (Ball & Crawford, 2005). The influence of family circumstance on the development of children's obesogenic behaviours and obesity risk is building. A review of literature published nearly 20 years ago found that one-third of studies reported an increased risk of obesity associated with low SES, another third demonstrated an increased risk of obesity associated with high SES, and the remaining third reported no relationship (Sobal & Stunkard, 1989). More recently in Australia

More recent research out of Germany suggests that SES is a strong independent risk factor of obesity in children (Danielzik, Czerwinski-Mast, Langnase, Dilba, &

Muller, 2004). International findings suggest parents' occupations and marital status may be the main SES predictors of children's obesity risk. Children of professional parents are least likely to become obese, and children in single-parent families have a greater risk (Strauss & Knight, 1999). The influence of SES on children's behaviours is possibly more established (Rosenkranz & Dzewaltowski, 2008) with evidence of lower economic status being associated with lower fruit and vegetable consumption (Vereecken, Keukelier, & Maes, 2004) and higher fast food consumption (Drewnowski & Darmon, 2005). Children from more disadvantaged families have been reported to watch more television than children from higher SES families (Langnase, Asbeck, Mast, & Muller, 2004; Story & French, 2004).

To date, studies conducted in Australia have found conflicting results, and some indicate that gender may be a confounding influence. In 12-year-old Australians, a lower SES was associated with a higher BMI in girls but not boys (Burke, Beilin, & Dunbar, 2001); however, other studies showed that this relationship may be significant in both sexes with a lower SES associated with an increased risk of overweight and obesity (Mellin, Neumark-Sztainer, Story, Ireland, & Resnick, 2002; O'Dea & Caputi, 2001).

While the effect of socioeconomic status on obesity risk in children is divided, the evidence is convincing enough for nutrition researchers to usually measure and account for such factors in analysis of family environment data. Socioeconomic circumstance of a family may be more useful in the tailoring of interventions, rather than exclusion from the problem. Obesity is a population level public health problem, and increases in prevalence are not confined to one social group.

2.7.2 Recognition of the Problem

Despite the vast mass media attention obesity has received in recent times, many parents do not accurately perceive the weight status of their children. In fact, many parents of overweight or obese children are unaware their children have a weight problem. For example, in a study conducted in the UK, parents' perceptions of their children's weight status were very inaccurate. When a quarter of the sample was overweight or obese, only 6% of parents recognised their children were overweight (Carnell, Edwards, Croker, Boniface, & Wardle, 2005). In the US, even higher levels of misclassification have been reported (Baughcum, Chamberlin, Deeks, Powers, & Whitaker, 2000; Maynard, Galuska, Blanck, & Serdula, 2003). This misjudgement does not reflect a lack of health-related knowledge (Etelson, Brand, Patrick, & Shirali, 2003) or socio-demographic variation, as the lack of awareness is evident across the population; and it is not because parents are ignorant about weight because almost all of them are able to correctly identify themselves as overweight (Baughcum et al., 2000).

This misclassification may be a reflection of a shift in population norms towards overweight. It could be said that parents are exposed to more overweight children, and therefore their overweight children no longer look very different from their peers (Carnell et al., 2005). It may also be possible that parents do not understand the definition of overweight in children, or may be reluctant to stigmatise their children with the label of overweight (Maynard et al., 2003). This lack of awareness of children's current weight status does not mean that parents are not concerned about their children's future weight, but rather it has been reported that they perceive the problem of childhood obesity as a short-term problem and something children will grow out of in time (Etelson et al., 2003).

The first step in tackling the problem of overweight and obesity is to recognise that there is a problem. Within a family setting, parents need to acknowledge their children have a weight problem before they can be expected to address it and make appropriate changes.

2.7.3 The Role of Knowledge in Weight-related Health Behaviour

The relationship between knowledge and behaviour may seem axiomatic, however, within a research setting, a positive relationship is not always evident. Knowledge is complex, and it is difficult to identify exactly what type or level of knowledge is required to modify health behaviour. It has been suggested that the type of knowledge is more important for behaviour change than the amount of knowledge (Wansink, Westgren, & Cheney, 2005).

The concept of health is often described by parents as the absence of disease (Borra, Kelly, Shirreffs, Neville, & Geiger, 2003). The association between health and weight only becomes an issue when parents believe their child's weight affects their ability to socialise with friends (Borra et al., 2003). Some parents and children recognise the problem of overweight but do not know how to address it; others need assistance in acknowledging the problem, and they too need assistance in addressing it (Borra et al., 2003). Some parents are not aware or not willing to acknowledge the longer-term consequences of their child being overweight, often believing that 'puppy fat' is something their child will grow out of (Baur, 2005; Borra et al., 2003).

In adults, a greater understanding of nutrition concepts has been associated with a healthier dietary intake. For example, nutrition knowledge – when measured using a broad measure including knowledge of recommendations, healthy food choices and the ability to identify healthy foods – was found to be significantly associated with increased fruit and vegetable consumption and a lower fat intake. In fact, individuals in the highest quartile for knowledge were more than 25 times more likely to meet the fruit, vegetable and fat intake recommendations than those with the lowest level of knowledge (Parmenter & Wardle, 1999). In adult populations, higher knowledge levels have also been associated with more successful weight loss (Klohe-Lehman et al., 2006), increased food label use and understanding (Drichoutis, Lazaridis, & Nayga, 2005) and compliance with health recommendations (Main & Wise, 2002).

It is important that researchers understand community knowledge levels before implementing a health program or intervention. Public opinion accuses experts of giving mixed messages in regard to nutrition information, which creates confusion about what constitutes a balanced diet (Navia et al., 2003), and parents remain confused as to what they should be providing their children (L. J. Taylor, Gallagher, & McCullough, 2004). Consumers may try to use food labels to make food choices, but 90% believe that food labels are difficult to understand (CSIRO Division of Human Nutrition, 1993; Hawkes & Nowak, 1998). Considering knowledge before implementing a behaviour change program is important because it allows a program to be individualised. Family-based interventions tailored towards parents' knowledge levels show more successful weight loss in both parents and their children (Epstein, McKenzie, Valoski, Klein, & Wing, 1994).

While nutrition knowledge has been shown to be an important influence of dietary behaviour in adolescents (Delisle, Chandra-Mouli, & De Benoist), few studies have focussed on younger children's nutrition knowledge. It is generally accepted that in young children, parental knowledge – in particular maternal knowledge – becomes an important influence of children's dietary intakes and behaviours (Variyam, Blaylock, Lin, Ralston, & Smallwood, 1999)

Knowledge appears to be one of the important influences of health behaviour, but it needs to be considered along with other personal and environmental influences which may mediate its significance, such as time constraints and food preferences and availability (Klohe-Lehman et al., 2006; Rasanen et al., 2003).

2.7.4 Early Life Home Environment

Early life refers to the first few years of life. There are a number of early family life factors which have been proposed to increase the risk of obesity in childhood, but it is difficult to determine which of these factors are most important (Moreno et al., 2004). The Avon longitudinal study conducted in the UK is a well-designed prospective cohort study of more than 8000 children and their parents, with an aim of identifying the early life risk factors of obesity. Twenty-five recognised risk factors of obesity were included in the study. In the final model, eight of the risk factors were associated with an increased risk of obesity at age seven – these included parental obesity, birth weight and television viewing at a young age. Consumption of unhealthy foods (classified as soft drinks, confectionary, biscuits, bread and high fat takeaway food) at age three was significantly associated with risk of obesity at age seven, although the association was only significant at the 10% level in the final model (Reilly et al., 2005). It is interesting to note that the authors of this study included bread as an unhealthy food, yet pasta and rice were considered healthy foods. In the Australian public health nutrition guidelines, bread is considered part of the cereals food group, along with pasta and rice – all deemed 'healthy' choices.

Rapid weight gain early in life is also a risk factor for childhood obesity. A German study used regression analysis to classify risk factors of childhood overweight in five to six year-olds, and reported that weight gain in the first two years of life and having overweight parents account for as much as 40% of overweight prevalence (Toschke, Beyerlein, & von Kries, 2005).

It is difficult to make exact recommendations from the research findings because they cover a broad range of early life factors across the age spectrum. However, it is clear that the early years of childhood are a time of intense behavioural development, and the home environment can play a crucial role in shaping children's weight-related behaviours and ultimately obesity risk.

2.7.5 The Development of Children's Food Preferences and Choices

Environmental factors interact with a genetic predisposition to produce food preferences. Children have an innate preference towards sweet and salty foods, and are generally neophobic – that is they have a dislike towards untried foods (Birch, 1999). Children's preferences and intake patterns are all learnt early in life (Birch & Fisher, 1998), therefore parents are particularly important in shaping the taste preferences of their children.

In environments where food is abundant, food preference is thought to be a valuable indicator of dietary intake. Children's food choices are influenced significantly by their preference for particular foods. In turn, familiarity with foods can influence preference and consumption (Birch & Ventura, 2009). In an American study, young children's (seven to nine year-olds) food preferences and eating behaviours were shown to be highly correlated (r=0.71). Regression analysis found food preference to be a significant predictor of food intake behaviour, explaining 71% of the variance (Harvey-Berino et al., 1997). Positive correlations between home availability (Gallaway, Jago, Baranowski, Baranowski, & Diamond, 2007), food preference (Gallaway et al., 2007) and intake of fruit and vegetables have also been reported.

Parents can shape children's eating environments in a number of ways, influencing the formation of food preferences and choices. Children share their environment with their parents, and therefore some family resemblances in food preferences have been observed. Skinner and colleagues (2002) described children's food preferences longitudinally for more than five years, and confirmed strong associations between children's and mothers' food preferences (Skinner, Carruth, Bounds, & Ziegler, 2002). The evidence for family resemblance in food preferences may increase with children's age (Birch, 1999).

Children's food choice is directly related to exposure – that is, children prefer the foods most familiar to them (Birch & Ventura, 2009), which is the food most available in the home (Patrick & Nicklas, 2005). In most cases, mothers acknowledge and are recognised by the family as having an extremely active role in the food provision, and therefore family food choice (Stratton & Bromley, 1999). Parents, particularly mothers, plan the meals and control the purchasing of food, and are generally considered the gatekeepers of the family home (Wansink, 2006). Food availability in the home is a significant predictor of children's food consumption. For example, when high sugar, high fat or salty snacks are always available in the home, children consume more (Gable & Lutz, 2000), similarly with fruits and vegetables, high availability correlates with greater intake (Gallaway et al., 2007; O'Connor et al., 2009; Pearson, Biddle, & Gorely, 2008).

Food preferences and intake patterns established early in life are maintained through to adulthood. An Australian longitudinal study tracked the total fat, saturated fat and energy intake of 219 children from ages nine to 18. This study reported weak yet significant correlations ($p<0.05$) between these dietary intake markers in the children at age nine and at 18. For example, the correlation coefficient (r) for fat intake in girls was $r=0.221$, for saturated fat $r=0.299$ and for kilojoules $r=0.210$ (Burke et al., 2001).

Overall, the literature supports the idea that food preferences are developed in early childhood. The family environment, in particular food availability within the home, is important in shaping children food choices and dietary intakes. It is important favourable preferences are encouraged early in childhood because these food preferences are likely to be maintained in later life.

2.7.6 Parents as Role Models

According to Bandura's Social Cognitive Theory, imitation is an essential aspect of learning, and the process of adopting a new behaviour can be enhanced by the presence of social models (Bandura, 1986). Parents can guide behaviour development or induce change in behaviour by modelling appropriate lifestyle behaviours, by making environmental changes within the home and external environments, and by encouraging healthy habits for their children.

Children seek guidance from their parents (Moag-Stahlberg et al., 2003) and often look towards parents or other significant adults in their life for encouragement and support to be involved in more healthful behaviours. Children have a tendency to model some – if not all – of the eating behaviours of their parents (Keller, Miner, & Wigglesworth, 2004).

Parents provide children with a model of when, what, how and how much to eat (Gehling et al., 2005). This is evident from studies which show the nutrient intakes of parents are generally strongly correlated with their children's intakes. The intake of fat (Burke et al., 2001) and intake of fruit and vegetables (J.O. Fisher, Mitchell, Smiciklas-Wright, & Birch, 2002; O'Connor et al., 2009; Pearson et al., 2008) in children have been showed to be positively associated with parents' intakes. The strongest relationships are usually seen between mothers and their children (J. P. Taylor et al., 2005).

The potential for role modelling extends beyond food intake to other weight-related behaviours. For example, mothers who are frequent dieters tend to have daughters who also diet frequently, and parents who report dietary disinhibition and problems controlling their energy intake have children with similar issues (Field et al., 2001; Pike & Rodin, 1991). A mother's dietary disinhibition has been shown to be an independent predictor of having an overweight daughter (Cutting, Fisher, Grimm-Thomas, & Birch, 1999). Higher levels of dietary restraint and disinhibition in parents have been associated with greater weight gain and fat mass in their children (Hood et al., 2000). The modelling of this type of behaviour can have a negative effect on children.

There is some evidence that the structure of family meals is changing (Neumark-Sztainer, Hannan, Story, Croll, & Perry, 2003; Nicklas et al., 2004). Family meals are infrequent because busy schedules make it hard to eat together on a regular basis (Neumark-Sztainer, Story, Ackard, Moe, & Perry, 2000). The family meal has been highlighted as important to provide a consistent meal pattern; reinforce family food rules and parenting control; transfer food-related skill, knowledge and attitudes from parent to child; increase family involvement in food preparation; and add value or appreciation to a meal. It has been suggested that fewer family meals at home translate to less opportunity for parents to role model appropriate eating behaviours (Benton, 2004). Inconsistency in mealtime structure also makes it harder for parents to monitor and control their children's eating habits (Borra et al., 2003).

Changes in the family mealtime structure have coincided with the increasing prevalence of obesity in children, and researchers have started to investigate a possible link. Parents who model behaviours that encourage the family to eat the evening meal together may actually instil some healthful dietary patterns in their children at an early age. For example, families who eat more frequently together have been shown to eat more fruit and vegetables (Fitzpatrick et al., 2007; Gable & Lutz, 2000; Gillman et al., 2000; Larson, Neumark-Sztainer, Hannan, & Story, 2007; Neumark-Sztainer et al., 2003). Other studies have shown children who eat dinner with their family every night eat less fried food (Gillman et al., 2000) and consume less soft drinks (Gillman et al., 2000; Larson et al., 2007; Neumark-Sztainer et al., 2003). The positive influence of family meals may have a lasting effect on meal patterns and diet quality beyond childhood (Larson et al., 2007), however, the positive influences of family meals may be undone by television viewing. Negative associations have been reported between the frequency of television viewing during dinner and fruit and vegetable intake in children (Fitzpatrick et al., 2007). Furthermore, families who eat two or more meals per day with the television on consume less healthy diets with more processed meats, non-nutritious snacks and more soft drinks (Coon, Goldberg, Rogers, & Tucker, 2001). Recent Australian longitudinal research (conducted during a three-year period) found that children who frequently ate dinner while watching television had a higher BMI z-score (Macfarlane, Cleland, Crawford, Campbell, & Timperio, 2009). The emergence of longitudinal evidence is compelling as most research to date has been cross-sectional in nature, limiting knowledge of causal relationships.

Parental role modelling is also important to encourage an active lifestyle for children. Active parents create a family culture or norm, which promotes physical activity, and often provides children – particularly young children – with opportunities to be active. Children's physical activity levels have been shown to increase when parents participate in activities with their children (Nelson, Gordon-Larsen, Adair, & Popkin, 2005). There are strong correlations between parent inactivity and child inactivity (Myers, Raynor, & Epstein, 1998).

It is suggested that time spent outdoors is the most consistent influence on children's physical activity (Cleland et al., 2008; Sallis, Prochaska, & Taylor, 2000), and more recently time spent outdoors has been related to a lower prevalence of overweight (Cleland et al., 2008). In the case of young children, time spent outside is regulated by parents, therefore discrete parent behaviour, such as allowing children to spend time outdoors, is indirectly encouraging and supporting an active lifestyle in children. These characteristics, encouragement, support and parental involvement have been identified as key positive predictors of physical activity in children (Ritchie, Welk, Styne, Gerstein, & Crawford, 2005).

Australian data provides further support for the importance of parental role modelling of active behaviours, and acknowledges that mothers and fathers may have different but equally important roles in promoting healthy behaviours within the family. It appears sons are more inclined to model their fathers' activity habits, while daughters are more incline to model their mothers' inactivity habits (Martin, Dollman, Norton, & Robertson, 2005). Mother and daughter time spent in sedentary behaviour, such as television viewing, has been shown to be significantly correlated (Bogaert, Steinbeck, Baur, Brock, & Bermingham, 2003; Salmon, Timperio, Telford, Carver, & Crawford, 2005), but there have also been significant relationships reported between mother and daughter participation in moderate to high intensity activity (Salmon et al., 2005).

When parents are inactive, they risk weight gain and obesity. Being overweight is often reported as a barrier to physical activity participation, and therefore as a parent, may limit opportunities to role model an active lifestyle for their children. Increased parental obesity has been related to a lack of physical fitness in children (Burke et al., 2001).

Therefore, in summary, we know children's dietary and physical activity patterns evolve within the family context, and familial trends in obesogenic behaviours have been well-documented (Cutting et al., 1999). Parents must see themselves as role models for their children, encouraging healthy behaviours and creating a supportive environment conducive to a healthy lifestyle.

2.7.7 Perceived Barriers to Healthy Behaviours

Health education theories suggest understanding the perceived barriers to behaviour can be useful in efforts to understand and modify behaviour. Because parents control the food availability and often the opportunity to be active, they play an integral role in children overcoming any barriers to health behaviour change.

The 1996 US Surgeon General's Report on physical activity reported that parental encouragement and direct support, support from other family members, access to facilities and time spent outdoors were among the most consistent modifiable correlates of physical activity (US Department of Health and Human Services, 1996). Australian data provides support for this observation. O'Dea (2003) asked a group of children (n=213) to identify their own barriers to healthful eating and physical activity participation. Children identified the major barrier to healthful eating as parental control over their food supply. Most children said they ate what was available and allowable to them at home. When asked about barriers to physical activity and ways to increase their activity, children suggested more time was needed to plan and organise activity, increased parental support and involvement was required, and restructuring of the physical environment was needed to facilitate active behaviours. Children felt that parents' support was crucial to help them increase their activity levels and change their eating behaviours (O'Dea, 2003).

There may be gender differences in the psychosocial factors influencing physical activity participation. For example, it appears that for boys self-efficacy to overcome barriers and having positive social influences for physical activity are most important in increasing their participation. For girls, their perception of their mothers' activity level is important. However, for all children, exposure and the opportunity to be physically active at a young age have been identified as predictors of healthy physical activity habits (Strauss & Knight, 1999).

There appears to be two consistent barriers for children to overcome when adopting an active lifestyle and healthy intake. In the case of physical activity, the opportunity to be active is crucial, and in the case of food intake, availability appears to be reported as the major barrier. Both of these rely on parental support to some extent, further reinforcing the importance of the family home environment in supporting healthy dietary and activity habits in children.

2.7.8 General Parenting Style

Parenting is complex but an important consideration as it can indirectly influence children's behaviours and the development of habits (Ritchie et al., 2005). Parenting styles are commonly classified into three main types: authoritarian, permissive and authoritative (Baumrind, 1971). Authoritarian parenting refers to a style where the parent has full control, and little regard is given to the child's attitude, preference or choice. Parents will place restrictions on 'bad' foods and enforce 'good' foods (J.O. Fisher & Birch, 1995). Often despite the parent's best intention, authoritarian parenting is associated with less healthy behaviours. For example, Wardle and colleagues (2005) conducted a study examining how parental control was related to fruit and vegetable intake in children. This study reported that high levels of parental control were associated with lower fruit and vegetable consumption (Wardle & Carnell, 2005). It has been suggested that when parenting strategies are too controlling, children's abilities to develop their own self-regulatory mechanisms are reduced, leaving them prone to obesity (Golan & Weizman, 2001).

A permissive style is characterised by a lack of interest in the child's food choices or intake. Parents adopting this style of parenting allow their children to eat what they want when they want, with little or no structure in their eating habits. Children do require some level of control considered to be adequate but not excessive. Children with a structured parenting style are better able to regulate their health behaviour (Chen & Kennedy, 2004) and body weight (Brann & Skinner, 2005; Chen & Kennedy, 2004).

The third style of parenting is referred to as authoritative. This represents a balanced approach which encourages children to consume healthful foods, but also gives them some freedom of choice. Under this style of parenting, parents are responsible for the foods offered at a meal, but children have a choice of which foods and the amounts they consume (J.O. Fisher & Birch, 1995; Patrick, Nicklas, Hughes, & Morales, 2005).

Most research into parenting style and health behaviour has been conducted with mothers and their daughters. Girls who report that their mothers are responsive to their needs and set clear expectations for behaviour are more physically active and spend less time in sedentary behaviours (Schmitz et al., 2002). Perceived parenting style also seems to be important in older children. Overweight adolescents who are able to talk to their parents about their problems and share activities with them are more likely to be involved in healthy behaviours (Wilkins, Kendrick, Stitt, Stinett, & Hammarlund, 1998). Longitudinal studies further support the importance of parenting style in predicting longer-term weight status (Wilkins et al., 1998).

Parents often try too hard to regulate children's behaviour and inadvertently have the reverse – often unintended – effect on behaviour. For example, when restrictions are placed on a child's sedentary activities like watching television, it may lead to an increased liking or desire to watch television (Epstein, Saelens, Myers, & Vito, 1997).

While the literature reports that parental control is important, the optimum level of control is not clear. It appears the most positive style is a 'division of responsibility', whereby parents have control and set boundaries, and then children are able to make choices within these boundaries (Satter, 2005). Parenting style is important to consider in a family approach to obesity prevention as research shows it can have an influence on children's dietary intake and energy expenditure behaviours.

2.7.9 Child Feeding Practices

Further to general parenting style, researchers have examined the influence of parenting techniques specific to feeding on children's eating behaviours. There are many different feeding practices employed by parents, such as restricting foods, pressuring children to eat, using food as a reward and monitoring children's intake. There appears to be a fine line between the positive and negative impacts of feeding practices when trying to promote healthy behaviours (Stang, Rehorst, & Golicic, 2004). A recent review of parent-child feeding strategies suggests there are short-term within meal effects and longer-term effects of feeding practices on children's eating behaviours (Faith, Scanlon, Birch, Francis, & Sherry, 2004).

Despite the intention of parents, child feeding practices often result in nutritionally undesirable behaviours. Excessive parental control of food intake can result in a reduction in children's ability to self-regulate their intake, which is a risk factor for obesity (S. L. Johnson & Birch, 1994). Limiting children's access to highly palatable foods in the home may actually increase their desire for such foods, then when they are offered or exposed to these foods outside the home, they have little self-control and overeat. This behavioural pattern persists in later childhood (J. O. Fisher & Birch, 2002; Spruijt-Metz, Lindquist, Birch, Fisher, & Goran, 2002), risking obesity-promoting eating behaviours.

Overly restrictive feeding practices by parents may have undesirable effects, such as weight gain in the short term (Birch & Fisher, 2000; Faith, Berkowitz et al., 2004), as well as influencing weight status in the longer term (Faith, Scanlon et al., 2004). On the other hand, a total lack of parental control when it comes to feeding has also been shown to lead to weight control problems in children (Wardle, Sanderson, Guthrie, Rapoport, & Plomin, 2002).

Birch and Fisher (2000) presented an in-depth model explaining the effects of mothers' child feeding practices on their daughters' eating and weight status. The model included the mothers' and daughters' weight, mothers' restriction on their daughters' eating, mothers' own restrained eating, and feedback of mothers' perceptions of their daughters' overweight risk. Birch and Fisher reported that higher degrees of maternal dietary restraint and mothers' perceptions of their daughters' weight were related to higher restriction of their daughters' food intake. Higher restriction led to children who were not as good as other children at self-regulating their short-term energy intake (Birch & Fisher, 2000). Although this model showed excellent fit, a large amount of variance remained unexplained, suggesting child feeding practices are just one of many influences on children's eating behaviours and weight status.

Seldom are fathers included in studies about feeding practices, as it is assumed that mothers are the gatekeepers to the family home (Wansink, 2006). Davidson and Birch (2001) conducted a unique cross-sectional analysis which included both parents and the relationship between feeding style, weight status and self-concept in their five-year-old daughters. Their results suggested that fathers' and mothers' concern for their children's weight had different effects on children's self-concept. Higher concern among fathers about their daughters' weight status was associated with lower body esteem in daughters. Higher concern among mothers about their daughters' weight status was associated with a lower perceived physical ability among their daughters (Davison & Birch, 2001b).

Child feeding practices have also been shown to influence other eating related behaviours. For example, excessive control and use of food as a reward have been shown to affect food preference (Epstein, 1996). The use of restrictive feeding practices has also been linked to an increase in eating in the absence of hunger, which represents a consistent behavioural risk factor for overweight (J. O. Fisher & Birch, 2002).

Further support is provided by a retrospective study conducted by Brunstrom and colleagues (2005), asking women to think back to their childhood and recall the feeding practices of their parents. This study found women who remembered their mothers using food as a reward and having pressure to finish their plate reported higher levels of dietary restraint and overeating as adults (Brunstrom, Mitchell, & Baguley, 2005). Despite the obvious limitation of the accuracy of long-term recall, this study and others provide some evidence for the long-term carryover of parent-child feeding interactions and the resulting child eating behaviours through to adulthood.

2.7.10 Providing Opportunity and Support

There are many different ways the family home environment can shape children's behaviour through exposure to certain foods, provision of opportunities for activity, and general encouragement and support for healthy behaviours. For example, early exposure to fruit and vegetables and high sugar or high fat foods may play an important role in the development of children's food preferences (Birch & Fisher, 1998). Exposure to sedentary activities, such as the number of televisions in the home, can also influence children's behaviours. A relatively distinct behaviour, such as having the television on when children return home from school, has been associated with increased viewing in children (Jago et al., 2008).

It is important that children are given the opportunity to make healthy food choices. Food availability (Cullen et al., 2001; Gallaway et al., 2007; Jago, Baranowski, & Baranowski, 2007; Pearson et al., 2008), familiarity (Birch & Ventura, 2009) and accessibility (Baranowski et al., 1993) have been associated with children's eating behaviours. Children who report that many different fruit or vegetables are present in their home appear to have higher fruit ($r=0.17$; $p<0.05$) and vegetable ($r=0.28$; $p<0.05$) intakes. In this study, parents' role modelling and support for fruit and vegetable consumption were also significantly associated with increased fruit consumption in children (Cullen et al., 2001).

Parents often avoid shopping with their children because of the demanding and stressful nature of the experience (Pettersson, Olsson, & Fjellstrom, 2004). However, participating in the family food shopping provides an opportunity for children to learn about food supply and be involved in meal planning. At the very least, being involved in the family supermarket shopping exposes children to fresh foods. It may even stimulate an interest in food or initiate a conversation about the origins of food between children and their parents (Pettersson et al., 2004).

Parental support for an active lifestyle is also important. Mothers and fathers may provide different forms of support for their children's physical activity. Mothers have been shown to be active in initiating participation by enrolling children and supporting them at sporting events, whereas fathers are more likely to use their own physical activity to support their children's activity (Davison, Cutting, & Birch, 2003). In this sample of 180 nine-year-old girls and their parents, parental support alone explained 12% of the variance in physical activity (Davison et al., 2003). What is most encouraging about the results of this study is that parents can adopt the style of support most natural to them and have a positive influence on the activity levels of their children.

A large family intervention called the Child and Adolescent Trial for Cardiovascular Health (CATCH) included parents in an essentially child-oriented program. The aim of parental involvement was to reinforce the concepts and skills taught to the children in the classroom, at home. The children had a 'take home' package of learning material and activities, which were to be completed with a parent. The children's perceived positive support for activity and reinforcement of food choice by parents increased as the extent of adult participation increased. The CATCH family program was a relatively low intensity program, yet was able to have a positive effect on knowledge and attitudes towards health behaviour (Nader et al., 1996).

Family involvement and support have also been shown to be crucial to the success of weight control interventions. Parental involvement in child weight control shows consistent positive results (McLean, Griffin, Toney, & Hardeman, 2003). Epstein (1996) researched the role of family involvement and support in children's weight management during a 10-year period. The design of the treatment program included components that tackled both diet and physical activity, and a change in parent-child interactions and the family environment. Behaviour change techniques used included self-monitoring, social reinforcement through praise and contracting, stimulus control in the exercise and eating environments, and parental modelling. Regression analysis on these variables showed that 34% of the variance in overweight (during a 10-year period) could be accounted for by environmental variables (such as number of meals eaten at home, living with fewer obese persons, and social support variables), behavioural factors (such as self-monitoring of weight), and the individual variables of gender and initial relative weight (Epstein, 1996). Importantly, Epstein showed that treating children together with their parents had a positive impact on weight control (Epstein, 1996).

2.8 Factors Associated with Weight Maintenance

Compared to the treatment of obesity, little work has been done in the area of weight maintenance (Glenny, O'Meara, Melville, Sheldon, & Wilson, 1997). Research into obesity has focussed on its predictors, rather than factors that are protective against obesity (Fiore, Travis, Whalen, Auinger, & Ryan, 2006). Knowing the factors that are predictive of a healthy weight maintenance or protective against weight gain would give an alternative perspective in tackling the obesity epidemic.

In an environment where food is abundant and opportunities to eat and be sedentary are endless, maintaining a stable weight proves hard for many adults, and maintaining a healthy weight involves behaviours that may run counter to societal norms. Australian data suggest that during a four-year period, less than half (44%) of the young women surveyed were able to successfully maintain their body weight (Ball, Brown, & Crawford, 2002). Short-term behaviour change is relatively easy because an individual’s motivation is elevated. Longer-term adoption of new behaviours is considered much more difficult as it requires the behaviours to be sustained in the individual’s everyday setting. A combination of factors need to be considered, such as individual preferences, family variables, demographics, socio-cultural influences and lifestyle factors, all of which have shaped the individual’s existing obesogenic behaviours (Kumanyika et al., 2000). Relatively little is known about the factors that may influence the process of successful weight maintenance in adults (Klem, Wing, Lang, McGuire, & Hill, 2000), and even less is known about children (Deforche et al., 2005).

In adults, weight maintenance is usually defined as maintenance after significant loss. Following is a brief summary of the key factors which have been associated with successful weight maintenance in adults.

Some of the individual factors associated with successful weight maintenance include nutritional knowledge (in a sample of women) (Colvin & Olson, 1983), the perception of being in control of one's actions (Byrne, 2002; Elfhag & Rössner, 2005), and self-efficacy associated with one's ability to control eating in different emotional and environmental situations (Byrne, 2002). Increased dietary restraint and decreased disinhibition (Vogels & Westerterp-Plantenga, 2005) have also been associated with successful weight maintenance.

The type of control technique adopted by an individual also seems to be important. A flexible approach to eating, like a 'more or less' rather than an 'all or nothing' approach, has been associated with better weight maintenance (Elfhag & Rössner, 2005). The 'all or nothing' approach has been linked to weight regain and cycling (Byrne, Cooper, & Fairburn, 2003), which in turn is related to long-term weight gain (Haus, Hoerr, Mavis, & Robison, 1994).

Successful weight management also requires an ability to carefully monitor oneself. Self-monitoring can include monitoring of food intake and physical activity in diaries, and frequent weighing (Byrne et al., 2003; Klem et al., 2000; McGuire, Wing, Klem, Seagle, & Hill, 1998; St Jeor et al., 1997; Winett, Tate, Anderson, Wojcik, & Winett, 2005), factors which have also been associated with adherence to weight control programs in children (Wrotniak, Epstein, Paluch, & Roemmich, 2005). A systematic review of literature (published between 1975 and 1994) suggested that self-monitoring, social encouragement and support were some of the most commonly used behaviour change techniques used in successful weight control and weight maintenance interventions (McLean et al., 2003).

Weight maintainers tend to be more aware of their dietary intake and make more conscious decisions regarding food selection (Elfhag & Rössner, 2005), and recognise this need for awareness and caution (Byrne, 2002). In the limited literature available on self-monitoring in children, monitoring in the form of weighing was not a common practice reported by children (Grignard, Jean-Pierre, Michel, Philippe, & Chantal, 2003), but exercise diaries have shown to be beneficial in increasing children's physical activity habits (Deforche et al., 2005; Wrotniak et al., 2005).

One of the few studies that has examined the protective factors against the development of obesity focused on American adolescents (Fiore et al., 2006). This study, by Fiore and colleagues, reanalysed data from the Third National Health and Nutrition Examination Survey (1988-1994), which suggested that watching television for less than one hour per day, participating in more physical activity and a lower daily kilojoule intake were all protective of obesity. For the high risk sub-group – adolescents with an obese parent or parents – the most protective behaviour was eating breakfast all or most days. Second to this was parents' education level. Children with obese but educated parents were at a lower risk of obesity than children with less educated obese parents. For children with healthy weight parents, physical activity participation was most important to reduce their risk of obesity (Fiore et al., 2006). It appears that the factors which protect children from obesity may differ depending on other family factors, such as parents' weight status. As well as providing an insight into some of the behaviours protective of obesity, this study highlights the importance of both sides of the energy balance equation – dietary intake and physical activity – in promoting healthy weight in children.

Family support is a form of social support and can reinforce positive behaviours. Parents who get involved and change their own behaviours will have an impact on their children's environment and social support system (Wilson, 1994). Greater involvement from family members has been highlighted as a way of increasing the effectiveness of weight control programs (Elfhag & Rössner, 2005; McLean et al., 2003).

2.9 Summary and Thesis Aims

Obesity is considered to be a major public health concern of 'epidemic' proportions. Adding to this, prevalence is thought to be increasing in adults and children. The current environment is 'obesogenic', promoting over-consumption and sedentary behaviours, while at the same time offering fewer opportunities to be physically active. This cluster of behaviours has been blamed for the progressive weight gain in what is now the majority of the adult community. In Australia, about one-fifth of the child population is overweight or obese, and this is likely to increase if rates of obesity continue to rise as they have during the past 10 years. Childhood obesity has serious public health implications, as obesity and obesogenic behaviours have been shown to track from childhood into adult life.

Children have been identified as an important target group for obesity prevention efforts, as they are at a life stage where they are forming a personal identity and habitual behaviour is developing. The importance of the family home in the development of children's dietary and physical activity habits is well accepted. Parents are the main providers of food, creators of the home environment, and are often essential to provide the opportunities for children to be active. Parents create the environment in which children learn 'healthy' behaviours, either directly through participation or indirectly via role modelling.

The poor long-term outcomes of current obesity treatment highlights that we do not understand the behavioural strategies most effective in promoting permanent weight loss or healthy weight maintenance in an individual or population setting. We do know that obesity is a public health problem, and in the current obesogenic environment, it is difficult for individuals to control their weight. But we also know that some people – albeit the minority – are successful in maintaining a healthy weight. Jain (2005) clearly identifies this gap in our understanding of the obesity problem, and suggests the question we should be asking is "Why are some people not obese despite living in an obesity promoting environment?" (Jain, 2005). This question forms the basic underlying focus of this thesis.

The development of childhood obesity involves a complex set of factors from many contexts which interact. Theory-driven research or modelling can help to increase our understanding of the complex nature of obesity and conceptualise the problem with the intention of ultimately designing a treatment program or successful prevention interventions. The literature presented in this chapter highlights the many factors to be considered in addressing childhood obesity and related behaviours, limiting itself to those within the family environment context. The many factors presented in previous research, in particular Davidson and Birch's Ecological Model of Predictors of Childhood Overweight

(2001), informed the scope of this research. Figure 2 shows a summary of the research outline for this thesis.

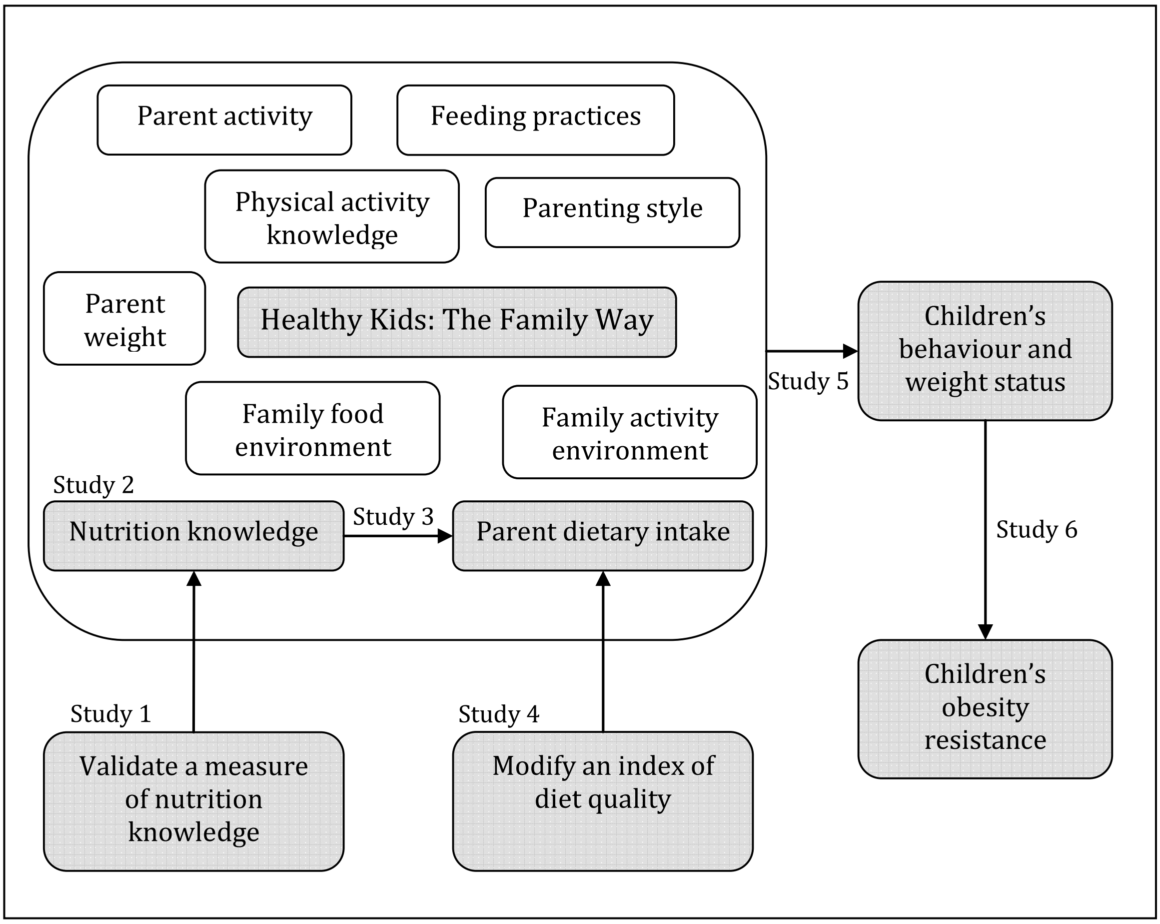

Figure 2 Summary of research outline for this thesis

Knowledge is the founding principal of nutrition education. Many psychosocial theories support knowledge as an influence of behaviour, and the Ecological Model of Predictors of Childhood Overweight (Davison & Birch, 2001a) includes parents' nutrition knowledge as an influence of children's behaviour. Scientific literature around nutrition knowledge as a determinant of dietary intake is inconsistent, and it has been suggested that methodological issues in measuring each construct (knowledge and intake) and not the theoretical foundation is to blame. This proposal motivated the first half of this thesis, which investigates the measurement of nutrition knowledge and dietary intake, and explores the relationship between the constructs when they are measured in a comprehensive manner. Four studies were conducted and the overarching aims were:

1. to validate a measure of general nutrition knowledge for use in an Australian adult community

2. to describe the current levels of nutrition knowledge in an Australian community sample

3. to explore the relationship between nutrition knowledge and dietary intake in an adult sample

4. to interpret reported dietary intake using a comprehensive measure of overall diet quality.

Gaining a greater understanding of nutrition knowledge and dietary intake allowed the global home environment to be considered in the context of children's dietary intake and energy expenditure behaviours. The second part of this thesis presents a study titled Healthy Kids: The Family Way, which aimed to provide knowledge of the relationships between the factors within the family home environment and the relative importance of these influences on children's energy-related behaviours (Figure 2). These behaviours are significant because of their influence on weight status at an individual level, and ultimately the prevalence of overweight and obesity at a population level. The specific aims were:

5. to explore the relationships between factors of the family home environment and children's energy-related behaviours and current weight status through the development of a conceptual statistical model

6. to use the conceptual model to explore how the factors of the family home environment promote obesity resistance in children.

The research differs from previous research in three ways. Firstly, it seeks to examine the influence of the family environment on behaviours from both sides of the energy balance equation, that is children's dietary intake and physical and sedentary activity, whereas other studies have tended to restrict themselves to either energy intake or expenditure behaviours. Secondly, it will take a preventive approach and focus on the protective factors of obesity – 'obesity resistance' – instead of the predictors of obesity. And finally, it will extend previous models by examining the interactions between the identified home environment factors, as well as their influence on children's relevant behaviours and weight status.

3 VALIDATION OF THE GENERAL NUTRITION KNOWLEDGE QUESTIONNAIRE IN AN AUSTRALIAN COMMUNITY SAMPLE

3.1 Introduction

As mentioned in the literature review, nutrition knowledge is one of the influences of children's dietary intake presented in the Ecological Model of Predictors of Childhood Overweight developed by Davison and Birch (Davison & Birch, 2001a). It is thought that parents' nutrition knowledge plays a role in the development of children's eating habits, and is integral to their dietary intake. However, the measurement of nutrition knowledge has proved to be challenging and may be a limiting factor in the strength of research findings. This chapter will review the issues associated with the measurement of nutrition knowledge and present the findings of the first study conducted as part of this thesis – a validation of a nutrition knowledge questionnaire in a community sample [1].

3.2 Background Literature

Knowledge is one of several factors required to change behaviour, although the influence of nutrition knowledge on food-related behaviours has not received consistent support from scientific literature (Worsley, 2002). A meta-analysis conducted in 1985 reported inconsistent correlations between nutrition knowledge and dietary intake, but overall the findings indicated a significant relationship between nutrition knowledge and dietary intake ($p<0.01$), however, the effect sizes were relatively small (Axelson, Federline, & Brinberg, 1985). The weak relationships reported in research papers has lead to doubt regarding the importance of nutrition knowledge in food choice and intake behaviour (Wardle, Parmenter, & Waller, 2000). However, it has been suggested that the inadequate conceptualisation of nutrition knowledge (Axelson & Brinberg, 1992) and the lack of psychometric testing of knowledge

[1] Part of this chapter has been published in the journal titled Nutrition & Dietetics, 2008; 65; 72-77. A copy is included in Appendix 1.

instruments (Wardle et al., 2000) may have led to a premature rejection of the importance of this relationship.

The conceptualisation of nutrition knowledge is often considered to be one-dimensional, and researchers limit their definition of the construct of knowledge; however, nutrition knowledge is a multifactorial construct and more complex to define. As a result, many past questionnaires have chosen to focus only on specific areas of knowledge, such as those related to an understanding of fat or fibre (Packman & Kirk, 2000; Resnicow et al., 1997), or limit the study to specific sub-samples of the community (Calfas, Sallis, & Nader, 1991; Hawkes & Nowak, 1998). Broadening the conceptualisation of nutrition knowledge beyond the basics is important to increase the effectiveness of nutrition education programs (Axelson & Brinberg, 1992).

The accuracy of tools used to measure knowledge is questionable when they are seldom assessed for reliability and validity. Researchers can have greater confidence in their findings when measures of known reliability and validity are used to explore theoretical relationships (Sapp & Jensen, 1997), such as that between knowledge and behaviour.

Parmenter and Wardle (1999) attempted to overcome some of the conceptualisation and measurement issues in the development of the General Nutrition Knowledge Questionnaire (GNKQ) (Parmenter & Wardle, 1999). The authors focussed heavily on the definition and comprehensive nature of the concepts included in the questionnaire and validation process.

The GNKQ was developed from a large pool of items (1201 items) covering five areas: understanding nutrition-related terminology, awareness of current dietary recommendations, knowledge of food sources related to nutrients, the use of dietary information to make dietary choices, and the awareness of diet-disease relationships. To validate the GNKQ, 900 questionnaires were distributed in the United Kingdom (UK) with a return rate of 43%. The results were analysed quantitatively to examine item difficulty, item discrimination and internal consistency, as well as qualitatively. The internal consistency of the items was measured using Cronbach's alpha, and those that did not reach statistical significance were excluded. The initial pool of items was reduced to 50 and further statistical analysis was performed. Test-retest reliability and validity were measured in a selected sample of university students – half were nutrition and dietetic students, the other half computer science students (n=168). The questionnaire showed acceptable levels of internal reliability, and importantly, it successfully differentiated the two student groups based on nutrition knowledge, therefore meeting the criterion for construct or concurrent validity. Reliability is the extent to which a test yields the same results with repeated trials (Sapp & Jensen, 1997). A two-week test-retest period was considered long enough for participants to have forgotten their original responses, but not sufficient time to see great change in nutrition knowledge. Test-retest reliabilities (correlation coefficients) were also above the identified acceptable 0.7 level (Parmenter & Wardle, 1999) (Table 1).

Table 1 Reliability and validity of the General Nutrition Knowledge Questionnaire developed by Parmenter and Wardle (1999)

Knowledge section	Internal reliability (Cronbach's alpha)	Test-retest reliability
Dietary recommendations	0.70	0.80
Sources of nutrients	0.95	0.94
Choosing everyday foods	0.76	0.87
Diet-disease relationship	0.94	0.97
Total nutrition knowledge	0.97	0.98

While the GNKQ proved to be a comprehensive and valid assessment of general nutrition knowledge in the UK community, validity should not be assumed in a sample outside the original study sample. The questionnaire was validated in a sample of final-year university students, who tend to be more educated, within a certain age bracket and not likely to represent the average population of the UK, therefore validity would need to be determined again for the general population. Validity would also need to be determined to assess the appropriateness of the tool for use in other mixed demographic community samples. In addition, there are a number of items related specifically to the UK nutrition recommendations and common food choices, which may or may not be as common in other settings, therefore estimates of validity and reliability in one population may not always be appropriate or accurate for another.

3.3 Chapter Aims

The purpose of this chapter is to report on the suitability of a modified 'Australian' version of the GNKQ – adapted from the original by Parmenter and Wardle (1999) – as a tool to measure general nutrition knowledge in an Australian community sample.

The objectives are:

1. to determine the validity of using the modified GNKQ in an Australian sample

2. to determine the reliability of the questionnaire

3. to compare results of reliability and validity measures between the original UK sample and the Australian sample.

3.4 Methods

3.4.1 Questionnaire Refinement

A number of minor adjustments were made to the original version of the questionnaire prior to administrating it to the study sample. The National Health and Medical Research Council produces the *Food for Health* booklet containing the *Dietary Guidelines for Australian Adults* and the *Australian Guide to Health Eating* (National Health and Medical Research Council, 2003). This document is based on the best available scientific evidence and provides information for both health professionals and the general population about healthy food choices. The guidelines encourage healthy eating practices that minimise the risk of the development of diet-related diseases within the Australian population (National Health and Medical Research Council, 2003). To ensure the questionnaire was consistent with the *Food for Health Booklet* and other key public health nutrition messages, three items were added to the original version of the GNKQ:

Firstly, to acknowledge that the Australian guidelines include a recommendation of dairy products, 'dairy products' as a food group was added to the section about knowledge of the recommendations in the *Dietary Guidelines for Australian Adults*.

Secondly, the original questionnaire contains one item referring to the recommended intakes of fruit and vegetables. Given the current Australian fruit and vegetable campaign – Go for 2&5® – separates out the guideline to be two serves of fruit and five serves of vegetables, this question was adjusted to be two separate items.

Lastly, an expert panel consisting of seven registered dietitians assessed the 'face' validity of the questionnaire – that is, the questions' relevance to specific situations or contexts in which they were to be administered. It was agreed that the common misperception of mushrooms as an appropriate substitute for red meat was appropriate for inclusion. This item was added to the appropriate section of the questionnaire.

The other modifications included substituting common UK food names or food items not commonly used or consumed in Australia with more familiar terminology for the Australian general public. Examples include replacing 'calories' with 'kilojoules', 'orange squash' with '35% orange juice' and 'luncheon meat' with 'lunch/sandwich meat'. The resulting self-administered questionnaire was 113 items, covering four areas of nutrition knowledge: knowledge of dietary recommendations (13 items), sources of nutrients (70 items), choosing everyday foods (10 items) and the diet-disease relationships (20 items). Appendix 2 contains a copy of the modified GNKQ and answers.

3.4.2 Measures

Nutrition knowledge

Nutrition knowledge was assessed using the modified GNKQ. For each correct response, participants scored one point, therefore the maximum knowledge score was 113.

The respondents answered on a range of different scales, such as 'more, same, less, don't know', 'yes, no, not sure', 'high, low, not sure', 'agree, disagree, not sure', or a choice of four different food options. The two items about recommended fruit and vegetable intake and the eight items about diet-disease relationships required written responses.

Demographic information

Questions sought details of gender, age, marital status, identified culture, number of children and those living at home, highest level of education, field of employment and employment status, nutrition-related qualifications, and any special diet.

3.4.3 Sample Selection

The sample consisted of community members aged 18 and over, who volunteered to participate in the study (n=156). Participants were drawn from established social or non-health-related extra curricular groups at three community facilities within the Adelaide metropolitan area (n=96). Other community members attending a public hospital community open day (n=20) in February 2006 also volunteered to complete the questionnaire. To compare how the questionnaire performed in nutrition-educated and non-nutrition-educated sample groups, an additional sample of third-year nutrition and dietetics students (n=40) were recruited from a local university. Table 2 shows a breakdown of the sample by recruitment location.

Table 2 Summary of the recruitment location of the study sample

Recruitment location		Number of participants (n)	Percentage of total sample (%)
Non-nutrition-educated	Community centres	96	61.5
	Public Hospital Open Day	20	12.8
Nutrition-educated	University students	40	25.6
Total sample		156	100.0

3.4.4 Data Collection

The study was approved by the Flinders University Social and Behavioural Research Ethics Committee. The participants from all the recruitment sites volunteered to complete the questionnaire and gave informed consent. The questionnaire was self-administered in small groups and supervised by the researcher. Participants were strongly encouraged to complete the questionnaire on their own without discussion with their peers. On completion, all participants received a copy of the answers. Provision of the answers usually stimulated group discussions, and any questions were answered by the researcher (a registered dietitian).

3.4.5 Data Management

The raw data from each participant's responses were coded numerically and converted to a corrected score, as defined by Parmenter and Wardle (Parmenter & Wardle, 1999). The questions within each section were totalled to give a knowledge section score, and all the sections totalled to give an overall nutrition knowledge score. Data was entered and analysed using Statistical Package for Social Sciences (SPSS) 14.0 (SPSS for Windows 14.0 Chicago: SPSS Inc.).

3.4.6 Statistical Analysis

Internal reliability

Internal reliability refers to the extent to which the questionnaire is consistent within itself – that is, how consistently the questions within each section measure the knowledge construct and overall nutrition knowledge. The

Cronbach's alpha coefficient indicated the consistency of responses to all items in the questionnaire (Anastasi & Urbina, 1997). Cronbach's alpha coefficient ranges from 0 to 1, and a score of 0.7 or more is generally acceptable (Hair, Anderson, Tatham, & Black, 1998).

Test-retest reliability

Test-retest reliability refers to a common method to determine reliability of a questionnaire that is to repeat the identical test on two separate sessions (Time 1 and Time 2). The reliability coefficient is the correlation between the scores obtained by the same person on the two administrations of the test (Anastasi & Urbina, 1997).

In this study, a sub-sample completed the questionnaire on two separate occasions, two weeks apart. This sub-sample (n=57) comprised nutrition-educated persons (n=33) and non-nutrition-educated persons (n=24). These scores were compared and the Pearson Product-Moment correlation coefficient (r) was used as an indicator of consistency. The correlation coefficients range from 0 to 1, and a high score indicates a more reliable scale. A high test-retest value is considered to be 0.7 or more (de Vaus, 1987).

Dates of birth and individuals' initials were used as a code to match the two completed questionnaires. Amongst this sub-sample, copies of the answers were only provided on completion of the second administration.

Concurrent validity

Concurrent validity refers to whether a scale which purports to measure nutrition knowledge actually does measure nutrition knowledge. If the GNKQ is an accurate measure of nutrition knowledge, then people with a known higher level of nutrition education should score better on the questionnaire than those without previous nutrition education. T-tests were used to assess whether the group of third-year university 'nutrition-educated' students had significantly higher levels of knowledge than those without education experience, the 'non-nutrition-educated' group (significance level $p<0.01$).

3.5 Results

3.5.1 Description of the Sample

Of the 156 people who participated, the majority (90%) were female, and their ages ranged from 18 to 74. Most were married or living as married and reported to be Australian. A detailed breakdown of the nutrition-educated, non-nutrition-educated, and the whole group is presented in Table 3.

Being university students, the nutrition-educated sample was younger than the non-nutrition educated sample, and as a result had a higher proportion of single persons with no children.

Table 3 Demographic characteristics of the study sample

Characteristics	Nutrition-educated sample (n=40)		Non-nutrition-educated sample (n=116)		Total sample (n=156)	
	n	(%)	n	(%)	n	(%)
Gender						
Female	38	(95.0)	103	(88.8)	141	(90.4)
Male	2	(5.0)	13	(11.2)	15	(9.6)
Age						
18-24	29	(72.5)	7	(6.0)	36	(23.1)
25-34	9	(22.5)	29	(25.0)	38	(24.4)
35-44	2	(5.0)	29	(25.0)	31	(19.9)
45-54	0	(0.0)	19	(16.4)	19	(12.2)
55-64	0	(0.0)	22	(19.0)	22	(14.1)
65-74	0	(0.0)	10	(8.6)	10	(6.4)
Marital status						
Single	30	(75.0)	14	(12.1)	44	(28.2)
Married/living as married	10	(25.0)	91	(78.5)	101	(64.7)
Separated/divorced/ widowed	0	(0.0)	11	(9.5)	11	(7.0)
Culture						
Australian	19	(47.5)	95	(81.9)	114	(73.0)
British/English/ Scottish/Welsh	0	0.0	8	(6.9)	8	(5.1)
Chinese	13	(32.5)	0	(0.0)	13	(8.3)
Australian and British	3	(7.5)	8	(6.9)	11	(7.1)
Other	5	(12.5)	5	(4.4)	10	(6.2)
Number of children						
0	38	(95.0)	19	(16.4)	57	(36.5)
1	2	(5.0)	27	(23.3)	29	(18.6)
2	0	(0.0)	42	(36.2)	42	(26.9)
3	0	(0.0)	23	(19.8)	23	(14.7)
4+	0	(0.0)	5	(4.3)	5	(3.2)
Education level						
Some high school or less	0	(0.0)	15	(13.0)	15	(9.6)
Completed high school	13	(32.5)	29	(25.0)	42	(26.9)
Tech or trade qualification	5	(12.5)	16	(13.8)	21	(13.5)
Tertiary degree	22	(55.0)	56	(48.3)	78	(50.0)
Primary employment status						
Employed full-time	1	(2.5)	26	(22.4)	27	(17.3)
Employed part-time	1	(2.5)	41	(35.3)	42	(26.9)
Student	37	(92.5)	2	(1.7)	39	(25.0)
Homemaker	0	(0.0)	29	(25.0)	29	(18.6)
Other	1	(2.5)	18	(15.4)	19	(12.2)

3.5.2 Distribution of Scored Data

The nutrition knowledge scores ranged from 21 to 100 (out of a maximum 113) in the non-nutrition-educated community group and 41 to 100 in the nutrition-educated student group (hence there was no ceiling effect of the scale). The scores for knowledge of diet-disease relationships tended to be lower than those for the other sections.

A histogram of knowledge scores would show a slight shift to the right (higher scores), as generally few people had 'zero' or no understanding about food and nutrition.

The maximum scores for the groups were similar across most of the knowledge sections, but the minimum scores tended to be higher in the nutrition-educated sample compared with the community group. The mean nutrition knowledge score for the nutrition-educated group was 12 points higher than the community groups (Table 4).

Table 4 Mean and range of correct scores obtained from the two sample groups

Knowledge components (number of items)	Nutrition-educated sample (n=40)				Non-nutrition-educated sample (n=116)				Total sample (n=156)	
	Min	Max	Mean	SD	Min	Max	Mean	SD	Mean	SD
Dietary recommendations (13)	2	12	10.12	1.95	4	12	8.89	1.56	9.21	1.75
Sources of nutrients (70)	23	66	54.27	9.32	15	67	47.45	9.22	48.20	9.69
Choosing everyday foods (10)	3	10	7.62	1.55	1	10	6.66	1.97	6.91	1.91
Diet-disease relationships (20)	5	17	12.70	2.66	0	16	9.42	2.95	10.26	3.21
Nutrition knowledge score (113)	41	100	84.72	13.11	21	100	72.42	13.51	75.58	14.41

3.5.3 Internal Reliability

The Cronbach's alpha coefficient for the whole scale and each of the knowledge components are presented in Table 5. The Cronbach's alpha coefficient were lowest for the 'dietary recommendations' and 'choosing everyday foods' sections and highest for the 'sources of nutrients' section. The internal reliability for the whole scale was 0.92.

Table 5 Internal reliability for the four knowledge components and the modified questionnaire overall

Knowledge components (number of items)	Cronbach's alpha coefficient
Dietary recommendations (13)	0.53
Sources of nutrients (70)	0.88
Choosing everyday foods (10)	0.56
Diet-disease relationships (20)	0.73
Nutrition knowledge score (113)	0.92

3.5.4 Test-retest Reliability

The Pearson Product-Moment correlation coefficient was used to assess test-retest reliability of the responses from groups on the two administration occasions. Table 6 presents the mean scores for the knowledge sections on Time 1 and Time 2. There were no significant differences between the two means scores for all knowledge sections, except in the nutrition-educated student group for the 'sources of nutrients' section. The mean score of Time 1 was 53.36, which was significantly lower than the mean score at Time 2, 55.39 ($p<0.05$).

Table 6 Mean scores for the sample at the two occasions of test-retest administration

Knowledge components (number of items)	Nutrition-educated sample (n=33) Mean score			Non-nutrition-educated sample (n=24) Mean score			Overall sample (n=57) Mean score		
	Time 1	Time 2	P value	Time 1	Time 2	P value	Time 1	Time 2	P value
Dietary recommendations (13)	10.15	10.70	0.10	9.67	9.25	0.19	9.95	10.09	0.55
Sources of nutrients (70)	53.36	55.39	0.02*	52.17	51.58	0.57	52.86	53.79	0.16
Choosing everyday foods (10)	7.58	7.58	1.00	7.33	7.33	1.00	7.47	7.47	1.00
Diet-disease relationships (20)	12.82	12.48	0.33	10.75	10.79	0.92	11.95	11.77	0.51
Nutrition knowledge score (113)	83.90	86.15	0.05	79.92	78.96	0.47	82.23	83.12	0.30

*Statistically significant difference between Time 1 and Time 2

Table 7 presents the Pearson Product-Moment correlation coefficients for the sub-groups of each knowledge section. The correlation coefficients ranged from 0.43 to 0.87 for the nutrition-educated student group and 0.21-0.84 for the non-nutrition-educated community group. The lowest values were seen for the 'dietary recommendations' section (r=0.37), and the highest for the 'sources of nutrients' section (r=0.85). The overall test-retest reliability coefficient for the questionnaire was 0.87.

Table 7 Test-retest reliability coefficients for the study sample

Knowledge components (number of items)	Pearson Product-Moment correlation coefficient					
	Nutrition-educated sample (n=33)		Non-nutrition-educated sample (n=24)		Overall sample (n=57)	
	r	P value	r	P value	r	P value
Dietary recommendations (13)	0.43	0.01	0.21	0.33	0.37	0.00
Sources of nutrients (70)	0.87	0.00	0.84	0.00	0.85	0.00
Choosing everyday foods (10)	0.80	0.00	0.72	0.00	0.75	0.00
Diet-disease relationships (20)	0.73	0.00	0.69	0.00	0.74	0.00
Nutrition knowledge score (113)	0.88	0.00	0.86	0.00	0.87	0.00

3.5.5 Concurrent Validity

The nutrition-educated student group scored consistently higher than the non-nutrition-educated community group on all knowledge sections of the nutrition awareness questionnaire (Table 8). The difference between the groups for mean nutrition knowledge score was 12 points. The differences between the scores of the two groups on each of the knowledge components and in the overall knowledge score were statistically significant ($p<0.05$).

Table 8 Mean scores, standard deviation and standard error of the mean of the nutrition and non-nutrition educated groups

Knowledge components (number of items)	Nutrition-educated sample (n=40)			Non-nutrition-educated sample (n=116)				
	Mean	SD	SEM	Mean	SD	SEM	Mean difference	P value
Dietary recommendations (13)	10.12	1.95	0.31	8.89	1.56	0.14	1.24	0.00
Sources of nutrients (70)	54.27	9.32	1.47	47.45	9.22	0.86	6.83	0.00
Choosing everyday foods (10)	7.62	1.55	0.24	6.66	1.97	0.18	0.96	0.01
Diet-disease relationships (20)	12.70	2.66	0.42	9.42	2.95	0.27	3.28	0.00
Nutrition knowledge score (113)	84.72	13.11	2.07	72.42	13.51	1.25	12.30	0.00

3.5.6 Comparison between the Original Questionnaire and the Australian Sample

Table 9 shows the internal reliability and test-retest reliability measures from the original sample used in the validation study by Parmenter and Wardle (1999) and the validation exercise in this study sample. The sample sizes were relatively similar – 168 for the UK study and 156 for this study. Despite the differences across each knowledge component, the Cronbach's alpha coefficients for the overall nutrition knowledge score were considered high – 0.97 for the UK study and 0.92 for this Australian sample. In the Australian and

UK studies, the 'dietary recommendations' and 'choosing everyday foods' knowledge sections had the lowest reliabilities.

The test-retest correlation coefficients for the Australian sample were lower overall than for the original UK sample. The biggest difference was seen in the coefficient of the 'dietary recommendations' component where the coefficient value for the UK sample was 0.8, and 0.37 for the Australian sample. The correlation coefficients were considered to be high for all other sections for both the Australian and UK studies. The test-retest reliability coefficient for the questionnaire for the Australian sample was 0.87, compared to 0.98 for the original UK sample.

Table 9 Comparison of the internal reliability and test-retest reliability measures in the original Parmenter and Wardle (1999) sample and the current study sample

Knowledge components (number of items)	UK study sample (n=168) Parmenter and Wardle (1999)		Australian sample (n=156) Current study (2006)	
	Internal reliability	Correlation coefficient	Internal reliability	Correlation coefficient
Dietary recommendations	0.70	0.80	0.525	0.367
Sources of nutrients	0.95	0.94	0.880	0.853
Choosing everyday foods	0.76	0.87	0.556	0.752
Diet-disease relationships	0.94	0.97	0.731	0.740
Nutrition knowledge score	0.97	0.98	0.917	0.866

3.6 Discussion

The aim of this study was to assess the validity and reliability of a modified nutrition knowledge questionnaire for use in an Australian setting.

The range of scores suggests that individuals vary substantially along the nutrition knowledge continuum. Following the analysis of data, the group known to have the most training and exposure to nutrition information (the nutrition and dietetic students) had the higher mean scores, demonstrating that the modified GNKQ has the ability to distinguish between sample groups with different levels of nutrition knowledge. The present study recruited individuals studying to be nutrition educators, and still clear differences were found between this group and those hypothesised to have a lower knowledge level. Given these initial findings, using this questionnaire may identify groups with even greater nutrition knowledge than third-year nutrition students; for example, qualified dietitians, or conversely, those with very little nutrition understanding. The questionnaire's ability to differentiate between groups of different knowledge is important for use in the future.

The reliability of the final instrument was high overall, however, it lacked consistency in some of the knowledge sections. The internal reliability measure was highest for the 'sources of nutrients' section, which had 70 items. Theoretically, reliability coefficients increase as the number of items increase (Ferguson & Takane, 1989) and, accordingly the coefficient for the overall knowledge score (113 items) was high. The 'dietary recommendations' and 'choosing everyday foods' sections had values below the suggested level for accepting reliability. These lower scores were also observed in the original validation study conducted by Parmenter and Wardle (1999). Despite this variation, the overall internal reliability of the questionnaire remains high.

The overall test-retest coefficients for the nutrition knowledge score for both groups, as well as the sample as a whole, were high, which indicated the questionnaire measures nutrition knowledge consistently over time from one testing occasion to another. The nutrition-educated student group did improve their score by two points in the 'sources of nutrients' section of the questionnaire. The students were in the middle of semester and actively learning, so it is possible their knowledge of this specific area did increased in the two-week period. It could also be argued that some students with an assumed interest in nutrition may have searched for answers of the questions that challenged them on the first administration, therefore performing slightly better on the second administration. This improvement in one knowledge section did not significantly influence the overall test-retest reliabilities – they remained high.

The internal reliability and validity measures reported in the original GNKQ paper were generally higher than those reported for this mixed demographic Australian sample. The UK sample was more homogeneous in nature, made up of younger, more educated individuals attending university, which may partially explain the stronger statistical results.

Participants had a limited understanding of the 'diet-disease relationships', and this was shown consistently over time, in the retest sub-sample, indicating that the GNKQ was measuring poor scores consistently for this section. This was not the case for the results of the section about 'dietary recommendations' – they were consistently weakest. The test-retest correlation coefficient was noticeably lowest for this section, and the internal reliability was also weak. The original questionnaire was validated in 1999, arguably prior to the low carbohydrate, high protein diet trend. Since then, media coverage of this trend has peaked and, consequently, this dietary information may be foremost in the public's mind. It is possible the weaker results in this area are a reflection of the confusion created by such media attention. Compared to new diet fashions, the information contained in the *Dietary Guidelines for Australians Adults* has not received widespread publicity, and its content may have been overshadowed by the more recent publicised dietary fads. This existing public uncertainty may partially explain the lower test-retest coefficients and weaker statistical results in general.

There are a few limitations of this research, mainly regarding the sample selection. The sample was based on convenience and not chosen primarily to represent the South Australian or Australian community as a whole. As a result of the nature of the community groups that the sample was selected from, the majority of the sample was female.

The sub-sample used for the test-retest reliability measures in this study was smaller than that of the original study – 57 people compared to 105 respectively. Parmenter and Wardle's sub-sample comprised university students who were thought to be more familiar with a testing environment than community members. These factors may partially explain their stronger retest correlation coefficients.

A positive aspect of the majority of this sample being female is that a potential confounding variable, gender, was controlled. The proportion of females in the student and community samples were relatively similar, therefore comparisons could be made between groups without controlling for gender. Furthermore, women are still considered to be the 'gatekeepers' of household food supply, and therefore are important in any food-related study. Clearly future studies involving men and women are still important. The sample was also over-representative of people with a tertiary education – 50% compared to 20% nationally (Australian Bureau of Statistics, 2005). Further work needs to be conducted to investigate the influence of socioeconomic status on nutrition knowledge in an Australian population.

Despite these sampling limitations, the one overriding benefit of this sample – and one of the major objectives in repeating this validation process – is that this validation process involved community members. Lower test-retest reliability among community group individuals may suggest that they are less familiar with testing situations, and this is more likely to reflect reliability in the wider community. As mentioned earlier, the sample used by Parmenter and Wardle (1999) was homogeneous in nature, in that it consisted of university students, and this was one of the primary barriers identified in assuming the validity of their questionnaire for use in a community sample.

Despite being a relatively long questionnaire (113 items), the majority of participants were able to complete it within 15 minutes. Ideally, a questionnaire should be valid, reliable and of a low burden to the participants, however, this can prove difficult in a complex domain such as nutrition. In this study, the knowledge questionnaire was the only questionnaire administered, however, if it was to be used in conjunction with a number of other tools, then further work may be required to reduce the number of items in the questionnaire, while maintaining the questionnaire's validity and reliability. Future work could reduce the overall number of items by factor analysis, or –

depending on the research question – sub-scales (eg 'diet-disease relationships') could be used.

3.7 Conclusion

Acknowledging the sampling limitations and reviewing the results of this validation exercise, the GNKQ, developed by Parmenter and Wardle and modified for use in Australia, is valid and reliable for use in a community sample and in groups with more advanced nutrition knowledge. This questionnaire is a useful tool for the comprehensive assessment of general nutrition knowledge, and differentiates between groups of different knowledge levels.

To have confidence in the validity of the measures will allow Australian researchers to have confidence to examine nutrition knowledge and its relationship with dietary behaviour (Axelson & Brinberg, 1992). This questionnaire will be used to describe the nutrition knowledge levels in a community group, and then explore the relationships between knowledge and dietary intake behaviour. It will also be used as part of the family environment study to measure parents' nutrition knowledge, as parents' knowledge has been identified as a possible predictor of children's obesity risk.

The following chapter will describe the nutrition knowledge levels in the South Australian community, using this modified GNKQ as the measure of nutrition knowledge.

4 EXPLORING NUTRITION KNOWLEDGE AND THE DEMOGRAPHIC VARIATION IN KNOWLEDGE LEVELS IN A SOUTH AUSTRALIAN COMMUNITY SAMPLE

4.1 Introduction

Knowledge is an integral part of some psychosocial theories and its influence on behaviour is one of the underlying assumptions of nutrition education. Although, as discussed in the previous chapter, measuring knowledge is complex, and a 'true' understanding of nutrition knowledge levels in the community is difficult to ascertain. This chapter will use the modified General Nutrition Knowledge Questionnaire (GNKQ) (Appendix 2), which covers a broad range of nutrition constructs, to describe nutrition knowledge within a South Australian community sample[2].

4.2 Background Literature

Social cognitive theory (SCT) is a commonly used framework for understanding health behaviour (Sallis, Patrick et al., 2000). The SCT incorporates personal, behavioural and environmental influences which can be used to explain how people acquire and maintain health behaviour habits. Knowledge is one of the personal factors which is considered a prerequisite for behaviour change (Bandura, 1998). Within social cognitive models, the relationship between knowledge and behaviour is logical, however strong scientific evidence is lacking (Axelson & Brinberg, 1992).

Despite inconsistent support, nutrition educators still consider knowledge to be a worthy mediator of food intake behaviour. An underlying assumption of nutrition education is that increasing knowledge or changing a person's beliefs about food and nutrition will result in a related behaviour change (Axelson &

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[2] Part of this chapter has been published in Public Health Nutrition, 2008; 11(12); 1365-1371. A copy of the article is included in Appendix 3.

Brinberg, 1992). Public health media campaigns provide some evidence that knowledge can be an effective means to behaviour change.

Australian Government departments and affiliated organisations have been providing nutrition advice to the Australian community for more than 75 years. The National Health and Medical Research Council has developed and distributed dietary advice in the form of the document titled *Dietary Guidelines for Australian Adults* (National Health and Medical Research Council, 2003). This document aims to "promote the potential benefits of healthy eating, not only to reduce the risk of diet-related disease, but also to improve the community's health and wellbeing" (National Health and Medical Research Council, 2003). Important questions of how this information is disseminated into the community – its direct influence on community knowledge, beliefs and attitudes to healthy eating, and ultimately its impact on dietary behaviour – are largely unknown. This is because this type of information has not been consistently captured in Australia.

The National Heart Foundation has been disseminating information about heart disease throughout the Australian community since the late 1950s (Coveney, 2006) in what is probably the most enduring nutrition message – fat and its relationship with heart disease and weight control (Parmenter, Waller, & Wardle, 2000). There is some evidence to suggest the messages from the National Heart Foundation nutrition education programs have been effective. In a randomly selected national community survey conducted in 1990 (n=916), two-thirds of the respondents were able to associate fat with an increased risk of heart disease, and 45% linked sodium intake with hypertension (Crawford & Baghurst, 1990). While a direct link cannot be assumed, this does provide some evidence that public nutrition education programs in Australia are reaching the public, however, there is still room for improvement. In terms of the direct impact these public health programs have on behaviour change, there is very little Australian evidence available. Crawford and Baghurst (1990) reported that about half the respondents felt they had reduced their fat intake, and an additional 35% had tried to reduce it but failed. About half the sample had also tried to reduce their sodium intake. Again, this dietary behaviour change cannot be directly attributed to a specific public health message or campaign, but still, positive dietary changes were reported by a proportion of the sample (Crawford & Baghurst, 1990).

A more recent public nutrition education program in Australia was the Western Australian Department of Health's Go for 2&5® campaign (2002-2005) (Pollard et al., 2008). This multi-strategy fruit and vegetable campaign included media advertising and, importantly, ongoing process evaluation. The simple nutrition message was well received by the community with about 90% of people able to recall the recommendation for fruit and 47% for vegetables 12 months after the campaign. With a discrete outcome measure (fruit and vegetable consumption), the effectiveness of the campaign in influencing behaviour could be measured. There was a population net increase of 0.8 in the mean number of servings of fruit and vegetables per day during the three-year campaign period (Pollard et al., 2008). Following this success, the campaign was rolled out nationally with a similar positive influence on behaviour change (Woolcott Research Pty Ltd, 2007).

The Go for 2&5 campaign is one of the few Australian examples of a public health program where the social marketing and dissemination has been carefully planned and implemented, and the effectiveness – in terms of awareness and behaviour change – has been monitored and evaluated.

The Health Education Monitoring Survey (HEMS) is a survey conducted in England, which aims to monitor trends in health-related knowledge, attitudes and behaviours. The 1996 survey included more than 4600 adults living in England, and asked questions over a range of health-related topics, such as smoking, drugs, nutrition and physical activity. From the reported nutrition findings, it was apparent that people broadly understood what constituted a healthy diet, but only 16% met the health promotion indicator which expected one to be "able to state correctly three of the following ways to achieving a healthier diet – eat less fat, eat more fruit, vegetables and salad, eat more starchy carbohydrate (potatoes, pasta or rice), and eat more fibre" (Hansbro, Bridgwood, Morgan, & Hickman, 1997).

In the United States (US), a study by Keenan and colleagues examined community awareness around the *Dietary Guidelines for Americans* (Keenan, AbuSabha, & Robinson, 2002). It was reported that the guidelines about fruit, vegetables and fat were mostly recognised, but more than half the sample was unaware that the *Dietary Guidelines for Americans* document existed. The authors reported concern that "only one in 400 respondents correctly identified the *Dietary Guidelines for Americans* as the US Government's nutrition policy document", and most people sourced their nutrition information from mass media outlets, such as television and newspapers (Keenan et al., 2002). It should be noted that the data collection for this study was completed within six months of the release of the 1995 edition of the guidelines, and therefore may not have allowed enough time to influence public awareness. Regardless, this study together with the survey data from England provides useful evidence of the progress, or lack thereof, in the dissemination of government health recommendations to the general public. Further work is required to provide insight into community understanding of nutrition education material.

4.2.1 Demographic Variation in Nutrition Knowledge

There are known demographic differences in nutrition knowledge. For example, females have been shown to have greater nutrition knowledge than males (Crawford & Baghurst, 1990; Hansbro et al., 1997; Parmenter et al., 2000; Sapp & Jensen, 1997; Variyam, Blaylock, & Smallwood, 1996). Nutrition knowledge has been shown to increase with age (Sapp & Jensen, 1997), possibly peaking in the 'middle ages' (Frank, Winkleby, Fortmann, & Farquhar, 1993; Levy, Fein, & Stephenson, 1993), and increase with level of formal education (Cotugna, Subar, Heimendinger, & Kahle, 1992; Frank et al., 1993; Levy et al., 1993; Sapp & Jensen, 1997; Variyam et al., 1996). There is some evidence to support the relationship between nutrition knowledge and socioeconomic status (SES), whereby populations with a higher SES have increased levels of nutrition knowledge (Hansbro et al., 1997; Parmenter et al., 2000; Sapp & Jensen, 1997).

People bring subjective knowledge and well-formed attitudes to food and nutrition related behaviours. Understanding these attitudes and knowledge, and the influence of nutrition knowledge within the community, is critical in developing dietary behaviour change strategies. With these considerations in mind, an assessment of nutrition knowledge was conducted in the community.

4.3 Chapter Aims

The aim of this chapter is to explore community nutrition knowledge in detail, by examining the levels of general nutrition knowledge within a South Australian community sample, using an instrument of known validity and reliability.

The objectives are:

1. to describe the level of understanding in four areas of nutrition knowledge – knowledge of dietary recommendations, sources of nutrients, choosing everyday foods and known diet-disease relationships

2. to explore the demographic variation in the levels of nutrition knowledge

3. to determine whether SES has a significant influence on nutrition knowledge level in an Australian setting.

4.4 Methods

4.4.1 Measures

Nutrition knowledge

Nutrition knowledge was measured using the modified 113-item GNKQ (Appendix 2) discussed in detail in the previous chapter.

Demographic information

Questions sought details of gender, age, marital status, identified culture, number of children and those living at home, highest level of education, field of employment and employment status, nutrition-related qualifications and any special diet.

4.4.2 Sample Selection

SES is thought to be a predictor of nutrition knowledge, therefore the objective of recruitment was to establish a sample from two areas of differing SES. In the validation study presented in Chapter 3, 96 adults were recruited from one local government council area of middle SES in the Adelaide metropolitan region (Area A).

A second sample of adults (n=105) was recruited from a community facility in a local government council area known to be of a lower SES (Area B). These adults were attending the community facility on a regular basis and were invited to participate in the study. Participation was voluntary with no incentive provided.

4.4.3 Demographic Information of the Sampling Areas

The Australian Bureau of Statistics (ABS) has developed indices to allow ranking of areas to reflect social and economic wellbeing. The Socio-Economic Index for Areas (SEIFA) consists of four indexes that summarise information about the economic and social resources of people within an area. The Index of Relative Socio-Economic Disadvantage (IRSD) was used in this study and includes attributes such as income, educational attainment and unemployment. A low index value reflects relative disadvantage and a high value reflects a lack of disadvantage in an area (Australian Bureau of Statistics, 2004).

Area A is ranked eighth out of 19 areas in the Adelaide Statistical Division (IRSD=1005.84) and Area B is ranked the lowest of all local government areas in the Adelaide Statistical Division (IRSD=873.92).

The 2006 ABS Census of Population and Housing (Australian Bureau of Statistics, 2007) revealed a number of notable demographic differences between the two council areas, some of which were reflected in the IRSD. In Area A (the 'middle SES' area), the median age was 40 and the median weekly household income was $872, compared to Area B (the 'low SES' area) where the median age was 34 and the median weekly household income was $719. The median values for Adelaide as a whole are 38 years and $914 per week respectively. In Area B, half the population is under 35 years.

Furthermore, in Area A, 42% of the population (aged 15 or older) have finished Year 12 schooling or equivalent and 11% have a Bachelor Degree, compared to 27% and 3% respectively in Area B. The unemployment rate in Area B (8.5%) is higher than Area A (5.1%). The average unemployed rate for Adelaide is estimated to be 5.3% of the population aged 15 or older (Australian Bureau of Statistics, 2007). Therefore, in all SES respects, differences exist between population areas A and B.

4.4.4 Data Collection

The study was approved by the Flinders University Social and Behavioural Research Ethics Committee. Participants from both recruitment areas volunteered to complete the questionnaire and gave informed consent. The questionnaire was administered and the data managed as detailed in the validation study (Chapter 3, section 3.4.5).

4.4.5 Statistical Analysis

Knowledge sub-scores and an overall nutrition knowledge score were calculated. Descriptive statistics were used to analyse the demographic information. Univariate analysis was used to examine the effect of demographic characteristics on nutrition knowledge levels, and simultaneous multiple regression analyses were used to explain the variance in nutrition knowledge levels within the sample. Data was entered and analysed using Statistical Package for Social Sciences (SPSS) 14.0 (SPSS for Windows 14.0 Chicago: SPSS Inc.)

4.5 Results

4.5.1 Description of the Sample

The total sample comprised 201 adults (aged 18 or older); the majority were female (85.1%) and identified themselves as Australian (77.6%). There was a relatively even distribution across the age group categories. The sub-sample from the low SES area (Area B) had the greatest representation in the 18-24 year age group, whereas Area A had the fewest people in this age group. There were some differences in the distributions between the two areas for age, marital status, education level and employment status. A detailed breakdown of the sample by area can be seen in Table 10.

Table 10 Demographic characteristics of the study sample

Characteristics	Low SES (n=105)		Middle SES (n=96)		Total sample (n=201)	
	n	(%)	n	(%)	n	(%)
Gender						
Female	84	80.0	87	90.6	171	85.1
Male	21	20.0	9	9.4	30	14.9
Age						
18-24	38	36.2	4	4.2	42	20.9
25-34	14	13.3	26	27.1	40	19.9
35-44	10	9.5	22	22.9	32	15.9
45-54	22	21.0	15	15.6	37	18.4
55-64	16	15.2	20	20.8	36	17.9
65+	5	4.8	9	9.4	14	7.0
Marital status						
Single	46	43.8	7	7.3	53	26.4
Married/living as married	45	42.9	81	84.4	126	62.6
Separated/divorced/ widowed	14	13.4	8	8.4	22	11.0
Culture						
Australian	77	73.3	79	82.3	156	77.6
British/English/ Scottish/Welsh	10	9.5	6	6.3	16	8.0
Australian and British	5	4.8	6	6.3	11	5.5
Other	13	12.4	5	5.2	18	8.9
Number of children						
0	29	27.6	10	10.4	39	19.4
1	26	24.8	24	25.0	50	24.9
2	24	22.9	37	38.5	61	30.3
3	14	13.3	20	20.8	34	16.9
4+	12	11.5	5	5.2	17	8.5
Education level						
Some high school or less	53	51.0	14	14.5	67	33.5
Completed high school	23	22.1	22	22.9	45	22.5
Tech or trade qualification	11	10.6	14	14.6	25	12.5
Tertiary degree	17	16.3	46	47.9	63	31.5
Primary employment status						
Employed full-time	10	9.6	16	16.8	26	13.1
Employed part-time	15	14.4	36	37.9	51	25.6
Student	34	32.7	1	1.1	35	17.6
Homemaker	19	18.3	28	29.5	47	23.6
Other	27	25.7	15	15.6	42	20.9

4.5.2 Detailed Examination of Nutrition Knowledge

Awareness of current dietary recommendations

This part of the questionnaire assessed knowledge of the Australian dietary guidelines and other public health nutrition messages. The mean score was 8.89 (SD=1.94) out of a maximum 13 points (Table 13). The basic nutrition messages about eating more fruit and vegetables and less sugary, fatty and salty foods were understood by the majority of the community, with 90% or more of respondents aware of the correct recommendations. There was also a high understanding (85%) of the recommendation to eat more fibre. There was some confusion about the detailed recommendations for lean meat, high complex carbohydrate foods and low-fat dairy products. For example, 96% of the respondents were unaware of the recommendation to consume more complex carbohydrate foods, and about three-quarters were not aware of the advice to eat less meat. On the other hand, most people knew to cut down on saturated fat (79%) and consume low-fat dairy products (69%). Regarding the current recommendations of consuming two servings of fruit and five servings of vegetables per day, 56% and 62% of the respondents, respectively, were aware of these recommendations.

Knowledge of food sources of nutrients

There was a maximum score of 70 in this section, and the mean in this sample was 43.23 (SD=12.73) (Table 13). It was evident there was some confusion as to what food groups provide certain nutrients. People were best able to identify food sources high or low in added sugar, salt and protein, and less able to identify foods high or low in fat, saturated fat and fibre. Respondents also found it difficult to identify healthy alternatives to red meat and foods high in carbohydrates. Despite the general confusion about foods high in carbohydrates, 75% of respondents identified from a list of bread types that wholegrain bread contained the most vitamins and minerals.

A number of specific questions about food sources of nutrients were poorly answered. Seventy-five percent of people were unaware that fat is the most energy dense macronutrient. About two-thirds of the sample failed to recognise that butter and margarine are similar in energy, dairy products are a source of saturated fat, and olive oil is a source of monounsaturated fat. More than half the sample (54%) incorrectly believed that brown sugar was a healthier alternative to white sugar.

Making everyday food choices

This section, identifying a healthy food choice, had a mean score of 6.03 (SD=2.13) out of a possible 10 (Table 13). Respondents were best able to select a low-sugar option from a list of four snack food alternatives, and least able to select a lower fat cheese from a list of four. There was uncertainty in two questions referring to mixed meal proportions of carbohydrates and protein. For example, one question refers to the healthiness of two thick slices of bread and a thin slice of cheese compared to two thin slices of bread and a thick slice of cheese – 59% of people answered correctly, choosing the thicker slices of bread. For a similar question with pasta and meat sauce, 65% of people answered correctly, choosing more pasta and less meat.

The listed food choices appeared to affect the responses. Most respondents (73%) were familiar with baked beans on toast as a high-fibre meal, however, less than half (48%) believed sultanas were a high-fibre snack. About 40% of people did not recognise that thick-cut chips were a healthier choice than crinkle or thin-cut chips, and a similar proportion did not recognise a baked apple as a healthy dessert option.

Diet-disease relationships

The section about known diet-disease relationships was the most poorly understood of the four sections with a mean score of 7.79 (SD=3.47) out of a possible 20 (Table 13). Respondents were most familiar with the relationship between the amount of fat in the diet and disease – more than 80% were aware of this relationship. Three-quarters reported that this relationship was with heart disease or obesity, but only one-quarter knew it was with both heart disease and obesity. Similarly, more than 80% of people were aware of a relationship between the amount of sugar in the diet and disease, but almost all believed that too much sugar directly increases the risk of diabetes.

Approximately two-thirds of the sample acknowledged a relationship between the intake of fruit and vegetables, fibre and sodium and disease, however, knowledge of specific diseases was poorly understood. For fruit and vegetables, the most commonly mentioned diseases were bowel disease and scurvy. Many people reported sodium intake to be related to heart disease in general, but only 24% mentioned elevated blood pressure specifically.

About seven out of 10 people (69%) correctly associated eating more fruit and vegetables and more fibre with a reduced risk of cancer, but the same proportion also believed eating less preservatives and additives would also reduce the risk of cancer. Seventy-two percent of respondents correctly identified a diet lower in saturated fat and salt and higher in fruit and vegetables as being protective against heart disease, but two-thirds also thought more fibre and fewer preservatives was protective.

Almost 70% of the respondents had heard of the term 'antioxidant vitamins', but most were unsure which vitamins were classified as antioxidants. When asked to identify which vitamins had antioxidant properties from a list, less than one-third gave the correct answer on any one vitamin, and only 14% correctly identified vitamins A, C and E as antioxidants.

4.5.3 Demographic Variation in Nutrition Knowledge

Using univariate analysis techniques, it is clear that there is demographic variation in nutrition knowledge levels. It appears that females have a higher knowledge level than males (Table 11). An independent samples t-test was conducted to test for significance in the observed differences, and results showed that this difference between females ($\mu=67.02$, sem=1.34) and males was significant ($\mu=59.77$, sem=3.42; $t(199)=-2.071$, $p<0.05$).

Nutrition knowledge appears to generally increase with age, peaking in the 45 to 64 year age group, and found to be lower in older age groups. The stepwise increase in knowledge with age was investigated using the Pearson Product-Moment correlation coefficient. The correlation coefficient was positive and of moderate strength ($r=0.413$; $p<0.01$). One-way between groups analysis of variance was conducted to explore the differences between the age groups.

There was a statistically significant difference between the age groups [$F(5,195)=11.14$; $p<0.001$] with post-hoc analysis, using Tukey HSD, revealing this difference was only significant between the youngest group (18-24 years) and the rest of the sample – that is, the youngest age group had significantly lower knowledge levels than older community members (Table 11).

Marital status had a significant influence on nutrition knowledge levels. Respondents who reported to be married ($\mu=69.30$, sem=1.39) had a significantly higher level of knowledge than single persons ($\mu=56.57$, sem=2.33; $t(199)=-4.68$; $p<0.001$). The difference between respondents who identified themselves as Australian ($\mu=66.27$, sem=1.33) and those who did not ($\mu=64.32$, sem=3.63; $t(1999)=0.58$, $p>0.05$) was not significant. The number of children in the family also had some influence on nutrition knowledge, however these differences were only significant between adults with none or one child and those with more [$F(3,197) = 5.901$, $P<0.01$] (Table 11).

Nutrition knowledge appeared to increase with the level of formal education. There was a significant association between level of education and knowledge ($r=0.452$, $p<0.01$). For this analysis, subjects were divided into three groups of approximately equal size, based on formal education levels (Group 1: completed some high school or less, Group 2: completed high school or a tech or trade qualification, Group 3: tertiary degree), and one-way between groups' analysis of variance was conducted. There were statistically significant differences ($p<0.001$) between the knowledge of the three groups [$F(2,197)=22.83$, $p<0.001$]. Post-hoc comparisons using Tukey HSD tests indicated that each of the three groups were statistically different from each other (Table 11).

One-way between groups' analysis of variance shows there are significant differences in nutrition knowledge levels by employment status [$F(3,195)=18.171$, $p<0.001$]. Post-hoc analysis using Tukey HSD indicated that those who are employed in some capacity (part-time or full-time) have the highest nutrition knowledge, and students have the lowest knowledge level (Table 11).

Table 11 Demographic variation in nutrition knowledge

Characteristics	n	(%)	Nutrition knowledge score Mean	SD
Gender				
Female	171	85.1	67.02	17.52
Male	30	14.9	59.77	18.72
Age				
18-24	42	20.9	51.14	15.96
25-34	40	19.9	63.37	16.12
35-44	32	15.9	69.81	15.08
45-54	37	18.4	73.38	17.06
55-64	36	17.9	71.83	16.28
65+	14	7.0	74.00	12.88
Marital status				
Single	53	26.4	56.57	16.98
Married/living as married/separated/divorced/ widowed	148	73.6	69.30	16.98
Culture				
Australian	167	83.1	66.27	17.14
Other	34	16.9	64.32	21.18
Number of Children				
0	39	19.4	59.41	19.08
1	50	24.9	60.94	18.53
2	61	30.3	71.13	14.86
3+	51	25.4	69.63	17.03
Education levels				
Some high school or less	67	33.5	57.49	17.52
Completed high school	45	22.5	63.42	19.23
Tech or trade qualification	25	12.5	69.08	11.35
Tertiary degree	63	31.5	76.27	12.39
Primary employment status				
Employed full-time	26	13.1	75.15	14.44
Employed part-time	51	25.6	74.90	11.57
Student	35	17.6	52.63	14.19
Homemaker	47	23.6	61.85	19.94
Other	42	20.9	65.75	16.39

4.5.4 Multivariate Analysis of Demographic Influences of Nutrition Knowledge

To determine the independent effects of each variable on nutrition knowledge level, multiple regression analysis was used. The significant predictors from the univariate analysis were entered into the model. Results showed that age, employment status, highest level of education and gender had significant independent effects on nutrition knowledge level ($p<0.05$) (Table 12). This means that the differences seen between the knowledge levels for marital status and number of children were not independent and possibly a result of differences in age or one of the other demographic variables.

Age was the strongest independent predictor of nutrition knowledge, followed by employment status and level of education. The model accounts for 40% of the variance in nutrition knowledge scores (Table 12).

Table 12 Multiple regression analysis of nutrition knowledge on age, employment status, education and gender

	Nutrition knowledge		
	Unstandardised β	Standardised β	P value
Age group	4.028	0.369	0.000
Employment status	3.183	0.266	0.000
Education level	3.607	0.262	0.000
Gender	8.168	0.167	0.003
	Multiple R=0.642 Adjusted R^2=0.400 $F(4,195)=34.170$; $p<0.001$		

4.5.5 The Effect of Socioeconomic Status on Nutrition Knowledge

The community sample as a whole (n=201) showed a wide range in nutrition knowledge scores, from 10 to 100 out of 113, with a mean of 65.94 (SD=17.84). Table 13 shows a summary of the means and standard deviation of the knowledge scores by SES group and for the sample as a whole. The community members from the middle SES group tended to score higher than those from the low SES group on each of the four knowledge components.

Table 13 Summary descriptive statistics of nutrition knowledge levels by socioeconomic status

Knowledge component	Low SES (n=105)		Middle SES (n=96)		Total Sample (n=201)	
	Mean	SD	Mean	SD	Mean	SD
Dietary recommendations (13)	8.84	2.22	8.95	1.60	8.89	1.94
Sources of nutrients (70)	39.18	14.13	47.67	9.21	43.23	12.73
Choosing everyday foods (10)	5.43	2.06	6.69	2.03	6.03	2.13
Diet-disease relationships (20)	6.95	3.65	8.70	3.03	7.79	3.47
Nutrition knowledge score (113)	60.40	19.39	72.00	13.70	65.94	17.84

When the sample is divided – based on nutrition knowledge level – into 10 percentile groups, it can be seen that the lowest six percentiles are predominately blue, and therefore represented mostly by individuals from the low SES group. Conversely, the upper four percentiles are mainly green, and therefore comprised mainly of individuals from the middle SES group (Figure 3).

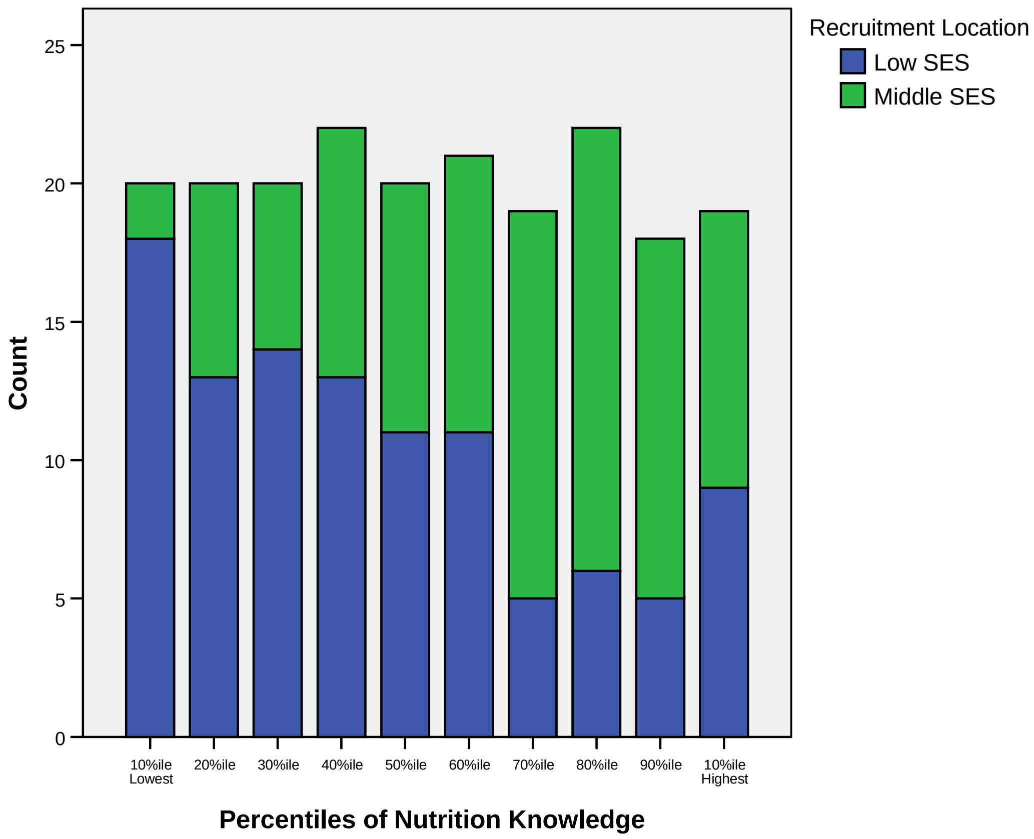


Figure 3 **Distribution of nutrition knowledge coded by socioeconomic status**

To test whether these observed differences were statistically significant, an independent samples t-test was conducted. Table 14 shows the mean knowledge scores for each of the four knowledge components, and the overall knowledge score for the two SES sub-samples. There were significant differences in knowledge levels on all sections of knowledge, except knowledge of the current dietary recommendations. For overall nutrition knowledge, the difference between the middles SES group (μ=72.00, sem=1.40) and low SES group was significant (μ=60.40, sem=0.36; $t(199)=-4.86$, $p<0.001$).

The influence of SES on nutrition knowledge levels needs to be considered independently of demographic variation between the two groups. There are differences between the two SES groups for gender and age distribution, employment status and level of formal education (further supported by the ABS Census data discussed earlier). To determine whether the differences between the two groups are significantly independent of the demographic variation, one-way analysis of covariance was conducted, controlling for variation in gender, age, employment status and level of education. After adjusting for the four demographic variables, there was no significant difference between the low and middle SES sub-samples for overall nutrition knowledge [F(1,194)=0.255, p=0.61, eta squared=0.001]. Multiple regression analysis confirms that SES, measured using the suburb IRSD, is not an independent predictor of nutrition knowledge.

Table 14 Independent samples t-test of nutrition knowledge by socioeconomic status

Knowledge component	Low SES (n=105)		Middle SES (n=96)		
	Mean	SEM	Mean	SEM	P value
Dietary recommendations (13)	8.84	0.22	8.95	0.16	0.691
Sources of nutrients (70)	39.18	1.38	47.67	0.94	0.000*
Choosing everyday foods (10)	5.43	0.20	6.69	0.21	0.000*
Diet-disease relationships (20)	6.95	0.36	8.70	0.31	0.000*
Nutrition knowledge score (113)	60.40	1.89	72.00	1.40	0.000*

*Significant at a level of 0<0.001

4.6 Discussion

4.6.1 General Nutrition Knowledge

The results of this study provide an indication of the levels of understanding of nutrition information within a sociodemographically diverse, South Australian community sample. Due to the nature of recruitment, the sample is not representative but biased towards females. Given that previous studies have shown that females have greater nutrition knowledge than males (Crawford & Baghurst, 1990; Hansbro et al., 1997; Parmenter et al., 2000; Sapp & Jensen, 1997; Variyam et al., 1996), the results of the present study could possibly overestimate the 'true' level of nutrition knowledge throughout the wider South Australian community. Knowledge levels reported in the present study may overestimate community knowledge levels up to twofold, as national data suggest 32% of people are aware of the recommended vegetable intake (Woolcott Research Pty Ltd, 2007) compared to 62% reported in the present study. While recruitment aimed to get a representative sample from two differing SES areas, due to the nature of volunteering, this was not possible. Caution should therefore be exercised if generalising beyond this sample. The demographic variation between the two groups described in this study was consistent with that described by ABS census data (Australian Bureau of Statistics, 2007), but generalisation must still be with caution. The results can still, however, be valuable in highlighting sections of the community with low knowledge to which nutrition education programs are to be targeted. The nutrition messages included in education programs targeting these sub-sections of the community may be different from those of different levels of knowledge. Collecting nationally representative data would be useful for the development of future national nutrition campaigns.

It appears that the key dietary guidelines, like eating more fruit and vegetables and less fatty foods, are reaching the community, but detailed knowledge of the nutrient content of foods and converting knowledge to food choice is poor. For example, the knowledge to eat more vegetables is good, but how many servings are recommended is less understood. Knowledge to reduce fat intake is good, but knowledge of the energy density of fat, the type of fat to cut down on, and the type of foods low or high in fat is poor. Targeting these specific areas of knowledge within the community needs further work.

Knowledge of diet-disease relationships has received much research attention (Sapp & Jensen, 1997), but community knowledge of these relationships is poor and has not improved for many years (Crawford & Baghurst, 1990; Parmenter et al., 2000). The relationship between fat intake and disease is best understood, yet one in five people are still oblivious to any relationship. This is alarming as messages about dietary fat are long-standing, relative to other nutrition messages, and the relationship with heart disease is almost axiomatic, yet still parts of the community are unaware. Crawford and Baghurst (1990) reported a strong perception that sugar in the diet will cause diabetes (Crawford & Baghurst, 1990). Despite education efforts during the past 20 years, results of this study suggest this misperception is still apparent. One of the more recent nutrition science findings is in regards to the protective properties of antioxidant vitamins. While the awareness of antioxidants may be improving (Cox & Bastiaans, 2007), results of this study and others (Parmenter et al., 2000) suggest some people recognise the term 'antioxidant', but few can name one. Nutrition educators need to find innovative ways to get these messages across to all sections of the community, and increase the awareness of the role of diet in disease prevention and health promotion.

The media is one of the most important sources of nutrition information (Fernandez-Celemin & Jung, 2006; Keenan et al., 2002) and misinformation in the community, but there is a need for health promoters to develop simple and consistent messages. Recent media attention in Australia has favoured high protein, low carbohydrate diets, and recognition of this information appears to be foremost in the community. This media attention has created uncertainty as to the healthiness of carbohydrate-rich foods, which was evident in responses throughout the questionnaire, despite the fact that a high carbohydrate, low fat dietary approach underlies the Australian public health nutrition guidelines.

A dated yet significant study found that most people had not heard of the term 'Australian dietary guidelines' (Worsley & Crawford, 1985). While the questionnaire used in this study did not directly ask this question, it does demonstrate that people are not aware of the content of the *Dietary Guidelines for Australians.* Considerable effort is needed to raise awareness of these government-endorsed nutrition messages in the community.

There is evidence that a well-designed campaign promoting nutrition messages, like the Go for 2&5 campaign, can be effective. Using mass media and a consistent, simple nutrition message, this campaign was successful in increasing community awareness about nutrition recommendations and changing behaviour. Despite scientific papers showing otherwise (Cannon, 1992), there is strong public opinion "that experts never agree about what foods are good for you" (Hansbro et al., 1997), and therefore it is imperative that nutrition educators and policy makers promote consistent and concise nutrition messages via high-impact media outlets.

4.6.2 Demographic Variation in Nutrition Knowledge

The demographic variation in nutrition knowledge levels reported in this study are consistent with other findings. Sub-samples of the community with the lowest levels of knowledge include those residing in lower SES areas, the unemployed and less educated, and males. This is of concern as some of these groups are at increased risk of diet-related conditions (Australian Bureau of Statistics, 2004-05).

Accepting the premise that nutrition knowledge has some influence on dietary behaviour, the findings of this study can be useful in a number of ways. Firstly, health promotion campaigns can be targeted at those population groups most at risk of lower knowledge levels. If deficiencies in knowledge contribute to deficiencies in the diet, then education campaigns could be helpful in improving the dietary intake of targeted community groups. Secondly, future nutrition education programs can aspire to correct consumer misinformation and focus resources on sections of nutrition knowledge which are most poorly understood. This gain in knowledge could influence food choices and dietary intakes at a population level.

This study does stimulate thought as to the type and level of nutrition knowledge required by the community. What level of knowledge is needed to initiate positive changes in dietary behaviour and facilitate a healthy dietary intake to reduce disease risk? The General Nutrition Knowledge Questionnaire covers a broad range of nutrition knowledge however it is unclear whether all aspects of knowledge covered are important to eating behaviours. Addressing this question is outside the scope of this study, but future research could explore this and other domains of nutrition knowledge which may be influential in facilitating behaviour change.

4.7 Conclusion

In summary, this study provides a detailed insight into the levels of nutrition knowledge in a South Australian community sample. It is important to be aware of this level of understanding to inform more targeted and potentially more effective nutrition education campaigns. Nutrition knowledge was found to be most influenced by the demographic variables of age, gender, education and employment status. Regardless of the demographic variation in knowledge, there was a broad lack of public awareness of the nutrition advice promoted by the *Dietary Guidelines for Australian*. The primary objective of nutrition education campaigns, such as the *Dietary Guidelines for Australians*, is to promote healthy dietary behaviours through heightened awareness of what constitutes a healthy diet and an increased knowledge of the composition of healthy foods.

Comprehension of nutrition knowledge in the community may also help to target areas of misunderstanding and, in particular, areas of misunderstanding significant to behaviour. Nutrition education programs assume knowledge influences food choices and dietary intakes, which is not necessarily supported by scientific literature. The following chapter will use the validated measure of nutrition knowledge with the intent of providing support for the relationship between nutrition knowledge and dietary intake. The presence of a significant relationship will provide support for previous research, and justification for the inclusion of parents' knowledge in the exploratory study of the family environmental influences of children's health behaviours and weight status.

5 NUTRITION KNOWLEDGE AND DIETARY INTAKE: WHAT IS THE RELATIONSHIP?

5.1 Introduction

Knowledge is recognised as an important influence of behaviour, yet research supporting this theoretical foundation is inconsistent. Previous studies have used a variety of tools to measure knowledge and behaviour, ranging from short dichotomous questions to detailed multiple-day observations of intake. The subsequent variation in the level of detail and type of data collected becomes an issue when trying to compare and collate evidence to support this relationship. This chapter will use the modified General Nutrition Knowledge Questionnaire (GNKQ), which is a validated broad measure of general nutrition knowledge, and a detailed measure of intake to explore the relationship between nutrition knowledge and dietary intake.

5.2 Background Literature

5.2.1 What is the Current Evidence?

Past reviews include a meta-analysis of nine studies which found enough evidence to support a significant positive relationship between nutrition knowledge and 'healthier' dietary behaviour (Axelson et al., 1985). All the reported correlations were positive, yet of varying strengths (coefficients ranged from 0.03 to 0.32) (Axelson et al., 1985).

An issue in the area of food intake research is the variation in the outcome variables. The lack of consistency makes accumulating a strong evidence base difficult. Low-fat diets have been promoted universally as a 'healthy' dietary pattern, and therefore are one common outcome measure in studies of food intake. Higher levels of general nutrition knowledge (knowledge of the fat content of foods and knowledge of the types of fat in foods) have all been positively associated with low-fat dietary approaches (Dallongeville, Marecaux, Cottel, Bingham, & Amouyel, 2000; Kristal, Bowen, Curry, Shattuck, & Henry, 1990; Wardle et al., 2000).

Another common distinct dietary marker, and a relatively easy one to measure, is fruit and vegetable consumption. Nutrition knowledge has been shown to be a significant factor influencing the consumption of fruit (Baker & Wardle, 2003; van Dillen, Hiddink, Koelen, de Graaf, & van Woerkum, 2008; Wardle et al., 2000) and vegetables (Baker & Wardle, 2003; Ball, Crawford, & Mishra, 2006; van Dillen et al., 2008; Wardle et al., 2000).

An alternative outcome measure used in some studies in this area is disease risk. These studies tend to focus specifically on knowledge related to a particular nutrient, or dietary patterns associated with an increased or decreased disease risk. For example, Levy and colleagues (1993) were interested in dietary approaches promoting a healthy heart, and therefore their knowledge questionnaire focussed on consumer knowledge of dietary fats and cholesterol. In this study, people following a cholesterol lowering diet (nutrient intake markers used were fat and cholesterol) were found to have higher levels of nutrition knowledge than those following a less healthy diet (Levy et al., 1993).

Another example of a marker of dietary behaviour is compliance with nutrition recommendations. Main and Wise (2002) assessed individuals' knowledge of nutrition education messages and reported a significant correlation between knowledge of the nutrition education messages and self-reported compliance with these messages ($p<0.001$) (Main & Wise, 2002). Some other studies to support nutrition knowledge as an influential factor of favourable dietary behaviours have shown knowledge to be related to healthier food purchasing decisions (Turrell & Kavanagh, 2006), the adoption of healthy food preparation and cooking methods (Greenwell Arnold & Sobal, 2000), making healthy dietary changes (A. M. Smith, Baghurst, & Owen, 1995), following a healthy dietary pattern (Hansbro et al., 1997) and weight loss (Klohe-Lehman et al., 2006). Knowledge to use food labels specifically has been associated with better overall diet quality (Obayashi, Bianchi, & Song, 2003).

Because food and nutrition in general are so multifaceted, researchers have often limited their focus to selected aspects of dietary behaviour or knowledge. It is the studies which endeavour to measure each construct in their entirety that provide some of the strongest and most meaningful support for the relationship between nutrition knowledge and dietary behaviours. Wardle and colleagues used a broad multi-dimensional definition of nutrition knowledge and a number of single dietary outcome measures to show significant correlations between general nutrition knowledge and dietary intake in all the expected 'healthier' directions (vegetables: r=0.36, fruit: r=0.23, fat: r=-0.21). People with higher levels of nutrition knowledge consumed more fruits and vegetables and less fat. Secondary analysis using odds ratio analysis showed that people with the greatest knowledge levels were 24 times more likely to consume a healthier diet than people with the lowest levels of knowledge (Wardle et al., 2000).

5.3 The Measurement of Knowledge and Dietary Behaviours

It appears that in this area of research, the design of questionnaires and methodologies used to collect dietary intake data has a significant influence on the results. From previous research, we know the strongest support for the relationship between knowledge and behaviour has come from studies using validated measures of knowledge with a broad concept of nutrition knowledge, and when measured, dietary intake reflects usual intake rather than one specific nutrient. This study will therefore aim to collect quality data for both nutrition knowledge and dietary intake to get a thorough understanding of the relationship between knowledge and dietary behaviours.

5.3.1 Methods for Measuring Dietary Intake

Dietary intake can be assessed using several methods with different levels of participant involvement and outcome measures. The least complex methods and most feasible for large-scale community samples are the 24-hour food recalls and food frequency questionnaires (FFQ) (Davenport, Roderick, Elliott, Victor, & Geissler, 1995). These questionnaires are self-administered, processed at a relatively low cost and appropriate for use in community samples (Feskanich et al., 1993). Each method, however, has limitations that must be acknowledged when analysing data. Some of the sources of error associated with the use of FFQs are: the limited number of food items that can be included in the checklist style questionnaire; the accuracy of the data collected is reliant on individuals' memories of the foods they consume, the frequency with which they consume them, and their assessment of portion size; and interpretation of the questions (Newby et al., 2003). Like other dietary assessment methods, underreporting of energy intake occurs in FFQ, although there remains some uncertainty about the absolute amount of this problem (Kroke et al., 1999).

Despite the reported limitations, FFQs are the preferred method to investigate long-term usual intake (Kroke et al., 1999). The relative validity of FFQs is commonly assessed by comparing data with that of a reference method, such as diet recall or weighed record because a gold standard reference for dietary intake is not available (Kroke et al., 1999). Correlation coefficients between FFQs and food records for micronutrients are moderate (ranging from 0.4 to 0.7) (F. B. Hu et al., 1999; Marks, Hughes, & van der Pols, 2006; Newby et al., 2003; Rimm et al., 1992; Willet et al., 1985) and can be higher for macronutrients (up to 0.86) (Kroke et al., 1999). Assessing the reproducibility of an FFQ over a 12-month period, correlations of about 0.59 are reported for individual food items (Feskanich et al., 1993), and possibly higher for general dietary patterns (F. B. Hu et al., 1999).

Collecting dietary intake data in the community is difficult without significant participant burden. Taking into account the known limitations of FFQs, they are still considered to be an acceptable and readily available tool to measure the usual food intake of individuals within a community setting.

5.3.2 Dietary Intake in Australia

The last time national data was collected about the dietary intake of Australian adults was in the form of the National Nutrition Survey in 1995. Almost 14,000 people from urban and rural areas around Australia participated in the survey, which used 24-hour recalls and FFQs to measure food intake of the Australian community (Australian Bureau of Statistics & Department of Health and Family

Services, 1997). This survey found that males and females consumed about 11,000kJ and 7500kJ respectively, with South Australians consuming a little more than the national average. The macronutrient breakdown suggests about 46% of this energy is from carbohydrates, 32.5% from fat (of which 12.7% was saturated) and 17.2% from protein.

While this dietary information is more than 10 years old, it is the most current national data available, and will be a useful reference point with which to compare reported intake data from this study. There is more recent national data available for fruit and vegetable consumption. This data was collected as part of the evaluation of the national Go for 2&5 campaign. Results from a telephone survey conducted in 2005 (n=1200) suggested that while about 60% of people consumed the recommended two serves of fruit, only about 10% consumed five serves of vegetables (Woolcott Research Pty Ltd, 2007). Data collected in a South Australian survey (2002) showed that the proportion of people who met the vegetable recommendation was equal to the national data collected for the Go for 2&5 campaign (9.6%), but the fruit intake was lower. South Australia data suggested that 41.4% of people met the recommended two serves of fruit per day (The South Australian Monitoring and Surveillance System (SAMSS) Brief Report 2006-16, 2006).

5.4 Chapter Aims

The aim of this study is to add to the evidence base for the relationship between nutrition knowledge and dietary intake, using a broad and valid measure of nutrition knowledge and a comprehensive food frequency questionnaire which captures usual intake.

The objectives are:

1. to examine the dietary intakes of individuals with different nutrition knowledge levels

2. to explore the effect of nutrition knowledge on compliance with current Australian nutrition recommendations

3. to determine the correlation coefficients between nutrition knowledge and dietary intake, using macronutrients and micronutrients, as well as fruit and vegetable consumption

4. to use linear regression analysis to examine the independent effect of nutrition knowledge on dietary intake, controlling for known demographic variation.

5.5 Methods

5.5.1 Measures

Nutrition knowledge and demographic information

Nutrition knowledge and demographic information was measured using the modified GNKQ (Appendix 2).

Usual dietary intake information

Usual dietary intake was measured using a self-reported, self-administered, quantified FFQ containing more than 180 different food and beverage items, with qualitative and quantitative questions relating to food preparation practices and dietary habits (CSIRO Division of Human Nutrition, 1996). Participants reported the frequency with which they consumed the listed items and the quantities they usually consumed; for example, twice daily, once a week, three times a month, rarely or never. Participants also had the opportunity to record foods consumed that were not listed in the questionnaire (Appendix 4).

5.5.2 Australian Nutrition Recommendations

The current nutrition recommendations in Australia include the *Nutrient Reference Values for Australia and New Zealand* (National Health and Medical Research Council, 2006), *The Australian Guide to Healthy Eating* (Commonwealth Department of Health and Family Services, 1998), *Food for Health – Dietary guidelines for Australians: A guide to healthy eating* (National

Health and Medical Research Council, 2003), and the Go for 2&5 fruit and vegetable campaign (http://www.gofor2and5.com.au).

The *Nutrient Reference Values for Australia and New Zealand* is a recently updated set of guidelines expanding on the previous set of dietary recommendations known as the *Recommended Dietary Intakes for Use in Australia, 1991* (National Health & Medical Research Council, 1991). Included in this document are recommended dietary intakes (RDI), as well as other intake estimations, such as estimated average requirements and upper level (UL) limits, depending on the nutrient and evidence base. In this study, for most micronutrients the RDI was used as the reference point because for individuals it indicates a usual intake which has a low probability of inadequacy, as it is sufficient to meet the nutrient requirements of nearly all healthy individuals in the population (National Health and Medical Research Council, 2006). For fibre, the guideline is in terms of an adequate intake, which is defined as an "average daily nutrient intake level based on observed or experimentally-determined approximations or estimates of nutrient intake by a group of apparently healthy people that are assumed to be adequate". Because increased sodium intake is associated with an increased risk of high blood pressure, the recommendation for sodium intake is a UL (National Health and Medical Research Council, 2006). The recommendations for fat and saturated fat intakes are as proportions of the total energy intake, 30% and 10% respectively (Commonwealth Department of Health and Family Services, 1998). Some nutrients have gender specific recommendations and these were used in the analysis.

In Australia, the Go for 2&5 fruit and vegetable campaign states that individuals should aim to consume two serves of fruit and five serves of vegetables every day (http://www.gofor2and5.com.au). One serve of fruit is defined as a medium piece of fruit or 150g, and a serve of vegetables is defined as a ½ cup of cooked vegetables or 75g of cooked vegetables or a cup of salad vegetables.

5.5.3 Sample Selection

The 201 adults who participated in the previous study (Chapter 4) were also asked to complete a FFQ in their own time. Participants were volunteers and recruitment is discussed in detail in Chapter 4.

5.5.4 Data Collection

The study submitted as part of the previous study was approved by the Flinders University Social and Behavioural Research Ethics Committee. Participants volunteered to complete the questionnaire and provided informed consent. After completing the nutrition knowledge questionnaire, participants received the FFQ. The FFQ was explained to participants and they were asked to complete the questionnaire in their own time and return it to the researcher via a reply paid envelope provided. No incentives were provided for completing either questionnaire.

One hundred and thirty four FFQs were returned. Questionnaires that had a significant proportion incomplete or whole food group sections incomplete were not submitted for coding. Ninety-five questionnaires were double-entered into database software (SIR Pty Ltd) by a data entry consultant. This information was analysed using a food database and exported into Statistical Package for Social Sciences (SPSS) 14.0 for analysis. Five outliers were removed based on kilojoule consumption (less than 3500kJ or more than 20000kJ), which suggested the FFQs were not completed correctly. Eighty-nine completed FFQs formed part of the dataset for further analysis.

The nutrition knowledge questionnaire was administered and the data managed as detailed in the validation study (Chapter 3, section 3.4.5).

5.5.5 Statistical Analysis

Univariate descriptive statistics and Pearson Product-Moment correlation coefficients were used to explore the relationships between nutrition knowledge, dietary intake and compliance with Australian nutrition recommendations. Multiple regressions were used to explain the independent effects of knowledge on dietary intake, controlling for demographic variation. Data was entered and analysed using SPSS (SPSS for Windows 14.0 Chicago: SPSS Inc.).

5.6 Results

5.6.1 Description of the Sample

This sample comprised of 89 adults (aged 18 or older), mainly female (94.4%), with more than half aged between 18 and 34. Fifty-five percent of respondents reported to be married or living as married, and almost 70% identified with the Australian culture. One-third of the sample had a tertiary qualification and about a quarter had completed high school. A large portion of the sample was students (38.2%) and homemakers (22.5%) (Table 15).

Table 15 Demographic characteristics of the study sample

Characteristics		n	(%)
Gender			
	Female	84	94.4
	Male	5	5.6
Age			
	18-24	35	39.3
	25-34	16	18.0
	35-44	10	11.2
	45-54	16	18.0
	55-64	9	10.1
	65+	3	3.3
Marital status			
	Single	33	37.1
	Married/living as married	49	55.1
	Separated/divorced/ widowed	7	7.8
Culture			
	Australian	62	69.7
	British/English/Scottish/Welsh	5	5.6
	Australian and British	7	7.9
	Other	15	16.8
Number of children			
	0	34	38.2
	1	19	21.3
	2	16	18.0
	3	17	19.1
	4+	3	3.4
Education level			
	Some high school or less	24	27.0
	Completed high school	22	24.7
	Tech or trade qualification	13	14.6
	Tertiary degree	30	33.7
Primary employment status			
	Employed full-time	9	10.1
	Employed part-time	14	15.7
	Student	34	38.2
	Homemaker	20	22.5
	Other	12	13.5

5.6.2 The Influence of Knowledge Level on Dietary Intake

For the initial investigation into the influence of nutrition knowledge on dietary intake, the sample was divided into three groups (tertiles) based on nutrition knowledge scores (out of 113). The cut-offs were arbitrary and provided three equal sized groups.

Group 1 (low knowledge) comprised of participants with an overall nutrition knowledge score of 66 or less, Group 2 (moderate knowledge) participants scored between 67 and 81, and Group 3 (high knowledge) participants scored at least 82. Table 16 shows the mean and standard error of the mean for each of the three groups. Importantly, results from one-way analysis of variance show that the knowledge levels between the three groups are statistically significant [F(2,86)=174.75, p<0.001]. Post-hoc analysis using Tukey HSD indicates that each of the three groups are distinct (p<0.001).

Table 16 One-way Analysis of Variance of nutrition knowledge between the three sub-groups

Group: Knowledge level	N	Mean	Std error	P value
Low	30	50.43	2.39	
Moderate	29	73.24	0.82	0.000
High	30	90.83	0.80	

Results showed that the mean kilojoule intake of the sample as a whole was 8003kJ. The macronutrient breakdown was 44% carbohydrates, 19% protein and 33% fat (14% saturated fat). The sample reported to consume 1.58 serves of fruit per day and 4.57 serves of vegetables. Table 17 shows a summary of the macronutrient and micronutrient intakes and fruit and vegetable consumption for the total sample, and a breakdown by knowledge level group.

Table 17 Dietary intake (kilojoule, micronutrient and macronutrient, fruit and vegetables) by knowledge level

	Total sample (n=89)		Group 1 Low knowledge level (n=30)		Group 2 Moderate knowledge level (n=29)		Group 3 High knowledge level (n=30)		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	P value
Kilojoules (kJ)	8003	2763	8372	3371	7665	2281	7963	2554	0.620
Macronutrients (% energy)									
Carbohydrate	43.84	6.18	42.65	5.92	44.64	6.65	44.26	6.00	0.427
Protein	19.27	3.56	18.52	3.96	19.98	3.18	19.34	3.44	0.290
Fat	32.90	5.42	34.73	4.79	31.61	6.14	32.34	4.94	0.067
Saturated fat	14.19	3.34	16.02	3.37	13.37	2.87	13.14	3.04	0.001*
Monounsat fat	11.44	2.37	12.38	2.45	10.80	2.43	11.13	1.99	0.023*
Polyunsat fat	5.37	2.19	4.68	1.71	5.36	1.66	6.09	2.82	0.043*
Micronutrients									
Sodium (mg)	2754	1117	2914	1219	2552	964	2790	1156	0.456
Calcium (mg)	1074	497	1042	582	1083	367	1096	528	0.911
Iron (mg)	12.93	4.65	12.12	5.43	13.19	3.99	13.49	4.44	0.496
Zinc (mg)	12.36	5.18	12.52	7.26	12.01	3.78	12.43	3.85	0.925
Total folate (µg)	257.70	102.15	217.81	112.52	270.39	83.73	285.32	98.18	0.025*
Fibre (g)	25.71	10.39	20.15	9.68	27.92	9.40	29.13	9.98	0.001*
Cholesterol (mg)	286.18	163.99	308.23	189.88	262.32	131.23	287.19	166.89	0.566
Food groups									
Serves of fruit	1.58	1.32	0.86	0.90	1.84	1.01	2.06	1.63	0.001*
Serves of vegetables	4.57	2.21	3.93	2.36	5.01	2.19	4.79	1.99	0.136

*p<0.05

There were some notable differences in the reported dietary intakes between the three groups (Table 17). Kilojoule intakes differed (range=707kJ), although this was not significant.

There were non-significant differences between the percentage of energy from carbohydrates, protein and fat. Group 1 had the highest percentage of energy from fat (34.73%) and saturated fat (16.02%). Saturated fat intake for Group 1 was significantly higher than the other two groups (13.14-13.37%) [$F(2,86)=7.960$, $p=0.001$]. There were also significant differences between the groups for the percentage of energy from monounsaturated fat [$F(2,86)=3.933$, $p=0.023$] and polyunsaturated fat [$F(2,86)=3.267$, $p=0.043$].

There were significant difference between the groups for intake of folate and fibre. Group 1 consumed 218 micrograms of folate compared to 270μg (Group 2) and 285μg (Group 3). The intake for Group 1 was significantly lower than the other two groups [$F(2,86)=3.841$, $p=0.025$]. Group 1 also consumed the least amount of fibre – 20.15g compared to 28g (Group 2) and 29g (Group 3). The difference between each of the three groups was significant [$F(2,86)=7.553$, $p=0.001$].

Group 1 consumed the highest amounts of sodium (2914mg), zinc (12g) and cholesterol (308mg), and the least amounts of calcium (1042mg) and iron (12mg). The differences between the groups for these micronutrients were not significant.

There was an observed stepwise increase in fruit consumption with increasing knowledge level. Group 1 consumed significantly less fruit (0.86 serves) than Group 2 (1.84 serves) and Group 3 (2.06 serves) respectively [$F(2,86)=8.138$, $p=0.001$]. The pattern for vegetable consumption was not consistent – Group 1 consumed the least, but there were no significant differences between the groups.

5.6.3 Compliance with Current Australian Nutrition Recommendations

From this point forward, kilojoules, carbohydrates and protein are not included in the analysis. The two main reasons for this are: individual intakes of energy can vary based on variables not measured in this study, such as physical activity, and the intake recommendations for protein and carbohydrates are generally not accepted at a population level like the recommendations for fat and saturated fat.

Figure 4 shows the percentage of each knowledge group that met the nutrition recommendations for fat, saturated fat and some micronutrients. The recommended intake for each nutrient is shown in brackets. Intakes greater than or equal to the recommendations for calcium, iron, zinc, folate and fibre are considered compliant, as well as those that are less than or equal to the recommendations for fat, saturated fat, sodium and cholesterol.

For example, the recommended intake of fat is 30% or less of total kilojoule intake. In this sample, almost 27% of Group 1 met this recommendation, and this increased in a stepwise manner with 31% of Group 2 and 40% of Group 3 meeting this recommendation. A stepwise relationship was also observed with saturated fat intake. No one in Group 1 met the recommendation (10% or less of kilojoules from saturated fat), but 10% and 13% of Group 2 and Group 3 respectively met it (Figure 4).

In this study sample, the mean fruit (1.6 serves) and vegetable (4.6 serves) intakes were below the recommendations of two and five serves respectively. Figure 5 shows compliance with the Go for 2&5, as well as fibre and folate recommendations.

For folate intake, Group 1 (6.7%) and Group 2 (6.9%) had similar percentages meeting the recommendation (greater than or equal to 400mg), while Group 3 (10%) had the greatest percentage. There was a distinct difference in compliance with the recommendation for fibre in Group 1 compared to the other two groups. This was also evident in fruit intake – 13% of Group 1 consumed at least two serves per day compared to 41% and 40% for Group 2 and Group 3 respectively. The differences for vegetable intake were less marked. Thirty percent, 28% and 37% of groups 1, 2 and 3 respectively consumed five serves of vegetables or more. The final measure included in

Figure 5 is the percentage of people meeting both the fruit and vegetable recommendations. Group 1 had the fewest amount of people meeting both recommendations (10%), compared to 28% in Group 2 and 20% in Group 3.

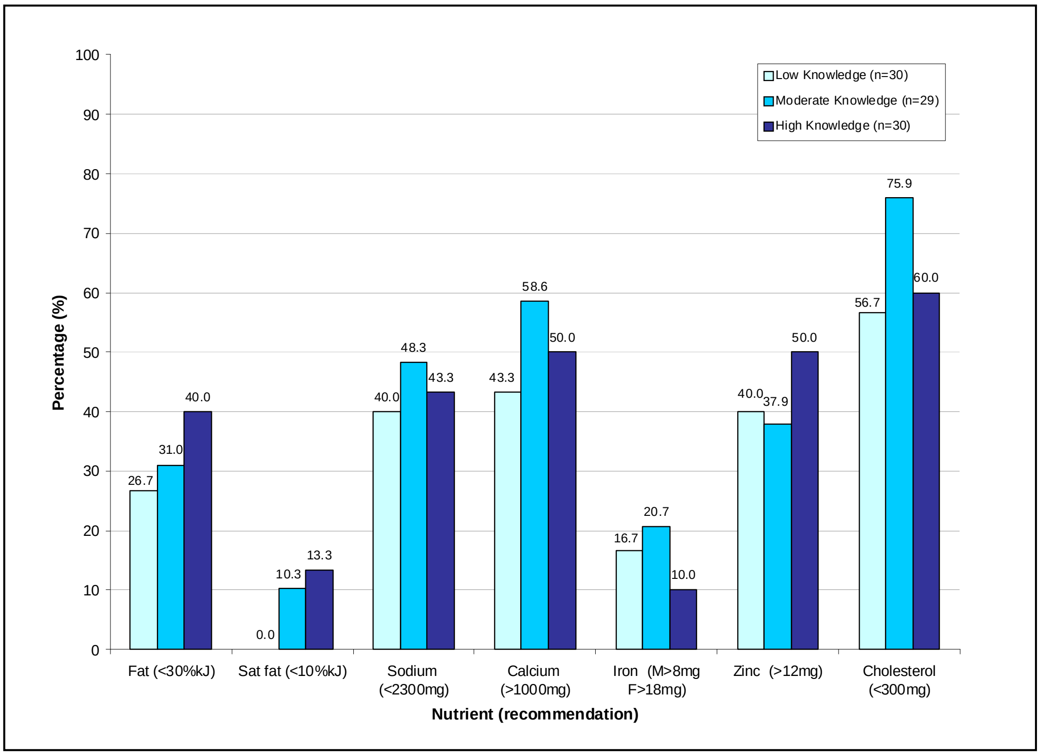


Figure 4 **Percentage of people in each knowledge level group complying with Australian nutrient recommendations**

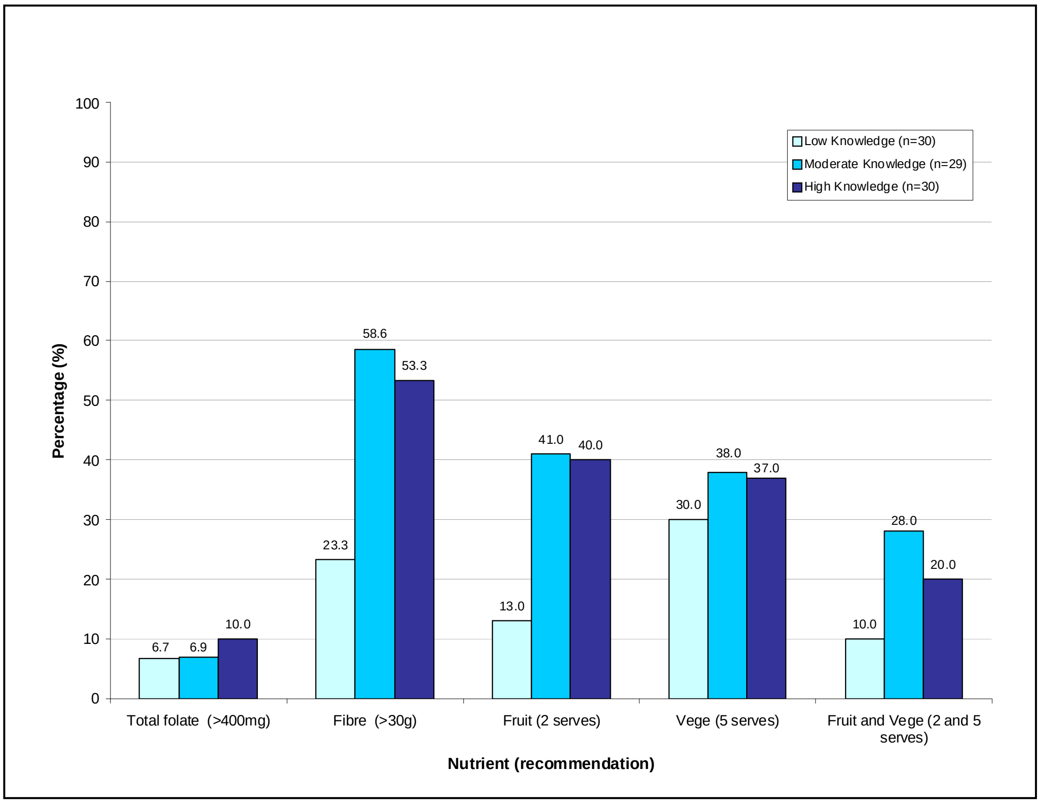


Figure 5 Percentage of people in each knowledge level group complying with Australian nutrient and fruit and vegetable recommendations

5.6.4 Relationships between Nutrition Knowledge and Dietary Intake

Pearson Product-Moment correlations

Using a simple test of association (the Pearson Product-Moment correlation coefficient), nutrition knowledge was significantly correlated with a number of dietary intake variables (Table 18). Nutrition knowledge was negatively associated with saturated fat ($r=-0.351$, $p<0.01$) and monounsaturated fat ($r=-0.255$, $p<0.05$) intakes, but positively associated with polyunsaturated fat ($r=0.263$, $p<0.05$), total folate ($r=0.349$, $p<0.01$), fibre ($r=0.405$, $p<0.001$), fruit ($r=0.383$, $p<0.001$) and vegetable ($r=0.240$, $p<0.05$) intakes.

As shown in the previous chapter, nutrition knowledge varies with demographic characteristics. Findings of the previous work (Chapter 4) show age, gender, employment status and highest level of education to be significant predictors of nutrition knowledge levels. When statistically controlling for these demographic variables, the correlation coefficients between knowledge and monounsaturated fat and vegetable intakes become non-significant (p>0.05). Significant correlations are still observed between knowledge and fruit (r=0.283; p=0.009), fibre (r=0.284; p=0.009), folate (r=0.226; p=0.037), polyunsaturated (r-0.247; p=0.023) and saturated fat (r=-0.240, p=0.027) intakes (Table 18). Higher nutrition knowledge levels are associated with consuming more fruit, fibre and folate, and a diet lower in saturated and polyunsaturated fats.

Table 18 Pearson Product-Moment correlation coefficients between nutrition knowledge and dietary intake, controlling for demographic variation

	Pearson Product-Moment correlation coefficient			
	Zero order correlation		Controlling for demographic variables [a]	
	Correlation coefficient	P value	Correlation coefficient	P value
Kilojoules (kJ)	-0.054	0.613		
% energy carbohydrate	0.064	0.550		
% energy protein	0.187	0.079		
% energy fat	-0.184	0.085		
% energy saturated fat	-0.351	0.001*	-0.240	0.027*
% energy monounsat fat	-0.255	0.016*	-0.149	ns
% energy polyunsat fat	0.263	0.013*	0.247	0.023*
Sodium (mg)	-0.055	0.609		
Calcium (mg)	0.147	0.169		
Iron (mg)	0.162	0.130		
Zinc (mg)	0.050	0.642		
Total folate (µg)	0.349	0.001*	0.226	0.037*
Fibre (g)	0.405	0.000*	0.284	0.009*
Cholesterol	-0.009	0.932		
Serves of fruit	0.383	0.000*	0.283	0.009*
Serves of vegetables	0.240	0.023*	0.157	ns

[a] Demographic variables: age, gender, employment status and highest level of education
* Correlation is significant at the 0.05 level
ns = Correlation becomes non-significant

Multiple regression analysis

To determine the independent effect of nutrition knowledge on dietary intake, linear regression analysis was used. The demographic variables (Model 1) and nutrition knowledge (Model 2) were entered into a linear hierarchical regression. The five dietary intake variables – which were significantly correlated with nutrition knowledge – were included in the regression analysis, as well as vegetable intake, as it almost reached significance.

The demographic variables accounted for between 2.9% and 17.6% of variation for the different dietary intake variables (Table 19). Age was the most consistent significant demographic predictor across the six dietary markers analysed. Nutrition knowledge was an independent significant predictor of fruit (accounting for 6.7% of the variance), saturated fat (5.2% of the variance), folate (4.3% of the variance), polyunsaturated fat (5.9% of the variance) and fibre (6.6% of the variance) intakes (Table 19). Nutrition knowledge was not an independent predictor of vegetable intake.

Table 19 Summary of hierarchical regression analysis of dietary intake on demographic variables (Model 1) and demographic variables with nutrition knowledge (Model 2)

	Fruit intake				Vegetable intake				% energy from saturated fat		
	Unstandardised coefficients		Standardised coefficients		Unstandardised coefficients		Standardised coefficients		Unstandardised coefficients		Standardised coefficients
	Beta	SE Beta	Beta		Beta	SE Beta	Beta		Beta	SE Beta	Beta
Model 1				**Model 1**				**Model 1**			
Gender	0.531	0.582	0.093	Gender	2.112	0.986	0.221*	Gender	-1.264	1.525	-0.088
Age	0.283	0.085	0.341**	Age	0.462	0.144	0.332**	Age	-0.276	0.223	-0.131
Education level	0.216	0.114	0.199	Education level	0.153	0.194	0.084	Education level	-0.665	0.300	-0.242*
Employment status	0.002	0.075	0.004	Employment status	0.145	0.126	0.123	Employment status	0.106	0.195	0.060
	R value =0.398				R value = 0.373				R value = 0.311		
	R^2 adjusted = 0.118				R^2 adjusted = 0.099				R^2 adjusted = 0.054		
	R^2 value = 0.159**				R^2 value = 0.139*				R^2 value = 0.097		
Model 2				**Model 2**				**Model 2**			
Gender	0.147	0.580	0.026	Gender	1.752	1.011	0.183	Gender	-0.411	1.537	-0.029
Age	0.236	0.084	0.283**	Age	0.418	0.146	0.300**	Age	-0.170	0.223	-0.081
Education level	0.035	0.129	0.032	Education level	-0.018	0.226	-0.010	Education level	-0.262	0.343	-0.095
Employment status	-0.021	0.072	-0.030	Employment status	0.123	0.126	0.104	Employment status	0.159	0.192	0.089
Nutrition knowledge	0.022	0.008	0.315**	Nutrition knowledge	0.021	0.014	0.177	Nutrition knowledge	-0.049	0.022	-0.277*
	R value = 0.475				R value = 0.401				R value = 0.386		
	R^2 adjusted = 0.179				R^2 adjusted = 0.110				R^2 adjusted = 0.098		
	R^2 change = 0.067**				R^2 change = 0.021				R^2 change = 0.052*		

** $p<0.01$; *$p\leq0.05$

	Total folate				Fibre intake				% energy polyunsaturated fat		
	Unstandardised coefficients		Standardised coefficients		Unstandardised coefficients		Standardised coefficients		Unstandardised coefficients		Standardised coefficients
	Beta	SE Beta	Beta		Beta	SE Beta	Beta		Beta	SE Beta	Beta
Model 1				**Model 1**				**Model 1**			
Gender	62.848	45.061	0.142	Gender	4.706	4.510	0.105	Gender	1.024	1.037	0.108
Age	21.481	6.579	0.334**	Age	2.338	0.658	0.357**	Age	0.208	0.151	0.151
Education level	18.616	8.854	0.222*	Education level	2.201	0.886	0.257*	Education level	0.089	0.204	0.049
Employment status	6.054	5.767	0.112	Employment status	0.548	0.577	0.099	Employment status	0.054	0.133	0.046
	R value =0.397				R value = 0.430				R value = 0.175		
	R^2 adjusted = 0.117				R^2 adjusted = 0.146				R^2 adjusted = -0.016		
	R^2 value = 0.157**				R^2 value = 0.184**				R^2 value = 0.030		
Model 2				**Model 2**				**Model 2**			
Gender	39.114	45.561	0.089	Gender	1.728	4.489	0.038	Gender	0.428	1.043	0.045
Age	18.529	6.597	0.288**	Age	1.967	0.650	0.301**	Age	0.134	0.151	0.097
Education level	7.395	10.170	0.088	Education level	0.793	1.002	0.093	Education level	-0.194	0.233	-0.107
Employment status	4.590	5.694	0.085	Employment status	0.365	0.561	0.066	Employment status	0.017	0.130	0.015
Nutrition knowledge	1.379	0.652	0.252*	Nutrition knowledge	0.173	0.064	0.311**	Nutrition knowledge	0.035	0.015	0.295*
	R value = 0.448				R value = 0.500				R value = 0.299		
	R^2 adjusted = 0.152				R^2 adjusted = 0.250				R^2 adjusted = 0.035		
	R^2 change = 0.043*				R^2 change = 0.066**				R^2 change = 0.059*		

** p<0.01, *p<0.05

5.7 Discussion

The unique aspect of this study is the use of comprehensive measurement tools for both the assessment of dietary intake and nutrition knowledge. Previous studies have chosen to use simplified nutrition knowledge questions and/or short food intake tools focusing on key nutrients such as fat or easily measured markers such as fruit intake. Using a broad and validated measure of knowledge and a comprehensive FFQ allowed this study to examine knowledge and dietary intake in detail, and therefore analyse the relationships between nutrition knowledge and dietary composition in more detail than some previous studies.

The FFQ used allowed intakes of all macronutrients and most micronutrients to be calculated, but the components that showed the strongest relationships with knowledge clustered around fat, fruit and vegetable intakes and related nutrients. These are the outcome variables which some previous studies have chosen only to measure through short targeted food intake questionnaires. While some of the micronutrients showed variation in intakes with knowledge level, these were not statistically significant. This study observed little to no relationship between nutrition knowledge and the majority of micronutrients measured (excluding folate and fibre). It is possible the sample size was insufficient to detect the difference in intakes, which were relatively small in any one micronutrient. This is a problem when collecting and interpreting food intake data. FFQs are designed to capture 'usual' intake, but when the whole diet is dissected for analysis into macronutrients and micronutrients, often the complexity is lost. Using an outcome measure consisting of a combination of many dietary components, reflecting a healthy diet, may be one way to overcome this issue.

In this study, the observed significant correlations between nutrition knowledge and dietary components were between 0.23 and 0.28 in the expected directions. Other studies have found similar correlations of 0.21-0.36 (Axelson et al., 1985; van Dillen et al., 2008; Wardle et al., 2000). Taking into account the known demographic variation in knowledge levels, knowledge was shown to be an independent predictor of fruit, fibre, folate, saturated fat and polyunsaturated fat intakes, explaining 4.3-6.7% of the variance. Another study also using multiple regression analysis found similar results – knowledge explained 2-8% of the variation in fruit, vegetable and fat intakes (Wardle et al., 2000). While results presented here provide stronger support for the relationship between knowledge and fat intake, the results for vegetable intakes were weaker. The level of detail collected in the food intake questionnaire allowed fibre intake from all food sources to be estimated, which few other studies have been able to do. The relationship between nutrition knowledge and fibre intake proved to be one of the strongest in this study. At a population level, providing health information to increase nutrition awareness about fibre and the benefits of a high fibre diet could have an influence on intake behaviour and possibly health outcomes at a broader level.

There is a recognised trade-off between the level of detail in the dietary intake data collected and the time taken to complete the questionnaire, possibly affecting participant burden and participant numbers. The food intake questionnaire used in this study was comprehensive enough for macronutrient and micronutrient intakes to be estimated. Despite this available level of detail, this study and others (van Dillen et al., 2008; Wardle et al., 2000) show it is some of the single markers of intake, such as fruit consumption, that provide the strongest support for the relationship between knowledge and behaviour. Fruit consumption is often considered a proxy measure for fibre intake. This study measured both fruit and fibre intakes, and the strength of their relationships with nutrition knowledge were very similar.

There are some limitations of this study that should be discussed. Due to the recruitment strategies and nature of volunteer samples, this sample was small and females were overrepresented. The small sample of volunteers completing the dietary questionnaire increases the likelihood of bias and may have impacted on the strength of the relationships reported. Despite this, the overall macronutrient composition reported in this study was very similar to that reported in the national survey. Nonetheless, caution should be adopted when extrapolating into populations outside the study sample. Despite the sample size, this study was able to show significant results and report correlations as strong – and stronger – as studies with more than 1000 people. The use of validated tools to measure the constructs also gives the researcher more confidence in the results.

The collection of food intake data is always subject to participants' compliance and their abilities to accurately recall and estimate their intakes. Self-reported measures are also subject to a social desirability bias. In attempts to minimise the bias in food intake responses, the questionnaires were de-identified, participants completed the food intake questionnaire in their own time without the researcher present, and completed questionnaires were returned by mail (ie not in person).

Within social cognitive models, the relationship between knowledge and behaviour is logical, but in the case of nutrition research, the evidence is relatively weaker, possibly the result of methodological issues. As a result, in more recent studies nutrition knowledge has been largely disregarded in favour of exploring other constructs such as the barriers to behaviour change. Acknowledging the limitations, this study used comprehensive measures of nutrition knowledge and dietary intake, and reported significant associations between knowledge and a number of dietary intake markers. Nutrition knowledge appears to have the greatest independent influence on intakes of nutrients such as fat and fibre. Knowledge is a necessary prerequisite for behaviour change, and this study provides support for the continued inclusion of nutrition knowledge in dietary interventions.

5.8 Conclusion

In summary, this study provides support for the relationship between nutrition knowledge and dietary behaviour in adults. In the context of the family environment, it is reasonable to suggest that parents' knowledge will influence their dietary intakes, which in turn is known to influence their children's intakes. The findings of this study have provided justification for the inclusion of parents' nutrition knowledge in the proposed family environment study.

This work has also highlighted the complexity of interpreting dietary intake information. It has been suggested that in order to simplify the interpretation of food intake research that one measure representing the whole diet is used as an outcome variable. The following chapter will further explore this idea of whole diet and the possible ways to measure overall dietary intake. Finding a robust indicator of dietary intake will provide a strong methodology to measure intake in parents. In addition to the previously validated knowledge questionnaire, this suite of robust tools will be used to measure parental characteristics within the family home environment and strengthen the proposed model of obesity resistance.

6 MODIFICATION OF A DIET QUALITY INDEX TO MEASURE COMPLIANCE WITH THE CURRENT AUSTRALIAN DIETARY GUIDELINES

6.1 Introduction

Food intake is highly variable and people with different eating patterns can maintain health and energy balance. As a result, there is no gold standard definition of a 'healthy' diet, which forces researchers to choose a proxy measure to represent an overall dietary pattern. Commonly chosen proxy measures include percentage of energy from fat, serves of fruit and vegetables, or the use of low-fat milk. The main disadvantage of these proxy measures is that they do not capture the synergy of the whole diet. Attempts to overcome this issue have led to the development of indexes, which combine a number of these proxy measures to better reflect an overall dietary pattern. This chapter will explore some of the more comprehensive indexes and the modification and application of one in an Australian setting.

6.2 Background Literature

There are a number of dietary patterns believed to be associated with the increased risk of chronic disease, including a high intake of saturated fat and an increased risk of heart disease, and low fruit and vegetable intake and an increased risk of some cancers; yet the underlying issue remains – there is no gold standard definition of a 'healthy' diet. While the ideal diet profile remains elusive, choosing an outcome variable in food intake research is difficult. Researchers tend to choose dietary markers or outcome variables dependent on their research interests or the quality of data collected.

In previous attempts to capture whole diet or overall diet quality, researchers have combined a number of markers into an index. The combination can be specific to the researcher's focus or the nutrients considered most important in relation to health promotion or disease prevention (Newby et al., 2003). The greatest advantage of a quality index is its potential to capture this idea of whole diet or 'dietary synergy' (Australian Institute of Health and Welfare, 2007), and not just selected foods, food groups or single nutrients (Kant, 1996; Patterson, Haines, & Popkin, 1994), which have tended to be the dietary markers to dominate nutrition research in the past.

There has been a small amount of research into diet quality and disease risk, indicating high quality diets offer weak to moderate protection from cardiovascular disease, but little benefit in reducing cancer risk (McCullough, Feskanich, Rimm et al., 2000; McCullough, Feskanich, Stampfer et al., 2000). A poor diet quality has also been associated with a greater risk of overweight and obesity (Guo, Warden, Paeratakul, & Bray, 2004). Although the body of evidence linking diet quality and chronic disease prevention is small, measures of overall quality are still thought to be more robust indicators of healthy eating behaviour than any single indicator (Evans, Wilson, Scudeller, & Jorm).

6.2.1 Diet Quality Indexes

The more comprehensive diet quality indexes reported in literature are developed based on a combination of nutrient intake, foods and food group consumption, and include a measure of diet variety.

The Australian Institute of Health and Welfare has recently developed an Australian diet quality index. The index – referred to as Aust-HEI – focuses on usual consumption and diet variety, fruit and vegetable intake, and behaviours and consumption associated with fat intake, particularly saturated fat. It consists of seven variables, representing these three dietary aspects. All aspects are given equal weighting (20 points out of a score of 60) and have been shown to be related to chronic disease risk (Australian Institute of Health and Welfare, 2007). An advantage of this index is that it can be derived from short dietary questions and food frequency questionnaires (FFQs) without complex nutrient analysis, but its simplicity is also its limitation, in that if an individual scores poorly on one of the three aspects, they will generally score poorly on the whole index.

Since this study was completed, a second Australian index has been developed by McNaughton and colleagues (2008), which is designed to measure compliance with the current Australian nutrition recommendations. This index, known as the Dietary Guideline Index, has 15 components, each of which represents a dietary guideline food group or message. The Dietary Guideline Index is a comprehensive assessment of diet quality, appropriate for use with data collected from FFQs, and appears to adequately discriminate between dietary patterns within the Australian population (McNaughton, Ball, Crawford, & Mishra, 2008). Future research may compare the ability of this Australian index and other well-established international indexes, such as the Healthy Eating Index (HEI), to predict health behaviours and risk factors associated with diet quality.

An early review of diet quality indexes (Kant, 1996) identifies two comprehensive measures of quality – the HEI (Kennedy, Ohls, Carlson, & Fleming, 1995) and the Diet Quality Index (DQI) (Haines, Siega-Riz, & Popkin, 1999). Both are similar in their construction, are based on a range of dietary aspects that require nutrient analysis to calculate, and include a measure of variety or moderation.

The HEI is used by the United States Department of Agriculture (USDA) to measure the compliance of Americans with the *Dietary Guidelines for Americans* and *Food Guide Pyramid* (Kennedy et al., 1995). The HEI has been applied to dietary data since 1989 and has been used for data collected by the diet recall and FFQ methods (McCullough, Feskanich, Rimm et al., 2000). Since its development, the HEI has been used repeatedly on national American dietary intake data to monitor diet quality at a population level. With the recent updating of the USDA's dietary guidelines, the original HEI has been revised, with particular emphasis on wholegrains, specific fat types, various vegetable types, discretionary kilojoules and nutrient density (Guenther, Reedy, Krebs-Smith, Reeve, & Basiotis, 2007). While this revision, referred to as the HEI-2005, is considered an improvement on the original HEI (because it takes into consideration more recent nutrition concepts and assesses the quality of the diet based on consumption of nutrients per 1000 calories), it is not suited to the current Australian context. At present, the Australian nutrition guidelines (National Health and Medical Research Council, 2003; A. Smith, Kellet, &

Schmerlaib, 1998) are more similar to the preceding US guidelines, and therefore for the purpose of this application, a modification of the original HEI will be discussed.

The original HEI is better able to capture whole diet than the Aust-HEI as it is the sum of 10 dietary components (each having a maximum score of 10). The HEI includes five components relating to compliance with the Food Pyramid food group recommendations, four components relating to nutrient intakes (fat, saturated fat, cholesterol and sodium) and a measure of diet variety.

The DQI was the second comprehensive index of diet quality identified by Kant (1996). It was originally developed by Patterson and colleagues (Patterson et al., 1994) from food recalls, and later revised by Haines and colleagues to include measures of variety, moderation and proportionality (and now referred to as the Diet Quality Index Revised (DQI-R)) (Haines et al., 1999). Like the HEI, the index requires quantitative estimates of nutrient and food group intakes.

Both the HEI and DQI-R make assessments of fat intake (total fat, saturated fat and cholesterol), as well as comparing fruit, vegetable and grain food serves against current nutrition recommendations. The main differences in the composition of these indexes are that the HEI measures calcium and iron intake in terms of food groups – that is dairy and meat respectively – and salt intake in terms of milligrams of sodium, whereas the DQI-R measures calcium and iron intake as a percentage of the recommended daily intake (RDI) in milligrams and includes sodium intake in the moderation score, along with alcohol, added sugar and discretionary fat intake.

After considering the alternatives, the original HEI was chosen for use in the current application as it is a comprehensive measure of diet quality best suited to assess Australian food intake data relative to the Australian nutrition guidelines. Following is a summary of the reasons for the choice of the HEI and its tailoring to the Australian context. The HEI was originally developed to compare US intakes to their nutrition guidelines, which were very similar in content to the current Australian nutrition guidelines. The HEI is thought to be a more comprehensive measure of diet quality than the Aust-HEI because it includes a greater range of dietary components to better represent whole diet. The HEI has been used more frequently than the DQI-R over many years to assess population intake, and continues to be reviewed and updated as the guidelines change. Academic researchers have also used the HEI to explore the relationships between diet quality and health outcomes (Guo et al., 2004; McCullough, Feskanich, Rimm et al., 2000; McCullough, Feskanich, Stampfer et al., 2000). And finally, in terms of the application of the criteria to Australian guidelines, the HEI variety component was better suited to the intake data available in this study.

6.3 Chapter Aims

The aim of this study is to apply a comprehensive measure of diet quality (the HEI) to Australian food intake data.

The objectives include:

1. to adjust the HEI component scoring criteria to be consistent with the current Australian nutrition guidelines
2. to apply the modified HEI to food intake data from a South Australian community sample and explore the demographic variation in HEI scores
3. to use linear regression analysis to examine the independent effect of nutrition knowledge on overall diet quality (as measure using the modified HEI), controlling for demographic variation.

6.4 Method Part 1: Modification of the HEI Criteria to Australian Nutrition Guidelines

The construction of the USDA's HEI is described in detail elsewhere (Kennedy et al., 1995). In summary, it has 10 components – five measuring compliance with food groups, four based on nutrient intakes, and one measure of diet variety. For each component, respondents receive a score ranging between zero and 10, dependent on their intake compared to the recommendation. The overall index therefore has a range from zero to 100. The following is a description of how the HEI criteria were modified to be consistent with the Australian nutrition guidelines.

6.4.1 Components 1-5: Food Groups

The criteria for the food group components of the modified HEI were based on information contained within the *Food for Health – Dietary guidelines for Australians: A guide to healthy eating* booklet (National Health and Medical Research Council, 2003) and *The Australian Guide to Healthy Eating* (A. Smith et al., 1998). Table 20 shows a summary of the scoring criteria for this adaptation. For each of the food group components, a minimum and maximum criterion was set, and scores were assigned as zero for the minimum and 10 for the maximum. The maximum value was set as the guideline recommendation, and the minimum at zero or no intake. The scores between the minimum and maximum criteria were calculated proportionately.

Table 20 Summary of the modified Healthy Eating Index scoring criteria

Component	Recommendation	Criteria for perfect score of 10	Criteria for minimum score of 0
Cereals (bread, cereal, rice, pasta)	Women: 4-9 serves Men: 6-12 serves	Women: ≥4 serves Men: ≥6 serves	Women: 0 serves Men: 0 serves
Vegetables	5 serves	5 serves	0 serves
Fruit	2 serves	2 serves	0 serves
Milk, yoghurt, cheese	2 serves	2 serves	0 serves
Meat, eggs, nuts, legumes	1 serve	1 serve	0 serves
Total fat	30% or less of total energy from fat	≤30% of total energy	≥45% of total energy
Saturated fat	Less than 10% of total energy from saturated fat	≤10% of total energy	≥15% of total energy
Cholesterol	Less than 300mg	≤300mg	≥450mg
Sodium	Less than 2300mg	≤2300mg	≥4600mg
Variety	8 or more different foods in a day	≥8 different foods	≤3 different foods

Component 1: Cereal products

The recommendations for cereal food products for women (aged 60 or less) is four to nine serves per day, and six to 12 for men. Criteria for a maximum score were set at the minimum intake recommendation – four serves daily for women and six for men. Table 21 shows the food items included in the cereal food group and the serve sizes used for calculation of the index score.

Table 21 Serve sizes of food items included in the cereal food group

One serve of cereal food products	
Bread (including fruit bread)	2 slices (60g)
Bread roll	1 medium roll (60g)
Crumpets	2 crumpets (100g)
Crisp bread, eg Ryvita	4 biscuits (50g)
Cooked rice, noodles, pasta	1 cup (180g)
Porridge	1 cup (230g)
Breakfast cereal flakes	1 $^{1}/3$ cup (40g)
Muesli	½ cup (65g)

Component 2: Vegetables

The guideline recommends five serves of vegetables per day for both women and men. This includes cooked and salad vegetables, potatoes and tomatoes. One serve of vegetables is the equivalent of 75g.

Component 3: Fruit

The guideline for fruit is two serves per day for women and men. For this analysis, avocado was included as a fruit. Table 22 shows the serve sizes for the fruit food group.

Table 22 Serve sizes of food items included in the fruit food group

One serve of fruit	
Fresh fruit	1 medium piece (150g)
Canned fruit	1 cup (150g)
Fruit juice	½ cup (125ml)
Dried fruit, eg apricots, peaches	4 dried halves (24g)
Dried fruit, eg sultanas, currants	1.5 tablespoons (22.5g)

Component 4: Dairy products

For all adults, two serves of milk, yoghurt or cheese are recommended. Custard is included in this food group. Table 23 shows the dairy food included in this component score and the serve sizes.

Table 23 Serve sizes of food items included in the dairy food group

One serve of dairy products	
Milk and flavoured milk drinks	1 cup (250ml)
Cheese	2 slices (40g)
Yoghurt	1 small carton (200g)
Custard	1 cup (250ml)

Component 5: Meat and alternatives

This food group included red meat, pork, poultry, fish, eggs, legumes, lentils and nuts. One serve of meat is described as 65-100g. For this analysis, one serve was equal to 65g. The items and serve sizes are presented in Table 24.

Table 24 Serve sizes of food items included in the meat and alternatives food group

One serve of meat products or alternatives	
Cooked meat or chicken	½ cup mince, 2 small chops, 2 slices roast meat 65-100g (65g)
Fish (fillet or canned)	80-120g (80g)
Eggs	2 small eggs (90g)
Lentils, chickpeas or beans	½ cup (80g)
Nuts	$^{1}/3$ cup (47g)

6.4.2 Components 6-9: Nutrients

The four nutrient component scores are based on calculated nutrient intakes – the percentage of energy from fat and saturated fat, total sodium (mg) and cholesterol (mg). The recommendations for these nutrient intakes were taken from the recently reviewed *Nutrient Reference Values for Australians* (National Health and Medical Research Council, 2006), which is based on the best scientific evidence available, and therefore – for the most part – is consistent with the US criteria for the original HEI.

While dietary recommendations are based on scientific evidence, there is no such evidence for a maximum intake or a zero score. Part of the development process of the original HEI involved consultation with nutrition researchers and exploration of the nutrient consumption distributions to form the zero score criteria. The zero scores for this analysis were calculated using the same rationale as in the original HEI. The criteria for minimum and maximum scores for the nutrient components are presented in Table 20.

6.4.3 Component 10: Diet variety

To calculate the diet variety component score, the HEI counts the total number of different foods eaten by a person that contribute substantially to meeting one of the five food groups. Foods consumed in amounts greater than or equal to half of one serve were counted in this variety component. Foods that were similar, such as boiled potatoes or baked potatoes, were counted once. People consuming eight or more different foods per day received a maximum score of 10 and those consuming three or less a score of zero. These minimum and maximum criteria were based on previous research using the HEI with data from a FFQ (Guo et al., 2004). Foods not listed in the five food groups (cereals, fruit, vegetables, milk and meat or equivalents) that were included as part of the component score were not used in the calculation of the diet variety component score.

6.5 Method Part 2: Applying the Modified HEI Criteria to Australian Nutrition Guidelines

6.5.1 Sample and Measures

The modified HEI was applied to the data collected for the previous study exploring the relationship between nutrition knowledge and food intake (Chapter 5). The demographic information for this sample of 89 adults is presented in Table 25.

6.5.2 Statistical Analysis

Individuals received a score for each component and these were summed to provide an overall HEI score. The HEI scores were classified according to the USDA defined categories of poor diet (a HEI score of less than 50), a diet that needs improvement (HEI between 51 and 80), and a good diet (HEI greater than 80).

Univariate descriptive statistics were used to explore the individual component scores and overall HEI scores. Analysis of variance and t-test statistics were used to examine the demographic variation in HEI scores, and Pearson Product-Moment correlation coefficients were used to determine the demographic variation in HEI scores. Multiple linear regression analysis was used to explain the independent effects of knowledge on HEI score, controlling for demographic variation. Data was entered and analysed using Statistical Package for Social Sciences (SPSS) 14.0 (SPSS for Windows 14.0 Chicago: SPSS Inc.).

6.6 Results

6.6.1 Descriptive Statistics for the HEI

The mean HEI score for this sample (n=89) was 70.61 (SD=12.63). Using the USDA categories, most of this sample (69.7%) consumed a diet that 'needs improvement', 24.7% had a 'good' diet and 5.6% consumed a 'poor' diet (Figure 6).

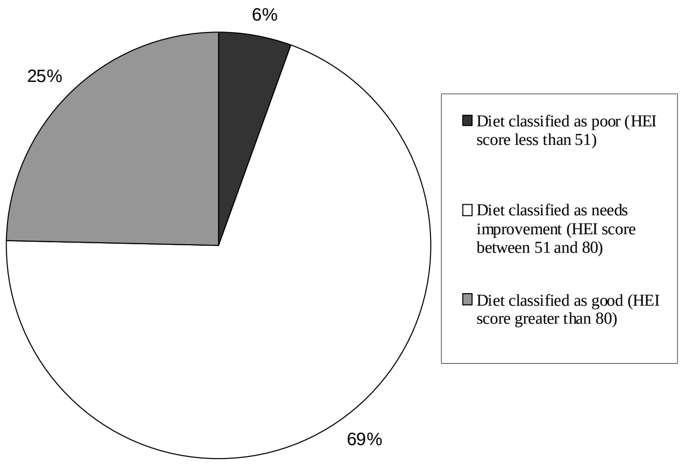


Figure 6 Classification of the sample's diets using the Healthy Eating Index categorisation definitions

6.6.2 HEI Component Scores

The mean score for each of the 10 components of the HEI can be seen in Figure 7. A higher score represents consumption closer to the recommendation. The highest mean HEI component scores were for the meat and alternatives (M=9.34, SD=1.70) and dairy food groups (M=8.23, SD=2.49). There were five components with a mean score in the mid-sevens (7.41-7.55) – these were fruit, vegetables, total fat, cholesterol and sodium. The lowest mean scores were for saturated fat intake (M=3.42, SD=3.49) and the cereal food group (M=5.51, SD=2.07) (Figure 7).

Figure 8 shows the percentage of the sample that met the recommendation (scored a maximum of 10) for each of the components. About three-quarters of the sample (75.3%) scored a maximum of 10 points for the meat and alternatives food group, and about two-thirds (64%) met the recommended intake for cholesterol. About half the sample met the recommended intakes for fruit (51.7%) and dairy foods (52.8%). Less than half the sample met the recommendations for the other components – sodium, total and saturated fat, cereals, vegetables and variety. Only a small proportion of the sample met the recommendations for saturated fat (7.9%) and the cereal food group (2.2%).

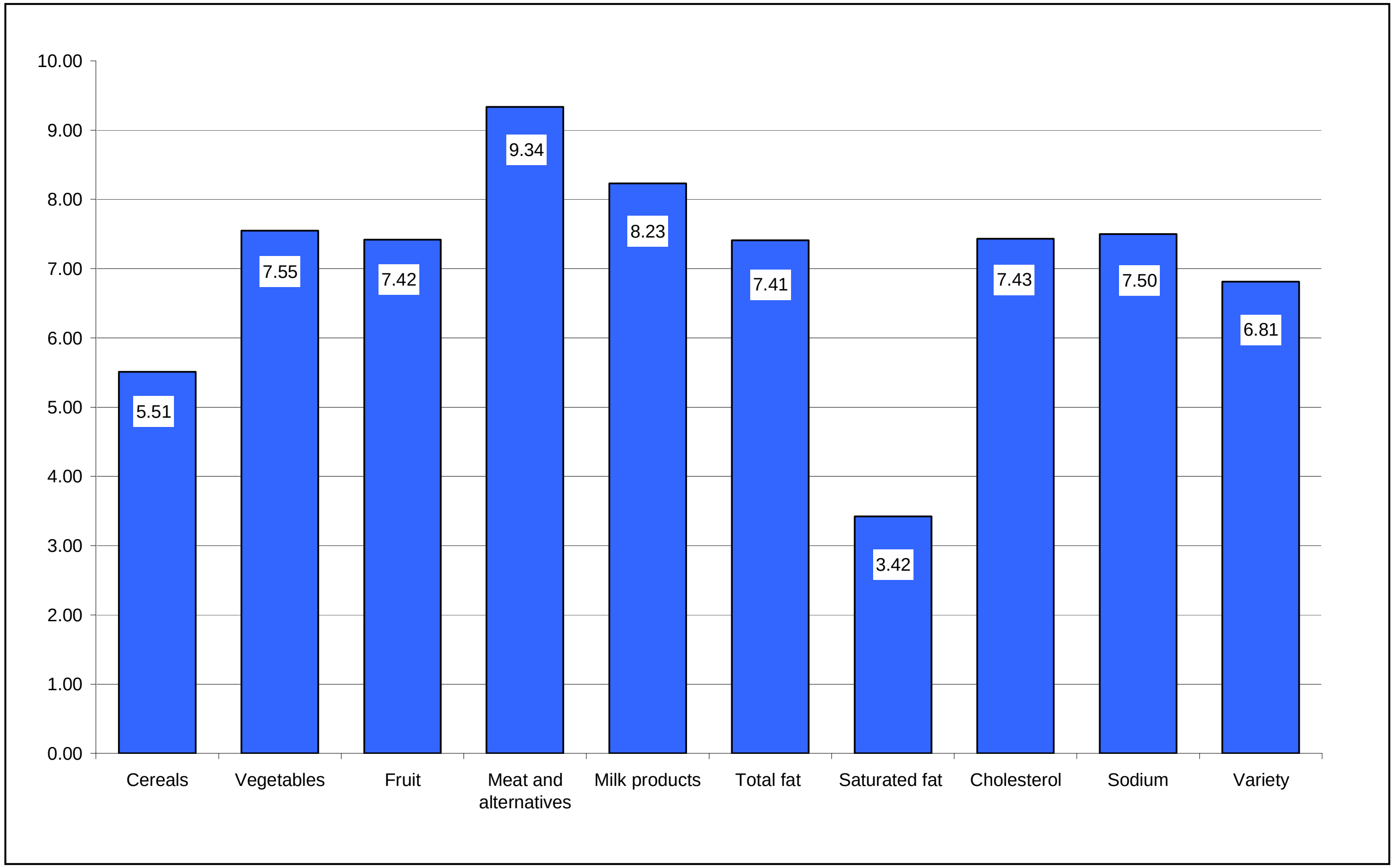


Figure 7 Healthy Eating Index component mean scores

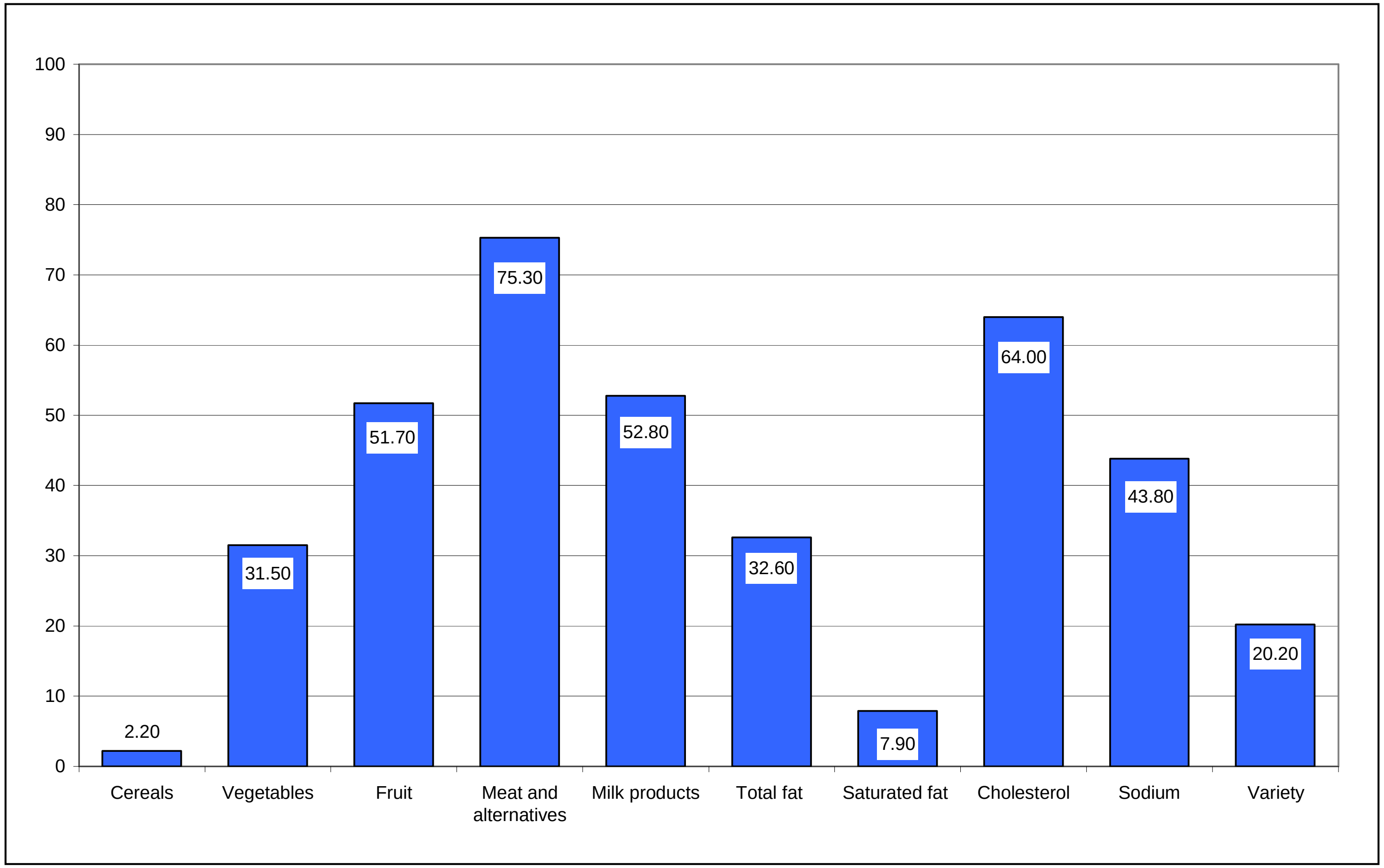


Figure 8 Percentage of the sample scoring a maximum score for each component

6.6.3 Demographic Variation in HEI Scores

The demographic variation in diet quality (HEI score) is presented in Table 25. Females appeared to consume a diet of slightly higher quality than males, and there was some increase with age, although this was not consistent. People who reported to be married or living as married had a higher diet quality than other groups. In this sample, the only significant differences in HEI scores were observed in different education levels. Individuals who had a tertiary qualification consumed a diet of significantly higher quality than those who had not completed high school [$F(3,85)=3.183$, $p=0.028$].

Table 25 Demographic variation in the Healthy Eating Index scores

Characteristics		HEI score	
	n	Mean	SD
Gender			
Female	84	70.89	12.74
Male	5	65.94	10.71
Age			
18-24	35	67.24	13.39
25-34	16	70.87	12.21
35-44	10	74.60	14.68
45-54	16	71.36	9.65
55+	12	75.80	11.60
Marital status			
Single	33	68.57	14.39
Married/living as married	49	72.10	12.00
Separated/divorced/widowed	7	69.81	6.32
Culture			
Australian	62	71.09	13.23
British/English/Scottish/Welsh	5	73.30	8.11
Australian and another culture	10	68.78	12.69
Other	12	68.59	11.73
Number of children			
0	34	71.67	13.26
1	19	69.16	15.18
2	16	70.34	9.80
3	17	70.27	12.64
4+	3	71.19	0.55
Education level			
Completed some high school or less	24	64.99	14.55
Completed high school	22	70.05	11.24
Tech or trade qualification	13	71.24	9.55
Tertiary degree	30	75.25	11.75
Employment status			
Employed full-time	9	71.96	11.49
Employed part-time	14	72.32	6.47
Student	34	68.35	14.00
Homemaker	20	70.48	14.98
Other	12	74.27	10.91

6.6.4 The Role of Nutrition Knowledge in Diet Quality

Individuals with a 'good' diet had a significantly higher knowledge level (μ=78.23, SD=12.01) than those with a diet that 'needs improvement' (μ=69.27, SD=19.97) [$F(1,87)=3.94$, $p=0.05$].

Using a simple test of association (the Pearson Product-Moment correlation coefficient), nutrition knowledge was significantly associated with diet quality (r=0.447, p<0.001). The analysis from Chapter 4 shows that nutrition knowledge varies with age, gender, employment status and education level. Controlling for these variables, the relationship between nutrition knowledge and diet quality remains significant (r=0.316, p=0.003).

To determine the independent influence of nutrition knowledge on diet quality, linear hierarchical regression was conducted. The demographic variables accounted for 15.4% of the variance associated with the HEI score (Model 1). Age and education level appeared to be significant independent predictors of diet quality (p<0.01). Nutrition knowledge was added to the model (Model 2), and results show that nutrition knowledge is a significant independent predictor of diet quality. Nutrition knowledge alone explains 8% of the variance in this diet quality index (Table 26).

Table 26 Summary of hierarchical regression analysis of Healthy Eating Index on demographic variables (Model 1) and demographic variables with nutrition knowledge (Model 2)

	HEI score		
	Unstandardised coefficients		Standardised coefficients
	Beta	SE Beta	Beta
Model 1			
Gender	6.133	5.46	0.112
Age	1.858	0.847	0.220*
Education level	3.164	1.037	0.304**
	R value = 0.392		
	R^2 adjusted = 0.124		
	R^2 value = 0.154**		
Model 2			
Gender	2.591	5.361	0.048
Age	1.335	0.830	0.158
Education level	1.395	1.158	0.134
Nutrition knowledge	0.232	0.078	0.342**
	R value = 0.484		
	R^2 adjusted = 0.198		
	R^2 change = 0.080**		

**p<0.01; *p<0.05

6.7 Discussion

6.7.1 The Application of the HEI in an Australian Setting

The HEI is an index of diet quality developed by the USDA, which includes 10 aspects of the diet considered to be representative of healthy eating. To the author's knowledge, this is the first time the HEI has been applied to international – in this case Australian – nutrition guidelines and food intake data. The aim of this application was to modify the criteria and use the modified index as a measure of compliance with Australian dietary guidelines. There were some assumptions made in the modification of the criteria from the US to the Australian setting, which need to be considered when interpreting these results.

There are two different publications containing nutrition recommendations for the Australian public, both of which are current: the *Food for Health – Dietary guidelines for Australians: A guide to healthy eating* (National Health and Medical Research Council, 2003) and *The Australian Guide to Healthy Eating* (A. Smith et al., 1998). Both publications make recommendations by age and gender for the five food groups, however, there are a few inconsistencies between the two publications worthy of discussion. *The Australian Guide to Healthy Eating* booklet provides two eating plans, and the main difference between the two plans is the recommended serves of cereal foods. In the development of these criteria, the eating plan common to both publications was used.

There were inconsistencies between the serve sizes listed in the two publications. For example, the suggested serves size for breakfast cereal flakes is 1 cup in *The Australian Guide to Healthy Eating* booklet and $1^{1}/_{3}$ cups or 40g in the *Food for Health* booklet. It is a similar case for lentils – one serve is described as $^{1}/_{3}$ cup in *The Australian Guide to Healthy Eating* and $^{1}/_{2}$ cup or 80g in the *Food for Health* booklet. For both these food items, the recommended serve size suggested in the *Food for Health* booklet was used because it provided a specified gram weight, which was more compatible with the FFQ data analysis and writing a SPSS syntax.

Lentils and legumes are listed as food items in both the vegetables and meat and alternatives food groups, but for this calculation they were counted only in the meat and alternatives group. There were some inconsistencies in the recommended serve sizes of vegetables as well; for example, one small potato versus one medium potato. For this calculation, one serve of all vegetables (including potatoes) was taken to be a standard 75g.

The nutrition publications list many food items within a food group, but not as many as contained in the FFQ used in this study. If a food item was not listed in the guideline publications but deemed suitable for a particular food group (by the researcher), then CalorieKing.com.au was used to determine an equivalent serve size, based on kilojoules, or the main nutrient content. For example, two crumpets were considered to be the equivalent of one serve of cereals, and CalorieKing.com.au was used to estimate the weight of the crumpets (100g). This website was also used to estimate a weight, in grams, if the guidelines only stated a household measure (eg a cup, teaspoon).

For some food items, such as meat and fish, the nutrition publications state a range for the recommended serve size, and in the calculation for this index the minimum weight was used. Body mass index or physical activity levels were not available in this study, so more individualised energy requirements could not be determined (this may partially explain the high scoring in the meat component). In the FFQ, a serve of meat was equal to approximately 100g compared to 65g, which was used in the index calculation, therefore, if a respondent reported to consume four serves of meat per week in the FFQ, their total intake per week was equal to 400g. This converts to six serves per week in the index calculation, which is closer to the guideline of one serve per day than the individual's original four times per week as reported in the FFQ. If this version of the HEI is going to be further developed and used for future research in an Australian setting to interpret diet quality, this needs to be considered to improve the accuracy of the reporting and the HEI as a measure of overall quality. Possibly using the mid-point of the guidelines' serve size recommendation would be a more realistic portion size for future calculations. Another possibility to improve the accuracy of the HEI is to revise the FFQ with a more up to date list of food supply, and to have the suggested serve sizes in the FFQ consistent with the nutrition guidelines.

If a mid-point is used for recommended serve sizes, then it may be argued that a mid-point should also be used when a range is given for food group recommended serves. For the cereal food group, the Australian guidelines state a recommended range for serves per day – four to nine for women and six to 12 for men. For this study, the minimum serve was used in the calculation of the HEI. Unlike the results for meat, very few people met the recommended daily intake for cereal foods. If the mid-point was used in the scoring criteria, then even fewer people would have met this recommendation.

Accepting these methodological issues, the results of this study highlight that people are not consuming 'plenty' of cereal foods, as recommended in current guideline publications, suggesting that Australians are not consuming diets in line with public health nutrition recommendations. The poor scores observed for cereal foods could reflect a number of things: possibly people are avoiding complex carbohydrate food sources, they are misreporting their intake, they are underestimating the cereal foods they consume, or they are choosing to consume 'unhealthy' carbohydrates – that is carbohydrate rich foods not listed in the cereals food group in the guidelines, such as pastry in pies or flour in cakes. Data from this study suggests that this could be the case. The macronutrient analysis of this sample's food intake (presented in Table 17 in the previous chapter) suggests that people are consuming carbohydrates in adequate amounts – 44% of their total energy comes from carbohydrates. However, examining intake using this diet quality index suggests only 2% of the sample is meeting the cereals recommendation, which is surprising as cereal foods are a major source of carbohydrates in the diet. Results may also be suggestive of the lasting effects of recent media attention given to high protein diets, and how this has changed people's food choices to avoid the classic complex carbohydrate rich foods such as bread, rice and pasta. Nonetheless, measuring dietary intake in a more comprehensive way, such as using an index to measure compliance with the dietary guidelines, adds significant value to understanding dietary intake patterns. It also allows for quality as well as quantity to be considered in the interpretation.

The Australian guidelines promote wholegrain bread and cereal products, however, the HEI criterion does not differentiate between white and wholegrains, scoring them equally. The latest US dietary guidelines specify that at least half of the grain intake should be wholegrain, and this is reflected in the scoring criteria for the new HEI-2005. In this scoring system, the grains food group has two components (each scored out of five) – one scoring total grain intake in comparison to the guidelines, and the second measuring wholegrain intake as a proportion of total grain intake. This further ensures that the quality as well as quantity of carbohydrate rich foods are taken into consideration in the assessment of overall diet quality.

Overall, about one in four Australians consume diets that could be classified as 'good' or almost consistent with the public health nutrition guidelines. Results from this study show that people are consuming diets rich in saturated fat and low in carbohydrate rich foods, contradicting a number of Australian dietary guidelines, including 'Eat plenty of cereals', 'Include lean meat' and choose 'reduced-fat' dairy products. The study sample was small, comprising of volunteers who were likely to consume 'healthier' diets than the Australian population, however, these results are still concerning. It has been well documented that saturated fat increases the risk of heart disease, therefore at a population level it is vital that individuals are aware of and comply with the nutrition recommendations focussed on reducing saturated fat intake. The Australian Heart Foundation has been providing nutrition education about heart health since the late 1950s, yet from this study it appears many people are still consuming saturated fat in excess. Likewise, there is increasing evidence that fruit and vegetable consumption offers protection against many cancers and heart disease (Mathers, Vos, & Stevenson, 1999), yet about half or less of this sample was meeting the recommended intakes. Nutrition guidelines are based on the best available evidence and aimed at promoting health within a population, therefore monitoring compliance with these guidelines is a valuable exercise.

A measure of diet quality could become a helpful tool to highlight areas for nutrition education programs. This small study found age and education level to be independent influences of diet quality. Using an index of compliance in a national survey could assist in identifying the demographic groups at risk of a lower diet quality, as US population data has consistently shown significant demographic variation in diet quality. If educators were able to identify groups of people at greater risk of poor diet quality, then health promotion efforts could be targeted specifically to meet the needs of such groups. Previous nutrition education interventions have focussed on specific areas of nutrition information and the corresponding dietary marker, yet using a measure of overall diet quality, such as the HEI, in future research could provide a common outcome variable to link a range of nutrition education programs and evaluate their effectiveness in terms of a common behaviour change – that is improving diet quality.

Using the HEI in population based surveys would be a useful way to monitor food intake changes and diet quality in populations over time. The USDA has applied the HEI to intake data since 1989 to evaluate the changes in overall diet quality. Unfortunately, at present Australia does not collect detailed population level food intake data on a regular basis, however, such an index would be useful to monitor diet quality nationally. The use of the diet quality index would not replace the existing dietary intake measures, rather it would complement them and provide a measure of 'whole' diet at a population level.

A common issue faced by nutrition researchers is the lack of a distinct dietary marker to indicate 'healthiness'. Fruit and vegetable intakes and high fat foods are two commonly selected markers, but any single indicator cannot be expected to reflect the complexity of current dietary intake patterns. Unlike a dietary marker, the benefits of a measure like the HEI is that it includes 10 aspects of a dietary pattern, which when combined in an index become a more robust measure of diet quality. A poor score on any one of the components will not result in the misclassification of overall diet quality. While single indicators such as fruit and vegetable consumption are important, it is thought that developing and using a measure with broader scope would provide a more accurate understanding of population dietary intake patterns. And as discussed previously, having a common outcome measure across nutrition research could help to strengthen the evidence base in this research area.

One limitation of the original HEI particularly pertinent in light of the obesity epidemic is quantifying excessive consumption. People who consume large quantities of food are more likely to score higher on the index, and therefore are more likely to have a diet classified as 'good' quality. The original HEI makes no adjustment for consuming more than the recommended serves per day. One rather easy method to account for excess consumption is to replace the maximum criteria cut-off with a bell-shaped scoring system, whereby intakes greater than the recommendations are deducted from the maximum criteria. The new HEI-2005 controls for energy intake by scoring each component as a proportion of total kilojoule intake. It also includes the concept of 'discretionary calories', or what the Australian guidelines may refer to as 'extra foods', which can contribute to excessive kilojoule consumption. This revision improves the index as a measure of diet quality by assessing quality in the context of quantity, and penalising individuals for excessive consumption of energy-dense nutrient poor foods.

The collection of nationally representative intake data in Australia is generally considered well overdue. Forethought into the interpretation and evaluation of the results of such a project would be beneficial. Considering the option to use a comprehensive measure of diet quality, such as the HEI, would be useful for public health research, but would require a level of compatibility with the method used to collect the food intake data and calculation of the index criteria. If a comprehensive measure of diet quality is considered for the next national survey in Australia and beyond, it could allow diet quality to be monitored at a population level, and also extend the knowledge of the relationships between diet quality and risk of disease.

6.7.2 Nutrition Knowledge and Diet Quality

It has been suggested that knowledge may have been disregarded as an influence of dietary intake behaviour due to methodological issues as opposed to theoretical justification. Some of the methodological issues refer to the simplified assessment of knowledge. The previous chapters have partially addressed this by using a comprehensive measure of knowledge and providing some positive support for the relationship between nutrition knowledge and dietary behaviour. There are similar issues in the measurement of dietary intake where measures have included single markers of intake. This chapter used a measure of overall diet quality and provided even stronger support for the role of knowledge in food intake behaviour. Nutrition knowledge was found to be an independent predictor of diet quality and accounted for 8% of the variance associated with intake. While these results are encouraging, they emphasise that knowledge, while important, is only one of many factors influencing behaviour.

6.8 Conclusion

The HEI is a robust measure of diet quality developed by the USDA. The results presented in this chapter have demonstrated how the HEI can be modified to be consistent with the Australian nutrition guidelines and used as a measure of dietary compliance for Australians. While the difficulties encountered and assumptions made in the modification of the index need to be considered, the HEI poses as a useful tool in nutrition research.

In summary, the first part of this thesis has provided a foundation for the longitudinal study which forms the second part of the thesis. The research so far has justified the inclusion of nutrition knowledge in studies examining food intake behaviour. The validated measure of nutrition knowledge provides a useful tool for researchers in this field as it is more comprehensive than existing tools, and is now validated for use in an Australian setting. The development of the modified HEI will also be useful for the Healthy Kids: The Family Way study to interpret parents' dietary intake, and explore the role of parents' diet quality as an influence of children's intake. The interpretation of parents' food intake in this way will be a unique aspect of the Healthy Kids: The Family Way study. Part two of this thesis will examine a number of influences within the family home environment, which have been identified in the literature review (Chapter 2) and shown to influence children's obesity risk, including parents' nutrition knowledge and diet quality. The overarching objective of the Healthy Kids: The Family Way study is to contribute significant knowledge of the family environment as an influence of obesity risk in children by proposing a comprehensive exploratory model of obesity resistance.

7 HEALTHY KIDS: THE FAMILY WAY – METHODOLOGY AND JUSTIFICATION FOR MEASUREMENT TOOLS

7.1 Introduction

As stated in the overall aims of this thesis, addressing the question “Why are some people not obese despite living in an obesity promoting environment?” (Jain, 2005) was the major motivation for this work. While the aetiology of obesity may appear simple – an imbalance between energy intake and expenditure – there are many personal and environmental influences of these behaviours that make addressing the problem more complex than first appears. The lack of effective intervention is evidence of this.

Dietary and physical activity behaviours are interdependent (Baranowski, 2004), both having an important role in weight regulation. Gaining an understanding of the influences of energy intake and expenditure behaviours may help researchers to understand how some individuals are able to maintain a healthy weight and resist obesity, while others are not. This knowledge will help guide the development of more effective obesity prevention strategies.

There has been considerable literature on the determinants of dietary and physical activity habits in adults, but relatively less attention has been given to the influences of these habits in children (Calfas et al., 1991). Children are at a life stage where they are forming behaviours, which may be more malleable and receptive to intervention. For young children, the family home environment is one of the biggest influences on dietary and activity related behavioural development as many of these lifestyle behaviours originate within this setting. As a result, the home environment has become a focal setting for obesity prevention programs.

Due to the complex nature of obesity, it is important that theory or modelling underpins research. Davidson and Birch summarise the various environmental influences on children’s weight status in their Ecological Model of Predictors of Childhood Overweight (2001) (Davison & Birch, 2001a). This model and others (Rosenkranz & Dzewaltowski, 2008) highlight the complexity surrounding obesity, and remind researchers that while obesity may be the result of personal behaviours, 'unhealthy' eating and a lack of exercise, there are strong environmental pressures and/or facilitators that always need to be considered. Models presented in literature to date do not show interactions between factors within the environment and how these in turn can influence an individual's behaviour. This study will use existing knowledge to explore the family environmental influences on children's energy balance behaviours and obesity risk, and also provide insight into the interaction between – and the relative importance of – these environmental factors. A more comprehensive understanding of the family home environment may help to guide the design of effective obesity prevention strategies in the future.

In summary, the focus of this study, Healthy Kids: The Family Way, was to explore the family environment as a determinant of obesity resistance in school-age children. It was a 12-month longitudinal study and the scope was limited to the family home environment. This study aimed to identify characteristics and interactions from within the family home that facilitated children to maintain healthy eating and activity habits and avoid unexpected weight gain – 'unexpected' meaning deviating from the body mass index (BMI) growth chart recommendations.

As highlighted earlier in this thesis in relation to nutrition knowledge and dietary intake, the measurement of human behaviour is challenging. Measurement of child behaviour offers unique challenges. The greatest challenge is to measure behaviour adequately so that it represents 'normal' behaviour but with the least possible burden on the participant to aid compliance. Previous research measuring child and parent behaviours has adopted a variety of methods to capture aspects of the home environment. This chapter provides a detailed description of how each of the family environment constructs was measured, and justification for the measurement tools selected. It also describes the recruitment and data collection methodology for the Healthy Kids: The Family Way study.

7.2 Chapter Aims

The aim of this chapter is to describe the design, recruitment and methodology of the Healthy Kids: The Family Way study.

The chapter objectives are to:

1. describe the recruitment of families involved in the Healthy Kids: The Family Way study
2. describe the methodology employed to conduct the 12-month longitudinal study
3. provide justification for selected measurement tools or techniques for each construct included in the Healthy Kids: The Family Way study.

7.3 Healthy Kids: The Family Way Methodology

7.3.1 Recruitment Procedures

Approval for this study was granted by the Department of Education and Children's Services and the Flinders University Social and Behavioural Research Ethics Committee. Participants from all the recruitment sites volunteered to complete the study questionnaires and provided informed consent.

Socioeconomic differences in food and physical activity related behaviours have been observed in previous research, so schools were purposely recruited to represent a spread of socioeconomic areas. Using the Australian Bureau of Statistics Socio-Economic Indexes for Areas (SEIFA), all local government areas in the Adelaide metropolitan area were ranked by SEIFA score and divided into quartiles, and a local government area was randomly selected from each quartile. The Department of Education and Children's Services website was used to indentify all government primary schools within each of the randomly selected local government areas. Ten schools were randomly selected from each quartile and an information letter was sent to the principals (Appendix 5). This letter was followed by a phone call within two weeks of mail-out, and further follow-up calls were made if required. Of the 40 schools selected, 11 agreed to participate; the remainder declined or principals were not able to be contacted (following a letter, two follow-up calls and providing contact details). Of the participating schools, two were from the lowest socioeconomic status (SES) quartile, and there were three from each of the other quartiles.

The researcher met with the principal or nominated teacher at each school to discuss the study and recruitment process, and to arrange measurement sessions. One week during Term 1 or 2 (2007) was assigned to each school, based on the school's availability. Depending on the number of children at the school, families were offered between three and five afternoons in the assigned week to attend a measurement session.

7.3.2 Recruitment Strategy

The researcher provided the school with parent information letters (Appendix 5), and asked for these to be sent home with all children in Reception through to Year 5. Families volunteered for the study by returning a response slip provided with the information letter to their classroom teacher. In total, approximately 3000 letters were provided to the schools. There was no direct contact with families until they attended a measurement session. One hundred and fifty seven families attended the first measurement session.

A small media piece was placed in the Flinders University magazine and on the institution's website. This article resulted in the recruitment of 12 families.

7.3.3 Data Collection Procedure

Parents and children volunteered to attend one of the measurement sessions offered at their school. The measurement session was held immediately after school in an allocated classroom or gymnasium. At this session, parents and children were briefed about the study before completing the Family Information Booklet and Questionnaire 1 (Appendix 5). Parents completed Questionnaire 1 in their own time with assistance from their child where appropriate. If a parent had more than one child enrolled at the school, they nominated one child to be the focus of the questionnaire. Height, weight and waist circumference were measured in parents and children using techniques consistent with the International Society for the Advancement of Kinanthropometry (Marfell-Jones, Olds, Stewart, & Carter, 2006). Each child's measurements were taken in private with two adults present (the researcher and the child's parent).

Questionnaire 2 (Appendix 5) was mailed out approximately two weeks after the first session, and Questionnaire 3 (Appendix 5) – the final questionnaire – was sent out two weeks following the return of Questionnaire 2. One reminder letter was sent to families if the questionnaire was not returned within a month of being sent out, and then a duplicate questionnaire was sent out the following month if required. No incentives were provided for the completion of questionnaires.

All questionnaires used in this study are presented in Appendix 5. Briefly, Questionnaire 1 contained questions that targeted the parent's knowledge using the previously validated General Nutrition Knowledge Questionnaire (Chapter 3), the child's dietary intake (24-hour recall), the child's physical activity and screen time habits, and the family's demographic characteristics. Questionnaire 2 collected information on the parent's usual dietary intake using the food frequency questionnaire (FFQ) discussed in Chapter 5. Questionnaire 3 contained questions about the family's food and physical activity environments, the parent's activity habits, and a second 24-hour recall of the child's dietary intake. Section 7.4 provides justification for the tools used to measure the various family constructs.

The anthropometric measurements of the children were remeasured approximately 12 months following the initial measurement session. Parents were aware of the follow-up measurement session and were sent a reminder letter three weeks prior to the session. The follow-up sessions were arranged with the school principals/nominated teachers and conducted at the schools during school hours. Height, weight and waist circumference of the children were remeasured in a public space, like the school corridor, but with some privacy (results were not visible to other children). Parents had the opportunity to withdraw their child from the study at any stage without consequence.

7.3.4 Recruitment Flowchart

One hundred and fifty seven families attended the first session, however, three did not stay to complete Questionnaire 1 due to reported time constraints. Eighty two percent of the parents who completed Questionnaire 1 completed and returned Questionnaire 2, and 69% of these went on to complete Questionnaire 3. Parents had the right to withdraw their family from the study at any stage without consequence.

At the 12-month follow-up session, 20 children were not remeasured – reasons including change of school, absence on the day of measurement, and two parents contacted the researcher because their child was self-conscious about their weight. Figure 9 describes the participation numbers throughout the study.

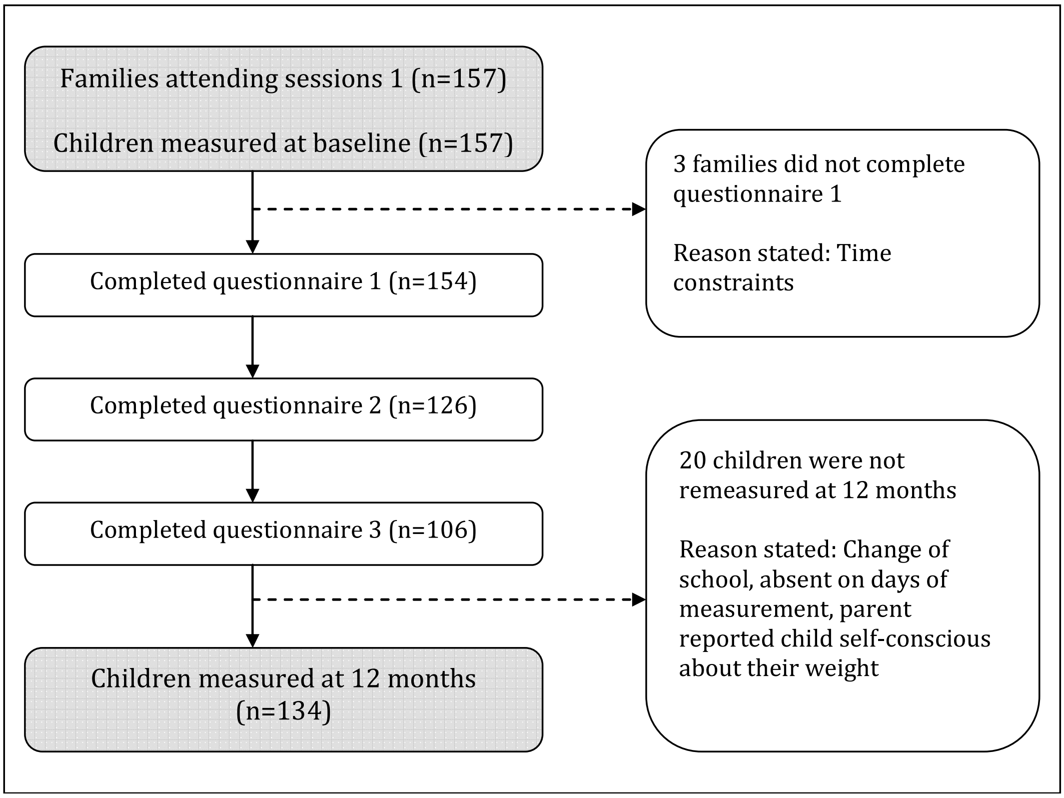


Figure 9 Flowchart of participation throughout the 12-month study

7.3.5 Data Management

On completion of Questionnaire 1, the researcher briefly checked all questionnaires for incomplete pages. In cases where pages had been inadvertently missed, participants were asked to complete the missing information.

The researcher entered data from Questionnaire 1 into the Statistical Package for Social Sciences (SPSS) 16.0 (SPSS for Windows 16.0 Chicago: SPSS Inc.), and the data from Questionnaires 2 and 3 was entered by a commercial data entry company. All data was double entered and checked for consistency.

The children's 24-hour dietary intake information was entered by the researcher and analysed using Foodworks Professional (Xyris Software Pty Ltd). The nutrients analysis from Foodworks was exported to SPSS (SPSS for Windows 16.0 Chicago: SPSS Inc.), and the examination of all data was conducted using SPSS.

7.4 Healthy Kids: The Family Way – Justification for Measurement Tools

The measurement of human behaviour in a research setting requires consideration of the trade-off between accuracy of data and participant burden. The design of this study required a questionnaire format to assess the selected constructs in parents and children. There are a range of questionnaires available to measure constructs, such as dietary intake and physical activity habits, and these can differ between adults and children. The following section describes the justification for the inclusion of family environment constructs and the selection of assessment tools.

7.5 Individual Measures

As obesity resistance is the underlying theme of this research, the key outcome measure is change in weight status in children and the two main behaviours that precede this – energy intake and energy expenditure. In adults, obesity resistance can be described as weight maintenance and defined as a change in body mass (kilograms), because adult height is assumed to be constant. In children it is more difficult as consideration needs to be given to their age, stage of development, and the different timing of growth spurts between boys and girls.

7.5.1 Anthropometric Measurements

As discussed in the literature review, body mass index (BMI) is widely accepted as a measure to assess overweight and obesity in adults, and the National Health & Medical Research Council (NHMRC) recommends that BMI is a "reasonable, easily determined surrogate measure for adiposity in children" (National Health & Medical Research Council, 2003b). To account for growth patterns in children, BMI values are compared to age and sex reference values. In a research setting, it is recommended that BMI is compared with a reference data set and reported as a z-score (National Health & Medical Research Council, 2003b). In absence of an Australian reference data set, BMI in this study was converted to a BMI z-score using the United States Centers for Disease Control and Prevention's (CDC) 2000 reference data provided as a computer program (Child Growth Foundation, London, United Kingdom) (Pan & Cole, 2002-07).

Because the BMI levels at which the risk of adverse health effects increase are unknown in children, cut-offs based on the adult point of 25 for overweight and 30 for obesity have been developed (Cole et al., 2000). For categorical analysis, participants in this study were classified as healthy weight, overweight or obese using the International Obesity Task Force definitions (Cole et al., 2000).

A measure of waist circumference represents central or abdominal adiposity and in adults is strongly correlated with risk of disease. Waist circumference is considered a good indicator for a range of health problems. To reduce the risk of disease, it is recommended that individuals aim for a waist circumference of less than 102cm for men and 88cm for women (National Health & Medical Research Council, 2003a). Measuring waist circumference in children is less common than in adults, however, there is enough evidence to suggest that waist circumference is positively associated with cardiovascular risk in children, and that childhood waist circumference tracks well into measures of adiposity in adults (National Health & Medical Research Council, 2003b). The NHMRC clinical guidelines for the management of obesity in children states that "waist circumference appears to be the best clinical determinant of truncal obesity" and “can be used for longitudinal assessment” in the management of obesity in children (National Health & Medical Research Council, 2003b). There is not enough evidence to have waist circumference cut-offs for children, but change in an individual’s waist circumference is a useful measure of change in abdominal fatness over time.

Anthropometric measures of height, weight and waist circumference for parents and children in the Healthy Kids: The Family Way study were taken at baseline. Children were remeasured 12 months following baseline. Changes in BMI z-scores and waist circumferences were calculated and used as a marker of body composition change in child over the period of this study.

7.5.2 Energy Intake

When measuring dietary intake, it is important to capture ‘usual’ intake, which can be difficult using a questionnaire format. A common method to assess usual intake in a community setting is with a FFQ. As discussed in Chapter 5, there are many reported advantages and limitations to this method, however, a FFQ is the recommended method to investigate long-term usual intake (Kroke et al., 1999). For this study, parents completed the FFQ discussed in Chapter 5 and presented in Appendix 4. Each parent’s dietary intake was interpreted using the modified Healthy Eating Index (HEI) presented in Chapter 6.

In the assessment of children’s dietary intake, researchers are faced with the same difficulties as with adults, but with the added challenge of children’s cognitive abilities, therefore children’s age becomes an important consideration when choosing a dietary collection method. The ability to self-report dietary intake is only developed in adolescence (M. B. E. Livingstone & Robson, 2000), so for younger children, parent recall is essential. Parental recall is most accurate for foods consumed within the home, but less accurate for foods consumed outside the home. If children assist with recording food intake, the novelty of participating in the recall may help to increase compliance with the data collection process (M. B. E. Livingstone & Robson, 2000).

This study involved primary school-age children, and therefore parental assistance with the recall was deemed essential. A FFQ requires the conceptualisation of food intake over a period of time, which is less appropriate for children than adults. A food recall requires a person to recall all foods consumed over a shorter period of time (usually 24 hours), and is therefore considered more suitable for dietary assessment in children. The major limitation with this method is that the 24-hour period may not reflect usual intake, and therefore the standard practice is to collect at least two days' worth of dietary intake information. For this study, parents were asked to complete multiple 24-hour recalls of their child's intake, including all foods and drinks consumed both inside and outside the home. The format followed a standard process with parents asked to list the approximate time of consumption, description of the food or drink (including food name, type, brand, cooking method and source), and the amount consumed. To increase compliance, children were strongly encouraged to assist parents in completing both 24-hour recalls.

7.5.3 Energy Expenditure

Like energy intake, there is no gold standard approach for measuring physical activity, therefore creating and validating questionnaires (Aaron et al., 1995) and making national and international comparisons are difficult (Bassett, 2003). The absence of such a measure has resulted in the development of the International Physical Activity Questionnaire (IPAQ). The IPAQ was developed and tested for suitability (validity and reliability) to measure activity levels in a range of populations, across cultures and language groups. Australia was one of the 12 countries used in the validation process. The IPAQ is a self-reported measure of physical activity designed for use in people aged 16 to 65. It collects information about organised and planned physical activity, as well as occupational activity, domestic and transport-related activity, and sedentary behaviour (Craig et al., 2003).

There are two versions of the questionnaire; a short version made up of nine items and a longer version of 31 items. The reliability has been assessed using test-retest measures (eight to 10 days apart) (n=1900), and was found to be generally good. For the longer questionnaire, the majority of the Spearman correlation coefficients were more than 0.70 (range 0.46-0.96), and for the short version most exceeded 0.65 (range 0.32-0.88). The two forms of the questionnaire showed reasonable agreement (correlation between the long and short forms of 0.67). Criterion validity was assessed against accelerometry, and overall there was fair to moderate agreement between the two measures, and both the long and short forms performed equivalently (Craig et al., 2003). Qualitative evaluation of the IPAQ suggested the short form was received more positively by participants than the longer form (Craig et al., 2003).

Furthermore, due to the large number of constructs included in this study, to minimise participant burden as much as possible, the short version of the IPAQ was used to measure usual physical activity for parents. Since the original development of the IPAQ, it has been used in adolescents (Guedes, Lopes, & Guedes, 2005), but unfortunately not in younger children, therefore an alternative method of assessment was required for children in this study.

There is generally a trade-off between accuracy and practicality in the measurement of physical activity, which is further complicated when measuring activity in children, as their activity tends to be much less structured than adults (Y. Miller, 2004). In choosing a method to measure children's physical activity habits, it is important to consider the type of activity and how often and for how long children participate in the activity, and try to reflect 'usual' activity as best as possible.

Ideally, the questionnaire would be self-reported, however, like dietary recall, cognitive competence in young children limits their ability to accurately recall and report this type of information (Sallis, Bruono, Roby, Carlson, & Nelson, 1990). It has been shown that young children's ability to recall activity is better when asked only to report "yesterday's physical activity", however, previous day recall may not reflect usual or habitual activity patterns. More representative of usual activity patterns are recalls for an extended period of time (seven days to 12 months) (McCormack & Giles-Corti, 2002), but parental assistance is vital for this type of recall.

A review prepared for the Western Australian Physical Activity Taskforce Evaluation and Monitoring Group summaries literature on self-reported measures of physical activity in children (McCormack & Giles-Corti, 2002). The authors of this report conclude that for the assessment of habitual activity in young children, the Physical Activity Questionnaire for Children (PAR-C) (Crocker et al 1997) and the Children's Leisure Activity Study Survey (CLASS) (Telford, Salmon, Jolley, & Crawford, 2004) show the greatest consistency. The CLASS questionnaire was selected to measure children's activity levels in this study. It is a checklist of 31 physical activities (20 moderate intensity activities and 11 vigorous activities), includes participation in a usual week (Monday to Friday) and on weekends (Saturday and Sunday), and is validated against accelerometry. This parent reported questionnaire is shown to be a reliable measure of the type, frequency and duration of children's usual physical activity (Telford et al., 2004).

7.6 Parental Characteristics

7.6.1 Knowledge

General nutrition knowledge

In the first part of this thesis provides evidence for the inclusion of nutrition knowledge in the assessment of the family environment as knowledge was found to predict dietary intake in adults, and parent intake is a known predictor of children's intake. A discussion of the measurement of knowledge is presented in Chapter 3. This study uses the modified and validated Australian version of the GNKQ (Appendix 2) to measure parents' nutrition knowledge.

Physical activity knowledge

Very few studies have examined the role of knowledge in relation to physical activity participation (Morrow, Krzewinski-Malone, Jackson, Bungum, & FitzGerald, 2004). Morrow and colleagues (2004) developed a questionnaire that assessed adults' knowledge of American physical activity recommendations. The questionnaire had moderate internal reliability (Kuder-Richardson value of 0.59) and demonstrated content-related validity (Morrow et al., 2004). There are two parts to the questionnaire – the first assesses knowledge of the American physical activity guidelines, and the second assesses knowledge of different exercise intensities and health benefits. For the purpose of the Healthy Kids: The Family Way study, the Morrow questionnaire was modified to reflect Australian physical activity guidelines for adults (Department of Health and Ageing, 1999) and children (Department of Health and Ageing, 2004). In particular, the Australian physical activity guidelines for children has two key messages – children need at least 60 minutes of moderate to vigorous physical activity every day, and children should not spend more than two hours a day using electronic media for entertainment (Department of Health and Ageing, 2004). These questions were added to the Morrow questionnaire.

The Active Australia campaign was a health promotion program aimed at increasing the Australian population's understanding of key physical activity messages. The effectiveness of the campaign was measured using five key questions relating to general public health messages (Armstrong, Bauman, & Davies, 2000). The five questions from the Active Australia evaluation were added to the modified version of Morrow and colleagues' questionnaire to complete the assessment of parental physical activity knowledge. A copy of the questionnaire is included in Appendix 5.

7.6.2 Parenting Styles

General parenting practices

Parenting styles have consistently been thought to enhance the development of socially appropriate behaviours (Robinson, Mandleco, Olsen, & Hart, 1995), and linked to the development of obesity-related behaviours (Rhee, Lumeng, Appugliese, Kaciroti, & Bradley, 2006).

Baurmind's authoritative, authoritarian and permissive typologies are widely used models of parenting styles (Baumrind, 1971). A common method of assessing Baurmind's three main typologies has been using questionnaires reported by adolescents in relation to their parents' parenting style. Younger children are unable to conceptualise parenting style and therefore these methods of assessment are not appropriate. Robinson and colleagues (1995) have developed a self-reported scale specifically designed to be completed by parents to identify their own parenting styles consistent with Baurmind's authoritative, authoritarian and permissive typologies.

The General Parenting Practices Questionnaire is a 62-item scale developed using factor analysis from more than 130 items and completed by 1251 parents (Robinson et al., 1995). This scale was specifically designed for use in parents of preschool and school-age children. The tool can be used with both mothers and fathers. Internal reliability was assessed using Cronbach's alpha and ranged from 0.75 to 0.91 (Table 27).

Following a formal ethical review of all questionnaire items used in the current study by the Department of Education and Children's Services, it was suggested that a number of questions (implied actions of anger or physical violence) included in the original 62-item scale were inappropriate to ask parents. As these items were not the focus of the study, seven items were removed, leaving a 55-item scale assessing general parenting styles (Appendix 5). Table 27 shows the reliability measures (Cronbach's alpha) from Robinson's original questionnaire and the modified version used in this study. The Cronbach's alpha coefficients for the modified questionnaire were comparable to the original, ranging from 0.74-0.86.

Table 27 Internal reliability (Cronbach's alpha) for the General Parenting Practices Questionnaire and the modified version for the Healthy Kids: The Family Way study

	Robinson et al. (1995) 62 items	Current study 55 items
Authoritative style	0.91 27 items	0.86 26 items
Authoritarian style	0.86 20 items	0.82 15 items
Permissive style	0.75 15 items	0.74 14 items
Cronbach's alpha range	0.75-0.91	0.74-0.86

Child feeding practices

The Child Feeding Questionnaire (CFQ) is a self-reported measure to assess parental beliefs, attitudes and practices regarding the feeding of their children (Birch et al., 2001). The questionnaire was developed with a focus on obesity risk. The CFQ is intended for use with parents of children aged two to 11, and is designed to assess aspects of child feeding perceptions, attitudes and practices in parents, and their relationships to children's development of food acceptance patterns, controls of food intake and obesity (Birch et al., 2001). The conceptual framework of this questionnaire centres on proposed ideas of Costanzo and Woody, who suggest that parenting styles differ between parents. They also suggested that parents who have greater concerns about health, weight and related behaviours will exert greater external control over the children's eating, influencing the children's self-control and responsiveness to internal cues (Costanzo & Woody, 1985).

The seven factors included in the questionnaire are: perceived feeding responsibility, perceived parent weight, perceived child weight, concerns about child weight, restriction, pressure to eat and monitoring. The CFQ is a reliable and valid tool, and is frequently cited in studies about parenting and food-related behaviours relevant to obesity development.

Table 28 shows the internal reliability (Cronbach's alpha coefficients) for the CFQ published by Birch and colleagues and for the Healthy Kids: The Family Way study sample. The range for the original questionnaire was 0.70-0.92, and for this study was 0.65-0.88. The Cronbach's alpha coefficient for the 'Pressure to eat' factor was slightly below the generally accepted value of 0.70, however, overall the internal reliabilities were similar to the original questionnaire.

Table 28 Internal reliability (Cronbach's alpha) for the Child Feeding Questionnaire (Birch et al., 2001) and for the Healthy Kids: The Family Way sample

CFQ section (number of items)	Birch et al (2001)	Current study
Perceived responsibility (3)	0.88	0.70
Concern about child weight (3)	0.75	0.80
Restriction (8)	0.73	0.81
Pressure to eat (4)	0.70	0.65
Monitoring (3)	0.92	0.88
Range	0.70-0.92	0.65-0.88

7.6.3 Food Involvement

Bell and Marshall describe food involvement as the level of importance of food in a person's life (Bell & Marshall, 2003), and suggest food involvement may directly influence food choices and the healthiness of a person's diet (Bell & Marshall, 2003). They developed the Food Involvement Scale (FIS), a 12-item scale with two sub-scales – 'Set and Disposal' and 'Preparation and Eating' – with items relating to food acquisition, preparation, cooking, eating and disposal. The scale was validated and showed good face and predictive validity. It demonstrated good test-retest reliability (correlation coefficients ranged from 0.75-0.85 for the two sub-scales for two and eight week retests) (Bell & Marshall, 2003). Parental food involvement was measured in the Healthy Kids: The Family Way study.

7.6.4 Food Environment

A number of domains of the family food environment were measured using questions designed and developed by Karen Campbell for the Children and Family Eating Study, presented in her doctoral thesis titled *Family food* *environments as determinants of children's eating: Implications for obesity prevention* (K. Campbell, 2004) and a subsequent paper (K. Campbell, Crawford, & Ball, 2006). The quantitative measures were based on qualitative interviews with parents of five to six year-old children from high and low SES areas in Victoria, Australia. The interviews elicited parental attitudes and beliefs about the influences of their child's eating habits and family food environment. From this work, Campbell derived questions aimed to measure aspects of the family food environment. The proposed factors included questions about usual food availability, parental perception of the adequacy of their child's diet, opportunities for parental modelling of eating behaviours, opportunities for parental modelling of food-related behaviours, parental views on meal preparation, meal preparation practices and television interruptions.

Factor analysis was conducted to determine the food environment constructs to be used in the structural equation modelling for the Healthy Kids: The Family Way study, and the results are briefly described in the following section.

Opportunities for modelling of eating behaviours (nine items)

The opportunities for parents' modelling of eating behaviours were assessed using the eight items designed by Campbell (2004). Parents responded on a Likert scale, indicating their level of agreement with the statement, ranging from 1 for 'strongly disagree' through to 5 for 'strongly agree'. Frequency of family meals has been associated with positive dietary behaviours, such as higher intakes of fruit and vegetables (Fitzpatrick et al., 2007; Gable & Lutz, 2000; Gillman et al., 2000; Larson et al., 2007; Neumark-Sztainer et al., 2003), and less fried foods (Gillman et al., 2000) and soft drinks (Gillman et al., 2000; Larson et al., 2007; Neumark-Sztainer et al., 2003). Because of this observed association between frequency of family meals and dietary intake, one item was added to Campbell's scale – 'How often does your whole family sit down together for an evening meal?'. Parents responded with their frequency on a scale of 1 for 'never' through to 5 for 'four or more times per week'. The statements are listed in Table 49.

Opportunities to model food-related behaviours: Meal preparation – parents' views (five items) and practices (nine items)

Campbell's questions were used to measure these two constructs: parental meal preparation view and meal preparation practices. Parents' meal preparation views were assessed by five items (Table 49). Again, parents responded on a Likert scale indicating their level of agreement with the statement, ranging from 1 for 'strongly disagree' through to 5 for 'strongly agree'.

Parental meal preparation practices were assessed using seven items designed by Campbell (K. Campbell, 2004), which are listed in Table 49. Adult food involvement has been associated with healthier dietary patterns (Bell & Marshall, 2003). Children often imitate their parents' behaviours, therefore two questions were added to this section to try and capture children's involvement in meal preparation – 'How often is your child involved in making their own breakfast?' and 'How often is your child involved in making their own lunch?'. Parents reported the frequency of these behaviours from 1 for 'never' through to 5 for 'four or more times per week'.

Perceived adequacy of the child's diet (six items)

Parents' perceptions of the adequacy of their child's diet, particularly in regard to their fruit and vegetable intake, was assessed using six items (Table 49). Parents responded with their level of agreement to statements on a Likert scale, ranging from 1 for 'strongly disagree' through to 5 for 'strongly agree'.

Perceived food availability (eight items)

Again, this was assessed using questions developed by Campbell (K. Campbell, 2004). This construct addressed parents' perceived availability of fruit and vegetables, and barriers to buying them, such as cost and family food preferences (Table 49). The Likert scale was used and parents responded with their level of agreement to the statement.

Television exposure (two items)

Two questions in this study assessed family practices regarding watching television during meal time (Table 49). One question included by Campbell about the influence of food advertising on children's food habits was excluded because the role of food advertising as an influence on children's eating habits was outside the scope of this study.

7.6.5 Physical Activity Environment

There have been few tools developed measuring the food environment as an influence of food intake, and measurement of the physical activity environment has been even more scarce. There are few tools that measure the physical activity environment to the same level of detail as Campbell's Family Food Environment scale. It is thought that the reported relationships between the home environment and children's dietary behaviour may also influence children's activity habits. A detailed measure of the home environment in relation to physical activity was required, therefore, instead of trying to create a new scale, the Healthy Kids: The Family Way study used the existing questionnaire items and modified them to address physical activity habits, behaviours and environment within the family home. The measurement of the physical activity environment was therefore based on the Family Food Environment scale (K. Campbell, 2004) and the FIS (Bell & Marshall, 2003).

Opportunities for parent role modelling of physical activity behaviours (eight items)

These were based on Campbell's questions about role modelling of food-related behaviours. Some examples of how the questions were modified include: 'Adult work schedules often make it difficult to have breakfast together' being altered to 'Adult work schedules often make it difficult to have time to play or be active together' and 'I am satisfied with how often my family eats the evening meal together' becoming 'I am satisfied with how often my family does physical activities together' (Table 52).

Opportunities to model physical activity related behaviours: Activity preparation – parents' views (five items) and practices (six items)

Again, Campbell's questions relating to parental food preparation views and practices were altered to cover physical activity. Parents' views of preparation of physical activity were assessed with five items. Examples of the questions can be seen in Table 52.

Similarly, six items about meal preparation practices were adjusted to be about physical activity (Table 52). Both constructs used similar scales to the food environment constructs for agreement with statements and reporting the frequency of behaviours.

Physical activity involvement (12 items)

The 12 items from the FIS (Bell & Marshall, 2003) were modified to focus on parents' physical activity involvement. The items are listed in Table 52. The response scale was consistent with the FIS – parents responded on a scale of 1 for 'disagree strongly' to 7 for 'agree strongly'.

7.7 Discussion

The Healthy Kids: The Family Way study is based on an extensive literature review of factors from within the family environment that influence children's dietary and activity habits and weight status. One unique aspect of the study is the inclusion of factors from both sides of the energy balance equation – that is, family influences on children's dietary intake, physical activity, and sedentary behaviours. The decision to include a large number of dependent variables was deliberate, despite the increased participant burden potentially limiting the sample size. This risk was considered, however, the opportunity to explore the family environment in a more comprehensive manner was deemed of greater value.

The study was voluntary in nature, and while attempts were made to optimise response rates, no incentives were offered to participants, and no contact was made with interested participants until they attended their first measurement session. However, beginning from this point of contact, attempts were made to optimise retention, and these strategies were guided by literature. For example, personalised letters were sent to participants, colour ink was used to make documentation more appealing, reply paid envelopes were provided (Edwards et al., 2002), and written reminders (Asch, Jedrziewski, & Christakis, 1997) and follow-up copies of questionnaires were sent to non-respondents (Edwards et al., 2002). Despite these efforts, there was a 16-19% drop-out rate between questionnaires. Eighty-five percent of the original sample of children were remeasured at the follow-up session.

The Healthy Kids: The Family Way study was designed to be exploratory in nature, and therefore no feedback or education could be given to participating families until the one-year follow-up session was complete so that there was no direct influence on the natural tracking of children's weight. It is known that studies which address issues of a sensitive nature (such as weight or the family home) without monetary rewards have lower participation rates (Edwards et al., 2002). This provides additional explanation for the small sample size of this study, and as a result, it should be recognised that this sample is likely to show bias in respect to participants' interest in health, weight and children's wellbeing. For this study, there is no way to assess the motivation of non-respondents, however, it may be assumed that their interest in health is lower than the participants.

To ensure families across the socioeconomic spectrum of Adelaide were represented in the study, the researcher tried to recruit schools from lower socioeconomic areas across the metropolitan area. The response rate from school principals and families from schools in lower SES areas was generally lower than those from schools in higher SES areas. It is difficult to recruit people from socioeconomic disadvantaged backgrounds as they are least likely to respond to and participate in survey research (Turrell & Najman, 1995). Lengthy self-administered mailed questionnaires are not ideal to capture information from lower SES groups (Turrell & Najman, 1995), but with limited resources available, this was the chosen format for this study. The multi-stage mail survey design required parents to be interested and motivated enough about the content to complete and return two questionnaires. Across all the recruitment areas, it is likely the more motivated people have participated, therefore the small sample is unlikely to be representative of the wider Adelaide or Australian population. As a result, the data about dietary intake and physical activity potentially overestimates the 'true' picture – that is, it purports a healthier profile than what is actually occurring within the general community. The magnitude of demographic variability in the food and physical activity related behaviours measured will be underestimated, therefore interpretation of the results must be undertaken with caution.

Where possible, the results of this study will be compared with nationally representative data, such as Australian Bureau of Statistics information about demographics, weight status and obesity trends in Australia (Armstrong et al., 2000; Australian Bureau of Statistics, 1998); national data in adults from the National Nutrition Survey (Australian Bureau of Statistics & Department of Health and Family Services, 1997) and the national physical activity survey (Armstrong et al., 2000); and data in children from the Australian National Children's Nutrition and Physical Activity Survey (Commonwealth Scientific Industrial Research Organisation (CSIRO) et al., 2008). The primary intention of the Healthy Kids: The Family Way study was to develop a model of family factors contributing to obesity resistance in children. It is expected that this model will be further tested in nationally represented Australian population samples and used to guide future obesity prevention research.

7.8 Conclusion

An extensive literature review guided the development of the Healthy Kids: The Family Way study. This chapter justified the inclusion of characteristics of the family environment that were measured, and provides rationale for the selection or development of measurement tools.

The following two chapters provide a description of the data collected about families that participated in the study. The findings will contribute to and build on existing knowledge about the family environment in relation to the prevention of obesity in children. The analysis will provide the foundation for the structural equation model presented in Chapter 10.

8 HEALTHY KIDS: THE FAMILY WAY, RESULTS PART 1 – PARENT AND CHILD CHARACTERISTICS

8.1 Introduction

The following three chapters present the results of the Healthy Kids: The Family Way study. Chapter 8 contains descriptive statistics of the parents and children involved in the study and Chapter 9 describes their family environments. Together these chapters form the foundation for the development of the model presented in Chapter 10, describing the predictors and interactions between influences of children's dietary and activity behaviours and their weight status.

This chapter summarises the demographic characteristics of the families. It describes the anthropometric, dietary intake and energy expenditure habits of the parents and children, and examines the parents' knowledge related to nutrition and physical activity. The demographic variation within and bivariate correlations between these outcomes are also explored.

8.2 Chapter Aims

The overall aim of this chapter is to describe in detail the families involved in the Healthy Kids: The Family Way study.

The aims of this chapter are to:

1. describe the demographic characteristics of the households
2. describe the anthropometric measurements of the sample
3. describe the self-reported dietary intake and activity levels of the sample
4. explore the nutrition and physical activity knowledge of parents
5. explore associations between demographic, anthropometric, energy balance and knowledge.

8.3 Methods

The methodology for this study is discussed in detail in Chapter 7. Data was entered and analysed using the Statistical Package for Social Sciences (SPSS) 16.0 (SPSS for Windows 16.0 Chicago: SPSS Inc.). Descriptive statistics were used to describe the characteristics of the sample. Independent samples t-tests and Pearson Product-Moment correlation coefficients were used to explore demographic variations within and relationships between constructs. The relationships between the demographic variables were investigated using Pearson correlation coefficients for the continuous variables (age, education level, annual income and number of children), independent samples t-tests for the dichotomous variables (gender and culture), and one-way analysis of variance for categorical variables (marital and employment status).

The results from this study were examined and compared, where appropriate, to findings from national surveys such as the Australian Bureau of Statistics (ABS) census data (Australian Bureau of Statistics, 2004), the Physical activity patterns of Australian adults (Armstrong et al., 2000), the National Nutrition Survey (Australian Bureau of Statistics & Department of Health and Family Services, 1997) and the Australian National Children's Nutrition and Physical Activity Survey (Commonwealth Scientific Industrial Research Organisation (CSIRO) et al., 2008).

8.4 Results

8.4.1 Descriptive Characteristics of the Sample

Data was collected from 157 families recruited from schools within the Adelaide metropolitan area. Household demographic information was reported by parents and is presented in Table 29.

The majority of parents completing the questionnaires were mothers (92.4%) aged between 35 and 44 (63.7%), married or living as married (80.9%), and reported being Australian (75.2%). It was most common for families participating in the study to comprise of two children (52.9%). One in five families had three children (19.1%) and about 15% had one child (15.3%).

There was a variation in the level of formal education completed by parents – 42% had tertiary qualifications, 22.3% had technical or trade qualifications, and 22.3% had completed high school or less. Approximately two-thirds of the sample were employed; 51% on a part-time basis and almost 17% on a full-time basis. About one in five parents (21.7%) were full-time homemakers, and those remaining (10.8%) were either studying, unemployed, retired or unable to work, or did not provide this information. The estimated annual household income and the Socio-Economic Index for Areas (SEIFA) distributions were relatively similar. About 40% of the sample reported their household income to be greater than $78,000 per annum, and the same proportion lived in suburbs in the highest SEIFA quintile. The four lower income brackets and SEIFA quintiles were relatively evenly represented in this sample.

Table 29 Parent and household demographic characteristics (n=157)

Characteristics	n	(%)
Gender		
Female	145	92.4
Male	12	7.6
Age		
25-34	28	17.8
35-44	100	63.7
45+	26	16.6
Missing	3	1.9
Marital status		
Single	14	8.9
Married/living as married	127	80.9
Separated/divorced/widowed	12	7.7
Missing	4	2.5
Culture		
Australian	118	75.2
Other	39	24.8
Education level		
Some high school or less	17	10.8
Completed high school	35	22.3
Tech or trade qualification	35	22.3
Tertiary degree	66	42.0
Missing	4	2.5
Employment status		
Full-time	26	16.6
Part-time	80	51.0
Home duties	34	21.7
Other (student, unemployed, retired/disabled or too ill to work)	12	7.6
Missing	5	3.2
Estimated annual household income		
Less than $20,800	15	9.6
$20,800-$36,399	25	15.9
$36,400-$51,999	18	11.5
$52,000-$77,999	28	17.8
$78,000+	63	40.1
Missing	8	5.1
Suburb SEIFA Quintile		
1	30	19.1
2	26	16.6
3	18	11.5
4	20	12.7
5	63	40.1
Number of children		
1	24	15.3
2	83	52.9
3	30	19.1
4+	15	9.5
Missing	5	3.2

8.4.2 Parents' Anthropometric Information

The mean body mass index (BMI) for the male and female parents was very similar; 25.43 for males and 25.34 for females. The average weight circumference was 90.29 for males and 85.87 for females (Table 30).

Table 30 Summary of parents' anthropometric measurements

Anthropometric measurement		Mean	SD	Min	Max
Body mass index	Male	25.43	3.77	17.82	30.72
	Female	25.34	5.32	17.57	56.44
	Sample	25.34	5.20	17.57	56.44
Waist circumference	Male	90.29	12.25	75.00	113.00
	Female	85.87	14.61	65.00	175.00
	Sample	86.21	14.46	65.00	175.00

The World Health Organisation's international classification cut-offs were used to classify parents' body sizes based on their BMIs and waist circumferences. For BMI, a value less than 25 is classified as a healthy weight, 25 to less than 30 is classified as overweight, and 30 or more is obese. Table 31 shows that 57.3% of the parents were a healthy weight or less, 27.4% were overweight and 15.3% were obese.

Table 31 Classification of parental Body Mass Index (BMI) and waist circumference using the World Health Organisation cut-offs

Weights status classification		Frequency (n)	Percentage (%)
BMI	Healthy weight or less (BMI<25)	90	57.3
	Overweight (BMI ≥25 and <30)	43	27.4
	Obese (BMI ≥30)	24	15.3
Waist circumference			
	Low risk (males <102,females <88)	97	61.8
	High risk (males ≥102, females ≥88)	60	38.2

The recommendations for waist circumference measurements are gender specific. Low risk for males is a circumference of less than 102cm, and for females it is less than 88cm, while a high risk is greater than or equal to these values. As seen in Table 31, 61.8% of the parents in this study had a waist circumference which would be considered 'healthy' or low risk, while 38.2% were high risk.

Demographic variations in parent anthropometric measurements

The relationships between the demographic variables and anthropometry were investigated using Pearson Product-Moment correlation coefficients, independent samples t-tests, and one-way analysis of variance. There was a significant, small negative correlation between parent BMI and level of education [$r=-0.175$, $n=153$, $p<0.05$], meaning parents with less formal education had higher BMI values. All other demographic variables had no significant influence on parents' BMI.

There was a significant small negative correlation between waist circumference and level of education [$r=-0.159$, $n=153$, $p<0.05$] and estimated annual income [$r=-0.175$, $n=149$, $p<0.05$], with parents of lower education and annual household incomes having higher waist circumferences. There was also a significant negative correlation between waist circumference and suburb SEIFA [$r=-0.201$, $n=157$, $p<0.05$], meaning those residing in the lower SEIFA suburbs tended to have higher waist circumferences. For all the other demographic variables, no significant associations were found with parents' waist circumferences.

8.4.3 Children's Anthropometric Information

The sample consisted of 157 children (51.6% girls) aged between five and 11 (μ=8.29 years, SD=1.55, min=5.17 years, max=10.84 years). Table 32 shows the mean and standard deviations for the anthropometric data and calculated BMI and BMI z-scores for the sample by age. Weight and height generally increased with age. The overall mean waist circumference was 61.56cm, and was highest in 10-year-olds and lowest in six-year-olds. The BMI ranged from 16.50 to 18.26 with a mean value of 16.94. A z-score of zero is equivalent to the median or 50th percentile. The BMI z-scores ranged from -0.0024 to 0.89. The mean BMI z-score was 0.28.

Table 32 Summary of children's anthropometric measurements

		Mean (SD)				
Age	n	Weight (kg)	Height (cm)	Waist circumference (cm)	BMI	BMI z-score
5	10	21.55 (3.38)	112.45 (5.01)	60.24 (5.95)	16.98 (2.00)	0.89 (0.89)
6	16	21.26 (3.52)	113.18 (3.90)	57.28 (4.64)	16.50 (1.80)	0.60 (0.91)
7	18	24.10 (2.63)	120.60 (4.04)	58.30 (3.13)	16.53 (1.11)	0.53 (0.49)
8	29	27.13 (5.98)	126.59 (5.96)	60.70 (7.61)	16.77 (2.62)	0.20 (0.98)
9	50	29.67 (4.64)	133.74 (5.92)	61.65 (5.68)	16.53 (1.84)	-0.0024 (0.87)
10	25	36.36 (6.58)	140.82 (6.48)	66.94 (8.38)	18.26 (2.64)	0.38 (1.03)
11	9	36.26 (5.92)	143.19 (6.41)	64.44 (5.07)	17.61 (2.22)	0.017 (1.12)
Overall	157	28.63 (7.01)	129.13 (11.15)	61.56 (6.81)	16.94 (2.17)	0.28 (0.93)

BMI can be used to define overweight and obesity in children using the International Obesity Task Force cut-offs (National Health & Medical Research Council, 2003b). Using these definitions, the majority of children (77.1%) in this sample were of a normal weight, 11.5% were classified as overweight and 5.1% were obese (Table 33).

Table 33 Weight status classification of children using the International Obesity Task Force cut-offs for age and gender

	N	% of sample
Underweight	10	6.4
Normal weight	121	77.1
Overweight	18	11.5
Obese	8	5.1

The influence of household demographic characteristics on children's anthropometric measurements

Significant relationships between household demographic characteristics and children's weight status (BMI z-score) were observed for estimated annual household incomes, parent's level of education and marital status. There was a significant, small negative correlation between children's BMI z-scores and estimated annual household incomes [r=-0.224, n=149, p<0.005] and highest level of education [r=-0.178, n=153, p<0.05], with children from lower income households or with less educated parents having higher BMI z-scores. Children of married parents (μ=0.126, SD=0.91) had significantly lower BMI z-scores than children whose parents were single (μ=1.04, SD=0.70), or separated or divorced (μ=0.82, SD=0.88) [F(2,150)=9.240, p<0.001]. There was no significant demographic variation in children's waist circumferences.

Relationships between parents' and children's BMI and waist circumferences

The relationship between parents' and children's BMI and waist circumferences were investigated using Pearson Product-Moment correlation coefficient. The demographic variables of education, estimated annual household income and marital status were controlled for because of their significant association with children's BMI z-scores.

Table 34 shows a positive moderate relationship between children's BMI z-scores and parents' BMI [r=0.315, n=144, p<0.001] and parents' waist circumferences [r=0.295, n=144, p<0.001]. Parents' and children's waist circumferences were also significantly correlated [r=0.162, n=144, p=0.05]. There was no significant correlation between children's waist circumferences and parents' BMI [r=0.150, n=144, p=0.070]. All the correlations were positive, indicating that higher measurements in parents were associated with higher measurements in children.

Table 34 Pearson Product-Moment correlation coefficients between parents' and children's body mass index (BMI) and waist circumferences controlling for education, annual household income and marital status

Children's characteristics	Parents' characteristics	
	BMI	Waist circumference
BMI z-score	0.315**	0.295**
Waist circumference	0.150	0.162*

*p=0.05; **p<0.001

Furthermore, the likelihood of having an overweight child was examined using cross-tabulations and odds ratio calculations. Using the cross-tabulation method, parents who were overweight or obese were about two and a half times more likely to have an overweight child (25.4%) than parents of a healthy weight (10.0%) (Table 35). Classifying parents by their waist circumference, 11.3% of parents in the low risk category had an overweight child, compared with 25.0% of parents in the high risk category (Table 35).

Table 35 Cross-tabulations of parents' body mass index (BMI) and waist circumference classifications and children's BMI classifications

Parents' characteristics	Children's BMI classifications	
	Healthy weight or less	Overweight or obese
BMI classifications		
Healthy weight	81 (90.0%)	9 (10.0%)
Overweight or obese	50 (74.6%)	17 (25.4%)
Waist circumference		
Low risk	86 (88.7%)	11 (11.3%)
High risk	45 (75.0%)	15 (25.0%)

These results are further supported by an odds ratio calculation. Independent of demographic circumstance, parents who were overweight were three times more likely to have an overweight child than parents of a healthy weight [OR = 3.060 (CI 1.267, 7.388) P<0.05]. And similarly, parents in the high risk waist circumference category were almost two and a half times more likely to have an overweight child than parents in the low risk category [OR=2.606, CI=1.106-6.143, P<0.05].

8.4.4 Parents' Nutrient and Food Group Intake

Parents' nutrient intake (n=126) was estimated from data collected in the food frequency questionnaire (FFQ). The average diet of parents in this sample consisted of 7452kJ (SD=2159kJ) – 42.51% of this energy came from carbohydrates, 32.87% from fat and 18.69% from protein. Saturated fat contributed 13.56% of the total energy intake (Table 36).

Table 36 Summary statistics for macronutrient composition of parents' dietary intakes

Macronutrients	Mean	SD	Min	Max
% energy carbohydrate	42.51	6.28	23.65	59.22
% energy protein	18.69	3.30	11.53	28.85
% energy fat	32.87	5.85	19.30	47.32
% energy saturated fat	13.56	3.52	7.17	25.73
% energy monounsaturated fat	11.11	2.13	6.54	17.75
% energy polyunsaturated fat	5.47	2.25	2.14	15.02

Fruit and vegetable consumption was also estimated from the FFQ, where one serve of fruit was equal to 150g and one serve of vegetables was 75g. On average, parents consumed 1.94 serves of fruit (SD=1.04) and 4.21 serves of vegetables (SD=1.45) per day. When fruit juices and fried potatoes were excluded from the respective categories, the average intake decreased to 1.56 serves of fruit (SD=0.87) and 4.11 serves of vegetables (SD=1.46).

The Healthy Eating Index (HEI) as described in Chapter 6 was used to interpret the overall diet quality of parents' dietary intake. The overall mean HEI score for parents was 76.04 (SD=10.26) out of a possible 100 (Range: 49.23 to 94.53). Using the diet ratings described in Chapter 6, very few people (1%) scored a 'poor' rating – most (60%) had a diet which 'needs improvement', while 39% consumed a diet classified as 'good'.

Figure 10 shows the percentage of parents scoring a maximum of 10 points on each of the dietary components included in the HEI, which means consuming foods and nutrients in amounts consistent with the nutrition guidelines. Most parents met the recommendations for meat and alternatives, and cholesterol – 82.54% and 78.57% respectively meeting the guidelines or better. Sixty percent consumed the recommended intake of two serves of fruit per day, however, only 23.81% consumed the recommended amount of vegetables (five serves per day).

The recommended intake for fat is 30% or less of total energy, of which 10% should be from saturated fat sources. In this sample, less than one-third of parents met the recommended intake for fat and 13% met the recommendation for saturated fat.

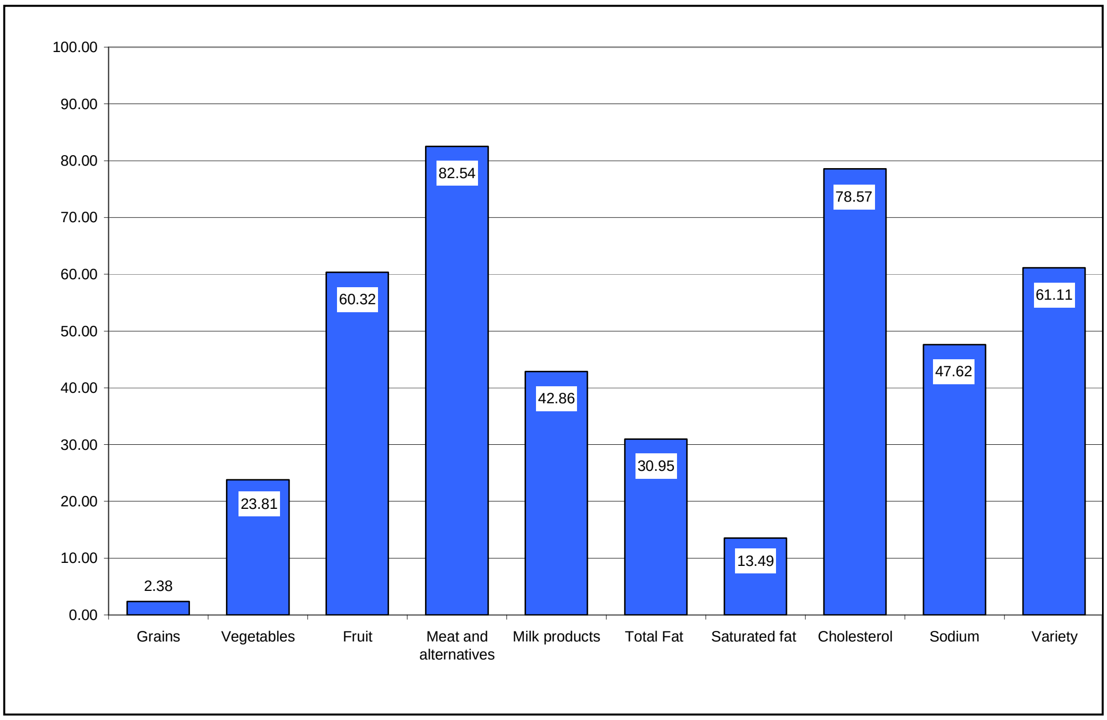


Figure 10 Interpretation of parents' intakes: Percentage of the sample scoring the maximum for each Healthy Eating Index component

There was little demographic variation in diet quality. Parents' age was the only significant influence, with overall diet quality increasing with age. Diet quality increased stepwise with age, with a significant difference between the oldest (μ=81.90, SD=7.66) and youngest parents (25-34 mean = 70.86, SD=12.54; 35-44 mean=75.81, SD=9.59) [$F(2,123)=6.541$, $p=0.002$].

8.4.5 Parents' Physical Activity

Estimated exercise time

One hundred and five parents provided information about their physical activity habits. Table 37 shows the total time (minutes) parents reported to spend in each category of physical activity and sedentary behaviour, estimated for the week previous to completing the questionnaire. Only three male parents completed the physical activity questionnaire, and on preliminary examination – using independent samples t-test – there was no significant difference in exercise time by gender, therefore results were combined for the following analysis.

Parents reported spending more than twice as much time sitting as being active. The mean exercise time was 491.2 minutes per week, which averaged out to approximately 70 minutes per day, most of which was spent walking. Moderate intensity exercise included activities such as gentle swimming, social tennis and golf. The overall sample mean for time spent in moderate activity was 28 minutes per week. Vigorous exercise included activities such as jogging, cycling and aerobics. The overall time spent in vigorous activity was about 105 minutes per week.

Table 37 Mean minutes for physical activity during the previous week by type of activity

	Mean exercise time for the previous week (minutes)					
	Walking	Moderate – intensity exercise	Vigorous – intensity exercise	Vigorous gardening	**Total exercise**	Sitting
Parents' exercise time	168.5	27.9	104.8	85.3	**491.2**	1129.0

Sedentary behaviour included time spent sitting at a computer, desk or in front of a television. The average reported sitting time was 1129 minutes per week (161 minutes per day).

Demographic variables, such as level of education or household income, had no significant influence on parents' reported time in physical or sedentary activity.

Physical activity to confer a health benefit – sufficient time and sessions

The Australian Institute of Health and Welfare's (AIHW) definition of sufficient physical activity has two components (Armstrong et al., 2000). The first component is sufficient or insufficient total exercise time. This is calculated by summing the four activity categories and weighting vigorous activity by a factor of two to account for its extra health benefits. Sufficient activity for a health benefit is defined as a total weighted activity time of greater than or equal to 150 minutes per week (Armstrong et al., 2000).

The second component of the definition refers to frequency of activity. The AIHW suggests that five or more sessions per week is sufficient (Armstrong et al., 2000), therefore the overall definition for sufficient activity as defined by the AIHW is the accumulation of at least 150 minutes of physical activity in at least five sessions per week. Using this definition, about three-quarters of parents (76.2%) participated in sufficient exercise for health benefits.

Relationships between healthy eating and exercise habits in parents

Independent samples t-tests were conducted to compare the dietary intakes for parents of different exercise levels. It appears that parents who reported sufficient levels of physical activity also reported healthier dietary patterns. The parents in the sufficient exercise category consumed diets significantly lower in fat and saturated fat, and significantly higher in vegetables (Table 38).

There was a significant difference in diet quality by exercise group, with parents in the sufficient exercise group consuming a diet of significantly higher quality (M=78.02, SD=9.25) compared to insufficient exercisers [M=71.65, SD=9.82; $t(102)=-2.957$, $p=0.004$] (Table 38).

Table 38 Parents' dietary intake patterns by exercise classification

Diet characteristics	Sufficient exercise (n=79)	Insufficient exercise (n=25)		
	Mean (SD)	Mean (SD)	t	sig
Macronutrient				
% energy carbohydrate	43.13(6.14)	41.72(6.57)	-0.980	0.329
% energy protein	18.66(3.33)	17.63(3.60)	-1.310	0.193
% energy fat	32.36(5.43)	35.19(6.53)	2.163	0.033*
% energy saturated fat	13.16(3.13)	15.18(4.34)	2.547	0.012*
% energy monounsaturated fat	10.97(2.09)	11.69(2.18)	1.484	0.141
% energy polyunsaturated fat	5.44(2.08)	5.58(2.78)	0.274	0.785
Fruit intake	1.92(0.99)	1.45(1.26)	-1.924	0.057
Vegetable intake	4.74(2.10)	3.71(1.52)	-2.263	0.026*
HEI score	78.02(9.25)	71.65(9.82)	-2.957	0.004*

*p<0.05

Relationship between parents' energy balance behaviours and weight status

There were no associations between parents' BMI and dietary intake, diet quality or total time spent exercising or in sedentary behaviours. There was a significant positive correlation between parents' BMI and total time spent doing vigorous gardening or heavy work (r=0.479, p<0.001), but this did not hold for total exercise time.

8.4.6 Children's Food and Nutrient Intakes

Children's energy intakes were explored using data from two 24-hour recalls, and analysed for both food group and nutrient analysis (n=149).

Children's macronutrient intakes are presented in Table 39. The average kilojoule intake was 7167kJ (3500-13,500kJ). Carbohydrates contributed 51.79% of the total kilojoule intake and fat contributed about 30%.

Table 39 Children's kilojoule and macronutrient intakes

Nutrient	Mean	SD	Min	Max
Energy (kJ)	7167	1926	3593	13650
Macronutrients				
% energy protein	17.72	3.80	10.22	29.84
% energy carbohydrate	51.79	8.02	33.98	70.55
% energy fat	30.49	6.84	13.72	48.69
% monounsaturated fat	37.63	4.57	26.88	62.11
% polyunsaturated fat	14.65	5.79	5.41	36.87
% saturated fat	47.72	7.58	26.89	65.58

Most children (90%) consumed at least one type of fruit in the 24 hours previous, and about three-quarters (77%) consumed at least one vegetable. A small proportion (2%) of the sample consumed no fruit or vegetables. The total number of fruit and vegetables reported in the 24-hour recall was totalled to give an indication of overall fruit and vegetable intake. Intakes ranged from zero to 13, with a mean of 3.76 (SD=2.32) and a median of 3.00, and most parents reported that their child consumed a total of two fruits or vegetables in the day previous. The household demographic characteristics had no significant influence on children's dietary intake.

The relationships between children's and parents' diets

The relationship between children's and parents' dietary intakes was analysed using Pearson Product-Moment correlation coefficients. Children's and parents' intakes of fruit and vegetables were positively associated – a higher intake in parents indicative of a higher intake in children. Parents' overall diet quality

(HEI) was also significantly associated with children's fruit and vegetable intakes (Table 40).

Table 40 Correlations between children's and parents' fruit and vegetable intakes and diet quality

	Pearson Product-Moment correlation coefficient (r)		
	Parents' fruit intake	Parents' vegetable intake	Parents' overall diet quality (HEI)
Children's fruit and vegetable intake	0.173*	0.243**	0.225**

*p=0.053; **p<0.01

8.4.7 Children's Energy Expenditure

Screen time was calculated from time spent watching television and playing computer or video games (total time spent in the morning and afternoon). Table 41 shows a breakdown of the time spent in these sedentary behaviours. There was a range in the reported time spent in these sedentary behaviours, from no time through to 420 minutes per day. Overall, children spent 112.23 minutes per day in front of a screen. Children tended to have more sedentary time in the afternoon compared to the morning. On average, children reported 19 minutes of screen time before school and 93 minutes in the time after school and before bed. The majority of this screen time was spent watching television (96 minutes).

Table 41 Children's time spent in sedentary behaviours

	Mean	SD	Min	Max
Morning screen time	19.49	25.58	0.00	180.00
Afternoon screen time	92.74	61.81	0.00	360.00
Television time	95.86	59.04	0.00	290.00
Computer/video games	16.37	36.56	0.00	240.00
Total screen time	**112.23**	**70.32**	**0.00**	**420.00**

Table 42 shows a summary of children's reported moderate and vigorous physical activity (minutes). On average, children spent 84 minutes per day being moderately active and 46 minutes being vigorously active. Overall, children spent approximately two hours per day being physically active.

Table 42 Children's time spent being physically active

	Mean	SD	Min	Max
Moderate exercise	84.29	72.07	0.00	527.14
Vigorous exercise	46.39	46.64	0.00	394.29
Total exercise	130.68	103.69	0.00	921.43

There were small variations in energy expenditure by gender. Girls reported more screen time (μ=117.99, SD=79.77) and less activity (μ=124.63, SD=88.60) than boys (μ=106.08, SD=58.49 and μ=137.14, SD=117.97 respectively), however, these differences were not statistically significant.

Relationships between children's dietary and physical activity behaviours

A significant negative correlation was observed between children's fruit and vegetable intake and total screen time ($r=-0.206$, $n=152$, $p<0.05$) (Table 43) – that is, children who consumed more fruit and vegetables reported to spend less time watching television or playing computer/video games.

Table 43 Correlations between children's and parents' exercise and sedentary behaviours

	Pearson Product-Moment correlation coefficient (r) Parents' behaviours	
Children's behaviours	Sitting time (mins)	Exercise time (mins)
Screen time (mins)	0.180	-0.102
Total exercise time (mins)	-0.201*	0.097

*p<0.05

Relationships between children's and parents' energy balance behaviours

There was no significant correlation between children's and parents exercise time. There was a significant small negative correlation between children's exercise time and parents' reported sitting time ($r=-0.201$, $n=152$, $p<0.05$) (Table 43), meaning parents who reported more time sitting had children who participated in less physical activity.

8.4.8 Parents' Nutrition Knowledge

The mean, standard deviation, minimum and maximum scores for each of the four sections of parents' nutrition knowledge (n=153) are presented in Table 44. The overall nutrition knowledge scores ranged from 26 to 97 out of a possible 113. The overall mean was 71.71 (SD=14.21). Of the four knowledge components, the section about diet-disease relationships was most poorly answered, with a mean score of 9.02 out of a possible 20.

Table 44 Parents' nutrition knowledge

	Mean	SD	Min	Max
Nutrition recommendations (13)	8.63	1.88	1.00	12.00
Food sources of nutrients (70)	47.50	10.21	9.00	66.00
Identifying healthy food choices (10)	6.76	1.79	2.00	10.00
Diet-disease relationships (20)	9.02	2.86	0.00	16.00
Overall nutrition knowledge score (113)	71.91	14.21	26.00	97.00

Demographic variation in nutrition knowledge

There was significant demographic variation in nutrition knowledge levels among parents. Nutrition knowledge was significantly associated with age [$F(2,150)=10.608$; $p<0.001$], marital status [$F(2,150)=8.473$; $p<0.001$], culture ($t(155)=3.974$, $p<0.001$), education [$F(3,149)=15.269$; $p<0.001$], employment status [$F(3,140)= 4.803$; $p=0.003$)] and household income ($r=0.406$; $p<0.001$).

Because many socio-demographic characteristics influenced nutrition knowledge, multiple regression analysis was conducted to assess the independent effect of demographic characteristics on parents' nutrition knowledge. All demographic variables were entered into a hierarchical multiple regression model. The results showed that four demographic variables made an independent significant contribution to nutrition knowledge ($p<0.05$). In order of effect they were: parents' education level (standardised beta coefficient (β) = 0.431), identified culture (β=-0.267), gender (β = 0.205) and age (β = 0.159) – that is, older female parents who identified themselves as Australian and had a higher level of education tended to have the highest nutrition knowledge levels.

These four variables combined accounted for 36.4% of the variation associated with nutrition knowledge levels [$F(4,148) = 21.180$, $p<0.05$].

8.4.9 Parents' Physical Activity Knowledge

Physical activity knowledge items examined parents' ability to recognise and understand the current public health messages concerning physical activity and health for both adults and children, and the general benefits of physical activity. There were four areas of knowledge assessed with a maximum score of 33. Table 45 shows a summary of the descriptive statistics from each of the four sections and parents' overall physical activity knowledge levels (n=153). Total physical activity knowledge scores ranged from 15.20 to 30.80. The mean knowledge score was 25.92.

Table 45 Parents' physical activity knowledge levels

	Mean	SD	Min	Max
Acceptance with PA messages (5)	3.88	0.59	1.00	5.00
Knowledge of children's PA recommendations (3)	1.52	0.76	0.00	3.00
Knowledge of intensity classification (10)	8.08	1.60	1.00	10.00
Knowledge of healthy benefits of exercise (15)	12.36	1.65	7.00	15.00
Total PA knowledge score (33)	25.92	2.56	15.20	30.80

The Active Australia campaign promotes five key physical activity messages (Armstrong et al., 2000). Of these, most parents (88-92%) in this study agreed with three: "Taking the stairs at work or generally being more active for at least 30 minutes each day is enough to improve you health", "Half an hour brisk walking on most days is enough to improve your health", and "Moderate exercise that increases your heart rate slightly can improve your health". There was less understanding of the following two messages: "To improve your health it is essential for you to do vigorous exercises for at least 20 minutes each time, three times a week" and "Exercise doesn't have to be done all at one time – blocks of 10 minutes are okay".

Parents' knowledge of the physical activity guidelines for children varied. Most parents (78.4%) knew of the recommendation for children to participate in vigorous activity and be active for at least one hour per day (58.2%). Very few parents (15.0%) were aware of the recommendation to limit children's screen time to two hours per day; most believed 30 minutes (32.0%) or one hour (58.2%) was recommended.

Demographic variation in physical activity knowledge

The demographic variables were entered into a hierarchical multiple regression model. Gender (being female, $\beta=0.177$, $p<0.05$) and culture (identifying with the Australian culture, $\beta=-0.185$, $p<0.05$) were the only independent predictors of physical knowledge, combining to account for 7.0% of the variation associated with parents' physical activity knowledge levels [$F(2,148) = 5.611$, $p<0.05$].

Relationship between parents' knowledge and behaviours

The relationship between parents' knowledge and behaviours was explored using the Pearson Product-Moment correlation coefficient. There was a small correlation between parents' nutrition knowledge and their dietary intake, with higher knowledge levels associated with better diet quality ($r=0.188$, $n=126$, $p=0.035$). There was no relationship between physical activity related knowledge and activity levels.

Correlation coefficients were also used to explore the relationship between parents' knowledge and children's behaviours. The children of parents with greater nutrition knowledge consumed more fruit and vegetables [$r=0.254$, $n=150$, $p<0.01$]. No significant relationships were observed between parents' physical activity knowledge and children's activity behaviours. A significant negative relationship was observed between parents' nutrition knowledge and children's BMI z-score ($r=-0.251$, $n=157$, $p<0.01$) – a higher level of knowledge was associated with a lower BMI.

8.5 Discussion

8.5.1 Sample Considerations

The families involved in this study predominately consisted of Australian married couples with two children. Mothers generally represented the family, which is common in this field of health-related research. Most mothers were well educated and employed in some capacity. Despite efforts to recruit families from lower socioeconomic areas, previous research shows that persons from socioeconomic disadvantaged backgrounds are least likely to participate in survey research (Turrell, 2000). To some extent, this may account for the slightly skewed distribution of responses in measures such as dietary intake, because indicators of socioeconomic status have been associated with fruit and vegetable intake (Ball et al., 2006), eating patterns (Mishra, Ball, Arbuckle, & Crawford, 2002) and diet quality (Chapter 6) in Australia. It is interesting to note, however, that the accuracy of reporting dietary information is not influenced by socioeconomic status (Baranowski, Sprague, Baranowski, & Harrison, 1991).

Indicators of household socioeconomic status have also been shown to influence children's risk of obesity (Mellin et al., 2002; O'Dea & Caputi, 2001). In this study, children from lower income households and of parents with less education were at the greatest risk of obesity. The risk of obesity in children also increased with obesity in parents. Children of overweight parents are more likely to be overweight (Cutting et al., 1999; Zeller et al., 2007) than children with healthy-weight parents, and possibly as much as three times more likely (Zeller et al., 2007).

It is widely accepted that parent behaviours will shape many aspects of their children's behaviours, therefore before discussing the implications of these findings, it is important to acknowledge the potential sampling bias of this study. The broad sampling issues are discussed in detail in Chapter 7.

There was concern that few overweight parents would volunteer to participate in this study, which clearly stated: a focus on healthy weight in children, an intention to collect information about the family home, and that parents would be weighed. The recruited sample was slightly skewed towards a healthy weight, with less parents classified as overweight or obese than what is estimated nationally (27% overweight and 15% obese in this sample compared with 35% and 18% nationally (Australian Bureau of Statistics, 2008a)).

Similarly, the distribution of children's weight status was skewed towards healthy weight. Recent national estimates suggest that 23% of children are overweight or obese, and in this sample approximately 17% were classified as overweight or obese, reminding the reader that the characteristics of volunteer samples need to be considered when interpreting these findings.

8.5.2 Children's Dietary Intakes and Activity Habits

The nature of children's behaviours, often unstructured and without routine, means measuring usual behaviours is difficult. This study used two 24-hour recalls in an attempt to capture usual food intake, however, it must be recognised that no dietary collection method is error-free – there is always some degree of misreporting. The recent Australian National Children's Nutrition and Physical Activity Survey minimised error by using food models and pictures to aid in portion size estimations and employed a rigorous multiple-pass technique (Commonwealth Scientific Industrial Research Organisation (CSIRO) et al., 2008). The estimated kilojoule intake for this sample was lower than the national estimate, which suggested four to eight year-olds consumed 7030-7740kJ and nine to 13 year-olds consumed 8333-9837kJ (Commonwealth Scientific Industrial Research Organisation (CSIRO) et al., 2008). The estimated fat intake of children was in line with recommendations (30% of total energy or less) and similar to national data (Commonwealth Scientific Industrial Research Organisation (CSIRO) et al., 2008), however, the estimated proportion of saturated fat exceeded recommendations and national estimates (Commonwealth Scientific Industrial Research Organisation (CSIRO) et al., 2008).

Boys tend to be more physically active than girls at a young age (Commonwealth Scientific Industrial Research Organisation (CSIRO) et al., 2008). This study found a small difference in activity levels between boys and girls, with boys spending 13 minutes longer being physically active per day – a difference which was not statistically significant. Gender differences in screen time reported in the Australian National Children's Nutrition and Physical Activity Survey were supported by this study (notably boys accumulated more screen time than girls) (Commonwealth Scientific Industrial Research

Organisation (CSIRO) et al., 2008). The variation in children's screen time in this study was large, however, on average screen time was limited to two hours per day as recommended. Results from the national survey suggest children spend three and a half hours doing screen-based activities, which may be a more accurate reflection of true behaviour considering the rigorous sampling and data collection methodology of the nationally representative survey. The concerns with screen-based activities are that they replace more vigorous activities (Caroli et al., 2004) and have been linked to less 'healthy' dietary behaviours, such as high energy and total fat intakes (S. A. Miller, Taveras, Rifas-Shiman, & Gillman, 2008), fatty foods and soft drinks (Coon et al., 2001), and sugar-sweetened drinks (Gubbels et al., 2009; S. A. Miller et al., 2008). In this study and in others, higher screen time was associated with the consumption of less fruit and vegetables (Coon et al., 2001; S. A. Miller et al., 2008) and a greater risk of overweight (Proctor et al., 2003; van Zutphen et al., 2007).

8.5.3 Familial Behaviour Patterns

To some extent, children have a tendency to model the behaviours of their parents (Keller et al., 2004). Because children share their environment with their parents, family resemblance in food preferences have been observed (Birch, 1999). Strong correlations have been found between parents' and children's fruit and vegetable intakes (Cooke et al., 2003; J.O. Fisher et al., 2002; O'Connor et al., 2009; Pearson et al., 2008), and in this study, between children's fruit and vegetable intakes and parents' overall diet quality. Similarities in activity patterns within families have also be observed. This study found a significant negative association between children's physical activity levels and parents' sedentary behaviours, meaning children of less sedentary parents were more active. While the outcome measures of studies vary, other studies have reported significant associations between parents' and children's inactivity (Martin et al., 2005; Myers et al., 1998) – a greater likelihood of similarity between fathers' and sons' activity habits (Martin et al., 2005) and mothers' and daughters' activity (Salmon et al., 2005) and television viewing habits (Bogaert et al., 2003; Salmon et al., 2005). Some research suggests that the strongest relationships are usually observed between mothers and their children (J. P. Taylor et al., 2005), particularly for nutrition behaviours (Stafleu, Van Staveren, De Graaf, Burema, & Hautvast, 1996). It is important to keep in mind that the majority of this study sample was mothers, and therefore understanding how different parents influence their children's behaviours is not possible from this data.

8.6 Conclusion

Three modifiable components in body weight regulation are dietary intake, physical activity and sedentary behaviour. We know children's dietary intake and activity patterns evolve within the family context, and familial trends in obesogenic behaviours have been well documented. Results presented in this study support familial trends in fruit and vegetable intakes, activity levels and body weight.

There are aspects of the family home environment which are also an important consideration when examining obesity risk in children. Parents are thought to be role models for their children, guiding the development of dietary and activity habits. A detailed understanding of how parental behaviours shape the home environment, and in turn children's behaviours, is not well understood. The following chapter will examine the home environment and how this environment supports children's eating and physical activity habits and influences their obesity risk.

9 HEALTHY KIDS: THE FAMILY WAY, RESULTS PART 2 – FAMILY FOOD AND PHYSICAL ACTIVITY ENVIRONMENTS

9.1 Introduction

The idea that the family home environment plays a crucial role in shaping children's behaviours – specifically dietary preferences, and intake and physical activity habits – is widely accepted. There are many factors within the family home that influence children's energy balance behaviours. The combination of factors and the relative importance of these factors in influencing children's behaviours and obesity risk remain unclear.

The family home environmental factors measured in this study were guided by previous research. This chapter describes aspects of the family home environment in relation to children's dietary and activity habits, the demographic variation, and interactions between these variables.

9.2 Chapter Aims

The overall aim of this chapter is to describe the parenting behaviours and home environments of the families that participated in this study.

The aims of this chapter are to:

1. describe the general parenting and feeding styles reported by parents
2. describe the food and physical activity environments
3. conduct factor analysis on the environmental constructs to aid in the development of the obesity resistance model.

9.3 Methods

The methodology of this study is discussed in detail in Chapter 7. Data was entered and analysed using the Statistical Package for Social Sciences (SPSS) 16.0 (SPSS for Windows 16.0 Chicago: SPSS Inc.). Responses answered on a Likert scale of 1 to 5 were collapsed into three groups for the analysis, such as 'Disagree', 'Neutral' and 'Agree' or 'Never', 'Sometimes' and 'Always', dependant on the response scale. Descriptive statistics were used to describe parental responses. Pearson Product-Moment correlations, independent samples t-tests and one-way analysis of variance were used to explore the demographic variation in these constructs.

To create environment factor scores, exploratory factor analysis was used. Questionnaire items were reduced to environment factors using SPSS. The suitability of the data for factor analysis was assessed with correlations of 0.35 or more included. The Kaiser-Meyer-Oklin value of 0.6 or more and a significant Bartlett's Test of Sphericity were used to support the factorability of the correlation matrix (Pallant, 2007). In determining the number of factors, in the first instance Eigen values of less than 1 were rejected, and then inspection of the Scree plot guided the decision on the number of factors to retain. An orthogonal transformation (Varimax rotation) was used to aid in the interpretation of factors. Reliability of the selected factors was calculated using Cronbach's alpha statistics, with a value of 0.7 or more considered acceptable (Nunnally, 1978).

9.4 Results

9.4.1 General Parenting Styles

The summary results for the three parenting typologies are presented in Table 46. Each question was answered on a scale of 1 ('Never') to 5 ('Always'), and questions were grouped into characteristics and the three main styles as described by Robinson (Robinson et al., 1995). The authoritative parenting style was the dominant style, with an overall mean score of 4.11, compared with the authoritarian style (μ=2.20) and the permissive style (μ=1.86) (n=104) (Table 46).

Table 46 Descriptive statistics for general parenting style typographies

Mean score for each factor	Mean (SD)	Min	Max
Authoritative (26 items)	**4.11 (0.37)**	**3.04**	**4.92**
Warmth and involvement (11 items)	4.45 (0.38)	3.36	5.00
Reasoning and induction (7 items)	4.07 (0.50)	3.00	5.00
Democratic participation (4 items)	3.41 (0.59)	2.25	4.75
Good natured/easy going (4 items)	3.91 (0.53)	2.50	5.00
Authoritarian (15 items)	**2.20 (0.48)**	**1.20**	**3.60**
Verbal hostility (3 items)	2.51 (0.63)	1.33	4.67
Corporal punishment (2 items)	2.06 (0.67)	1.00	4.50
Non-reasoning, punitive strategies (6 items)	1.78 (0.49)	1.00	3.17
Directiveness (4 items)	2.65 (0.63)	1.25	4.50
Permissive (14 items)	**1.86 (0.36)**	**1.07**	**2.64**
Lack of follow through (6 items)	2.01 (0.47)	1.17	3.17
Ignoring misbehaviour (4 items)	1.68 (0.43)	1.00	3.00
Self-confidence (4 items)	1.81 (0.48)	1.00	3.25

Demographic variation in general parenting styles

The demographic variation in parenting styles was assessed using correlations and independent samples t-tests. The only demographic variable to have a significant influence on parenting style was education level. There was a significant negative correlation between the authoritarian parenting style and highest level of education – that is, parents with a low level of formal education scored highly in the authoritarian parenting typography (r=-0.205, n=104, p=0.037).

Relationships between general parenting styles and children's intake, energy expenditure behaviours and weight

The authoritarian parenting style was significantly associated with a higher screen time [r=0.306, n=104, p<0.05] in children, along with a lower fruit and vegetable intake [r=-0.199, n=104, p<0.05]. The permissive parenting style was significantly associated with a higher BMI z-score in children [r=0.252, n=104, p<0.05], while the authoritative style was associated with higher physical activity levels in children [r=0.224, n=104, p<0.05].

9.4.2 Child Feeding Practices

Parents' responses to the Child Feeding Questionnaire (CFQ) were scored from 1 to 5, with 5 being the most affirmative response; for example, 'Always', 'Strongly agree' or 'Very concerned'. Scores for each item were added and the mean score (out of five) was calculated for each sub-scale of child feeding. Mean, standard deviation, minimum and maximum scores are presented in Table 47.

Table 47 Descriptive statistics for the Child Feeding Questionnaire factors

Child Feeding Questionnaire factors	Mean (SD)	Min	Max
Perceived responsibility (3)	4.41 (0.57)	2.33	5.00
Concern about child weight (3)	2.01 (1.05)	1.00	5.00
Restriction (8)	3.27 (0.88)	1.25	5.00
Pressure to eat (4)	2.60 (0.87)	1.00	4.75
Monitoring (3)	4.27 (0.67)	2.33	5.00

The following is a summary of the responses to the CFQ. A full table of the responses is included in Appendix 6.

In general, parents showed high levels of perceived responsibility (μ=4.40), which refers to the level of responsibility they feel for feeding their child and making decisions on portion sizes and food types. The lowest scoring sub-scale was 'Concern about child weight' (μ=2.01). Most parents (77.4%) reported little or no concern for their child having to diet to maintain a healthy weight, but about one in 10 parents were very concerned about their child maintaining a desirable weight. Nineteen percent of parents were 'Fairly concerned' to 'Very concerned' that their child would eat too much while they were not present, but most parents (70.8%) had little or no concern.

There was variation in the responses for the items on the restriction scale. Three-quarters of the parents felt they needed to restrict their child's intake of sweets and high fat foods, and half agreed to restricting their child's intake of their favourite foods. More than half felt that if they did not regulate their child's intake, then they would consume too much of their favourite foods (56.6%) and junk food (57.1%).

Responses to the 'Pressure to eat' sub-scale showed that about 60% of parents did not agree that children should always eat everything on their plate, and about one-third disagreed with getting their child to try when they were not hungry.

Almost all parents reported some level of monitoring. The highest proportion (91.5%) of parents reported 'Mostly' or 'Always' keeping track of their child's snack food intake, while 87.7% reported keeping track of consumption of sweets and 84% kept track of high fat food consumption.

Demographic variation in feeding styles

The demographic variation in feeding styles was assessed using correlations and independent samples t-tests. Perceived responsibility was significantly correlated with a number of demographic variables. Higher levels of perceived responsibility were reported by younger parents (r=-0.257, n=106, p=0.008), those with less formal education (r=-0.205, n=106, p=0.035), and those with a lower annual household income (r=-0.233, n=104, p=0.018). Younger parents also reported a higher level of monitoring (r=-0.206, n=106, p=0.034), and those with a lower level of education reported a higher concern for weight (r=-0.224, n=106, p=0.021). All other demographic influences were non-significant.

Relationships between feeding styles and children's intake, energy expenditure behaviours and weight

The relationships between parents' child feeding styles and children's intake, energy expenditure behaviours and weight were explored using Pearson Product-Moment correlation coefficients. Parents who reported the highest concern about their child's weight had a child with a higher BMI z-score ($r=0.237$, $n=106$, $p<0.05$), and had a higher BMI themselves ($r=0.226$, $n=106$, $p<0.05$). Higher perceived responsibly was significantly correlated with children's BMI z-score ($r=0.202$, $n=106$, $p<0.05$).

'Restriction' and 'Pressure to eat' were not associated with children's BMI z-score, but were associated with children's dietary intakes. A higher fruit and vegetable intake in children was associated with lower levels of parental restriction ($r=-0.253$, $n=106$, $p<0.05$) and a lower pressure to eat ($r=-0.285$, $n=106$, $p<0.05$).

Higher screen time in children was significantly associated with greater parental concern for weight ($r=0.211$, $n=106$, $p<0.05$) and higher levels of parental restriction ($r=0.226$, $n=106$, $p<0.05$).

9.4.3 Food Involvement

The Food Involvement Scale (FIS) has two sub-scales – 'Set and Disposal' and 'Preparation and Eating' involvement. Responses ranged from 1 ('Disagree strongly') to 7 ('Agree strongly'). A higher score represents greater food involvement. The overall FIS is out of a maximum of 84.

Table 48 shows a summary of the descriptive statistics for the FIS. A more detailed description of responses is included in Appendix 6. The overall mean food involvement score was 62.92.

Table 48 Descriptive statistics of the Food Involvement Scale factors

	Mean (SD)	Min	Max
Set and disposal (21)	16.15 (3.13)	6.00	21.00
Preparation and eating (63)	46.77 (7.20)	30.00	63.00
Food Involvement Scale (84)	62.92 (8.07)	39.00	79.00

Demographic variation in food involvement

Parents' level of education and estimated annual household income were significantly associated with their food involvement. There were positive correlations between 'Preparation and eating' involvement and level of education (r=0.229, n=106, p=0.018) and annual household income (r=0.294, n=104, p=0.002). Overall food involvement increased significantly with an increase in annual household income (r=0.266, n=104, p=0.006). All other demographic measures had no significant influence on food involvement.

Relationships between parents' food involvement and children's intake, energy expenditure behaviours and weight

There were no observed significant relationships between parents' food involvement and children's intake and energy expenditure behaviours or children's BMI z-score.

9.4.4 Factor Analysis of Food Environment Questions

Parents responded to items about the family food environment on a scale of 1 to 5, from least affirmative through to most affirmative, such as 'Strongly disagree' to 'Strongly agree' or 'Never' to '4 or more times per week'. A copy of the responses to each item is included in Appendix 6.

Exploratory factor analysis was performed on the food environment questions (37 items) using the raw data responses. Prior to performing the analysis, the suitability of the data for factor analysis was assessed. Inspection of the correlation matrix showed many coefficients of 0.35 or more. The Kaiser-

Meyer-Oklin value was 0.676 and the Bartlett's Test of Sphericity was significant, supporting the factorability of the correlation matrix.

On review of the items, it was decided that two items from the 'Opportunity for role modelling of eating behaviours' scale be removed as they asked about adult work commitments and only 16.6% of the sample reported to be employed full-time. Four questions had a factor loading of less than 0.35 and did not load onto any of the seven factors. These questions were "How often would you cook an evening meal?", "How often would your child have take-away for lunch?", "In our family we have a rule against answering the phone during the evening meal" and "How often does your child help to prepare the evening meal?". These were not included in the analysis and are not discussed.

Principal axis factoring analysis revealed 11 factors with Eigen values exceeding 1, explaining 70.31% of the variance. An inspection of the Screeplot revealed a clear plateau after seven factors. It was decided to retain seven factors for further investigation. To aid with the interpretation of the seven factors, Varimax rotation was performed. The rotated solution is presented in Table 49. The seven factors explained a total of 49.22% of the variance.

Table 49 Summary of the principal axis factor analysis with Varimax rotation for the family food environment factors

Factor	Factor items	Factor loadings	Variance explained	Cronbach's alpha
1. Perceived adequacy of child's diet (7 items)				
	Overall, I am satisfied with my child's eating habits	0.806	10.011%	0.836
	My child eats many different vegetables	0.782		
	My child eats enough vegetables to keep him/her healthy	0.736		
	My child eats many different foods	0.709		
	My child eats many different fruits	0.676		
	My child eats enough fruit to keep him/her healthy	0.623		
	How often would you say a disagreement about eating occurs during the evening meal?	-0.357		
2. Opportunities for role modelling – meal preparation views (5 items)				
	I feel confident to cook a wide range of meals	0.897	8.931%	0.824
	I feel confident cooking new dishes and trying new ingredients	0.807		
	I enjoy cooking for the family	0.754		
	I plan the evening meal in advance	0.507		
	It is difficult to find the time to cook the evening meal	-0.420		
3. Perceived food availability (7 items)				
	I do not buy many fruits because they cost too much	0.677	8.722%	0.748
	At the shop where I buy my groceries, the condition of fresh fruits and vegetables is poor	0.672		
	At the shop where I buy my groceries, the variety of fresh fruits and -vegetables is limited	0.657		
	The fresh produce in my area is usually of a high quality	-0.649		
	It is easy to buy food in my area	-0.624		
	I do not buy many vegetables because they cost too much	0.611		
	How often would you buy take-away for the evening meal?	-0.353		
4. Opportunities for role modelling of eating behaviours (5 items)				
	How often does your whole family sit down together for the evening meal?	0.685	7.089%	0.795
	I am satisfied with how often my family eats the evening meal together	0.685		
	The evening meal is usually a time when our family connects and talks with each other	0.683		
	In our family, it is OK for the children to eat dinner separately from the adults	-0.618		
	The evening meal is usually a pleasant time for the family	0.587		

5. TV interruptions to meals (2 items)			
Adults in the family want the television on during meal time	0.929	5.118%	0.903
How often is the television on during the evening meal?	0.852		
6. Family food preferences (4 items)			
I do not buy many fruits because my family doesn't like them	0.798	4.885%	0.669
I do not buy many vegetables because my family doesn't like them	0.530		
How often would you use ready-made sauces?	0.448		
How often would you use prepared dishes?	0.408		
7. Family's inclusion in food preparation (3 items)			
How often is your child involved in making their own lunch?	0.575	4.465%	0.610
How often would your child come shopping for food with you?	0.532		
How often is your child involved in making their own breakfast?	0.483		

9.4.5 Food Environment Factor Scores

Responses from each question within a factor were summed and then divided by the number of items to give a mean factor score. This score ranged from one to five. The descriptive statistics for the family food environment score including mean, standard deviation, minimum and maximum scores are presented in Table 50. The highest mean scores were for the 'Opportunity for role modelling of eating behaviours' (M=4.04, SD=0.63), 'Opportunities for role modelling – meal preparation views' (M=3.93, SD=0.54) and 'Perceived food availability' (M=3.91, SD=0.70). The lowest mean score was for 'TV interruptions to meals' (M=2.97, SD=1.31).

Table 50 Summary of factor scores for the family food environment

Factor	Mean	SD	Min	Max
Perceived adequacy of child's diet	3.78	0.71	1.43	5.00
Opportunities for role modelling – meal preparation views	3.91	0.70	1.60	5.00
Perceived food availability	3.93	0.54	1.57	4.86
Opportunities for role modelling of eating behaviours	4.04	0.63	2.20	5.00
TV interruptions to meals	2.97	1.31	1.50	5.00
Family food preferences	3.84	0.66	1.75	5.00
Family's inclusion in food preparation	3.32	0.84	1.33	4.67

Demographic variation in the food environment factor scores

The demographic variation in the food environment was explored using the Pearson Product-Moment correlation and independent samples t-tests. There was no observed significant influence of parents' gender, age, marital status, culture, or the number of children in a family on any of the family food environment factors. Parents' education level, employment status and estimated annual income did appear to influence the family food environment. A higher level of education was significantly correlated with higher 'Opportunities for role modelling – meal preparation views' (r=0.218, n=106, p=0.025), less 'TV interruptions to meals' (r=0.234, n=106, p=0.016) and higher 'Family food preferences' (r=0.290, n=106, p=0.003). There was a significant positive correlation between estimated annual household income and

‘Perceived food availability’ (r=0.343, n=104, p<0.001) and ‘Family food preferences’ (r=0.314, n=104, p=0.001). Parents who were full-time homemakers had significantly higher ‘Opportunities for role modelling – meal preparation views’ scores than those employed full-time [F(3,101)=5.899, p=0.001].

Relationships between the food environment and children’s intake, energy expenditure behaviours and weight

The relationships between the food environment factors and children’s intake, energy expenditure behaviours and weight were explored using Product-Moment correlations. There were no significant correlations observed between the family food environment factors and children’s BMI z-score. The correlation coefficients between the environment factors and energy balance behaviours are presented in Table 51. The significant correlations are discussed below.

There was a significant positive relationship between children’s fruit and vegetable intakes and parents’ ‘Perceived adequacy of child’s diet’ [r=0.281, n=106, p<0.05], ‘Perceived food availability’ [r=0.229, n=106, p<0.05] and ‘Opportunities for role modelling – meal preparation views’ [r=0.249, n=106, p<0.05].

There was a significant negative relationship between children’s exercise time and ‘Perceived food availability’ [r=-0.219, n=106, p<0.05]. Significant negative associations were observed between total screen time and a number of food environment factors. Higher screen time in children was associated with lower ‘Perceived food availability’ [r=-0.192, n=106, p<0.05], lower ‘Opportunities for role modelling of eating behaviours’ [r=-0.213, n=106, p<0.05], more ‘TV interruptions to meals’ [r=-0.237, n=106, p<0.05] and less ‘Family inclusion in food preparation’ [r=-0.212, n=106, p<0.05].

Table 51 Correlations between family food environment factors and children's energy balance behaviours

	Children behaviours (n=106)		
	Children's fruit and vegetable intakes	Total exercise (min)	Total screen time (min)
Perceived adequacy of child's diet	0.281*	0.063	-0.183
Opportunities for role modelling – meal preparation views	0.120	0.055	-0.135
Perceived food availability	0.229*	-0.219*	-0.192*
Opportunities for role modelling of eating behaviours	0.249*	-0.016	-0.213*
TV interruptions to meals	0.147	0.200	-0.237*
Family food preferences	0.189	-0.117	-0.095
Family's inclusion in food preparation	0.125	0.171	-0.212*

*p<0.05

Relationships between the food environment and parents' intake, energy expenditure behaviours, knowledge and weight

The relationships between the food environment and parental characteristics were explored using the Pearson Product-Moment correlation, and only the significant correlations are discussed.

Parents' diet quality was significantly correlated with their 'Perceived adequacy of child's diet' in a positive direction (r=0.266, n=105, p=0.006). Parents' exercise time showed significant positive associations with their 'Perceived adequacy of child's diet' (r=0.252, n=105, p=0.010), 'Opportunities for role modelling – meal preparation views' (r=0.208, n=105, p=0.033) and 'Family inclusion in food preparation' (r=0.306, n=105, p=0.002).

Parents' nutrition knowledge was positively associated with 'Perceived food availability' (r=0.245, n=106, p=0.011), 'TV interruptions to meals' (r=0.277, n=106, p=0.004) and 'Family food preferences' (r=0.290, n=106, p=0.003). 'Family food preferences' was negatively correlated with parents' BMI (r=-0.301, n=106, p=0.002).

9.4.6 Factor Analysis of the Physical Activity Environments

Exploratory factor analysis was performed on the physical activity environment questions (29 items) using the raw data responses (included in Appendix 6). The statistical process was similar to that of the factor analysis of the food environment questions. Prior to performing the analysis, the suitability of data for factor analysis was assessed. Inspection of the correlation matrix showed many coefficients of 0.35 or more. The Kaiser-Meyer-Oklin value was 0.766 and the Bartlett's Test of Sphericity was significant, supporting the factorability of the correlation matrix.

Again, the two questions referring to adult work schedules were removed prior to factor analysis because only a minority of the sample worked full-time. Four questions did not load onto any of the factors – that is, they had a factor loading of less than 0.35. There was one question from the role modelling of physical activity behaviours ("Adults in the family like watching television") and three from the involvement scale ("I do most or all of the planning for family activities", "I do most or all of my exercise sessions alone" and "I care what I look like or what people think of me when I am exercising"). These were not included in the analysis and are not discussed.

Principal axis factoring analysis revealed nine factors with Eigen values exceeding one, explaining 70.40% of the variance. An inspection of the screeplot suggested there was a plateau after the third factor. It was decided to retain three factors for further investigation. To aid in the interpretation of the three factors, Varimax rotation was performed. The rotated solution is presented in Table 52. The three factors explained a total of 37.596% of the variance.

Table 52 Summary of the principal axis factor analysis with Varimax rotation for the family physical activity environment factors

Factor	Factor items	Factor loadings	Variance explained	Cronbach's alpha
Parental physical activity involvement (14 items)				
	I don't think much about being active each day	-0.770	18.301%	0.877
	I enjoy exercising by myself and with others	0.721		
	I don't think or talk much about how much I am being active or involved in sports	-0.639		
	I feel confident trying new games, sports or playing with my children	0.601		
	Talking about what activity I have done or am going to do is something I like to do	0.598		
	Compared with other everyday decisions, my exercise choices are not very important	-0.597		
	I do not like getting sweaty and/or feeling tired after exercise	-0.571		
	I do not like to plan exercise for myself or activities for my family	-0.566		
	I feel confident being involved in activities with the family	0.559		
	Exercising or being active is not much fun	-0.556		
	I enjoy spending time being active with the family	0.515		
	When I travel, one of the things I anticipate most is how I am going to be active there	0.486		
	How often would you do 30 minutes or more of moderate to vigorous activity?	0.471		
	I plan the active things we are going to do in advance	0.416		
Opportunity for role modelling of physical activities (8 items)				
	I am satisfied with how often my family does activities together	0.682	10.246%	0.790
	Spending time with our child is usually a pleasant time for the family	0.675		
	The activities we do together as a family is usually a good time for us to connect and talk with each other	0.656		
	In our family we have rules about how much television our children are allowed to watch	0.604		
	How often does your family do something active together?	0.531		
	In our family we have rules about how much time the child can spend playing computer games	0.507		
	It is difficult to find the time to be	-0.374		

	active most days with my children			
	How often would you do 30 minutes or more of moderate to vigorous activity with your child?	0.363		
Parental support of physical activity (3 items)				
	How often do you stay and watch your children while at sport or active play?	0.794	9.049%	0.790
	How often is your child involved in organised sports or active play time?	0.771		
	How often would you take your child to somewhere to play sport or play?	0.523		

9.4.7 Physical Activity Environment Factor Scores

The response scales for the items were from 1 to 5 or 1 to 7. Scores were adjusted to give a mean score out of 5 for each factor. The descriptive statistics for each factor score is presented in Table 53. The factor scores were between 3.61 and 3.92. The highest mean score was for 'Parental support of physical activity' (μ=3.92, SD=0.68).

Table 53 Summary of factor scores for the family physical activity environment

	Mean (SD)	Min	Max
Parental physical activity involvement	3.61 (0.68)	1.53	5.00
Opportunity for role modelling of physical activities	3.72 (0.47)	2.25	4.75
Parental support of physical activity	3.92 (0.68)	1.67	5.00

Demographic variation in the physical activity environment factor scores

The demographic variation in the physical activity environment was explored using the Pearson Product-Moment correlation and independent samples t-tests. There was no observed influence of parents' gender, age, employment status or marital status on the family physical activity environment factor scores. The number of children in the family also had no influence on the physical activity environment scores. Using an independent samples t-test, the influence of identified culture on the physical activity environment was found to be significant. Australian parents reported significantly higher involvement (μ=3.67, SD=0.64) than parents from other cultures [μ=3.29, SD=0.76 t(104)=2.257, p=0.026].

Parents' education level and estimated annual income had a significant influence on the family physical activity environment. There was a significant positive correlation between level of education and 'Parental physical activity involvement' (r=0.193, n=106, p=0.048). A higher annual household income was significantly associated with more 'Parental physical activity involvement' (r=0.222, n=104, p=0.024) and 'Parental support of physical activity' (r=0.304, n=104, p=0.002).

Relationships between the physical activity environment and children's intake, energy expenditure behaviours and weight

There were no significant observed correlations between the family physical activity environment and children's BMI z-score.

Children's fruit and vegetable intake was significantly correlated with the three physical activity environment factors. Fruit and vegetable intake was most strongly correlated with 'Parental physical activity involvement' (r=0.23, n=106, p=0.001). 'Opportunity for role modelling of physical activities' was positively correlated with children's physical activity (r=0.247, n=106, p=0.011) and negatively correlated with screen time (r=-0.346, n=106, p<0.001). All other correlations were non-significant.

Table 54 Correlations between family physical activity environment factors and children's energy balance behaviours

	Children's fruit and vegetable intakes	Total exercise (min)	Total screen time (min)
Parental physical activity involvement	0.323**	0.145	-0.177
Opportunity for role modelling of physical activities	0.244*	0.247*	-0.346**
Parental support of physical activity	0.212*	0.162	-0.062

*p<0.05; **p<0.01

Relationships between the physical activity environment and parents' intake, energy expenditure behaviours, knowledge and weight

The relationships between parents' characteristics and the physical activity environment were explored using the Pearson Product-Moment correlation. Parents' BMI was negatively correlated with both 'Opportunity for role modelling of physical activities' ($r=-0.199$, $n=106$, $p=0.041$) and 'Parental support of physical activity' ($r=-0.356$, $n=106$, $p<0.001$), meaning more overweight parents provided less opportunities for role modelling and less support for physical activity. Parents' nutrition or physical activity knowledge was not associated with the physical activity environment factor scores.

Parents with higher physical activity levels were found to have a higher diet quality ($r=0.341$, $n=105$, $p<0.001$), have greater physical activity involvement ($r=0.306$, $n=105$, $p=0.002$) and show more support for activity ($r=2.06$, $n=105$, $p=0.035$). Parents consuming a higher quality diet were more supportive of physical activity ($r=0.241$, $n=105$, $p=0.013$) and showed more opportunities for role modelling ($r=0.256$, $n=105$, $p=0.008$).

Relationships between the physical activity and food environments

Aspects of the physical activity and food environments were correlated (Table 55). 'Parental physical activity involvement' was significantly correlated with 'Perceived adequacy of the child's diet' ($r=0.216$, $n=106$, $p=0.026$) and 'Family food preferences' ($r=0.213$, $n=106$, $p=0.028$). 'Opportunity for role modelling of physical activity' was significantly correlated with 'TV interruptions to meals' ($r=0.327$, $n=106$, $p=0.001$) and 'Family's inclusion in food preparation' ($r=0.229$, $n=106$, $p=0.018$). 'Parental support of physical activity' was not significantly correlated with any of the food environment factors.

Table 55 Correlations between family food and physical activity environment factors

	Parental physical activity involvement	Opportunity for role modelling of physical activities	Parental support of physical activity
Perceived adequacy of child's diet	0.216*	0.172	0.093
Opportunities for role modelling – meal preparation views	0.144	0.135	0.024
Perceived food availability	0.138	0.174	0.044
Opportunities for role modelling of eating behaviours	0.085	0.185	0.066
TV interruptions to meals	0.165	0.327**	0.023
Family food preferences	0.213*	0.153	-0.030
Family's inclusion in meal preparation	0.213	0.229*	0.112

*p<0.05; **p<0.01

9.4.8 Differences between Healthy Weight and Overweight Children

An independent samples t-test was used to determine any significant differences between the family environment measures of children classified as healthy weight and those classified as overweight or obese using the Cole cut-offs (Cole et al., 2000). The results from this analysis are presented in Table 56. There were many differences between the two groups of children, but only the significant results are discussed in detail.

Children of a healthy weight resided in households of parents with higher education levels and higher estimated annual incomes compared with overweight children. Healthy weight children had parents with significantly lower BMI values and waist circumferences.

In terms of parental energy intake and expenditure, there were no statistically significant differences in parents' diet quality or exercise time between the two groups of children. Parents of healthy weight children had a significantly higher level of nutrition and physical activity knowledge compared with parents of overweight children.

Parents of overweight children reported significantly more concern for weight and adopted a more permissive parenting style than parents of healthy weight children. None of the other family environmental factors differed significantly by children's weight status.

Table 56 Summary statistics of independent samples t-tests of parent, family and child characteristics by child's weight status

	Healthy weight		Overweight/ obese		T value	Sig
	Mean	SEM	Mean	SEM		p value
Household demographics						
Parents' highest level of education	5.05	0.09	4.60	0.19	1.992	0.048*
Annual household income	3.80	0.12	3.00	0.31	2.611	0.010*
Parents' characteristics						
Parent anthropometrics						
BMI	24.63	0.36	28.90	1.55	-2.680	0.012*
Waist circumference	84.13	1.00	96.71	4.33	-2.831	0.000*
Parent dietary markers						
Fruit intake (serves)	1.70	0.10	1.58	0.24	0.514	0.608
Vegetable intake (serves)	4.43	0.17	4.60	0.64	-0.369	0.713
Diet quality	76.37	0.97	74.36	2.57	0.822	0.413
Parent energy expenditure						
Exercise time	484.08	47.66	528.23	101.85	-0.376	0.708
Sitting time	1159.94	94.14	969.12	129.00	1.195	0.240
Knowledge						
Nutrition knowledge	72.19	1.46	59.46	4.10	3.393	0.001*
Physical activity knowledge	26.11	0.22	24.90	0.56	2.097	0.038*
Children's characteristics						
Child anthropometry						
Waist circumference	59.69	0.42	70.94	1.48	-7.293	0.000*
Child dietary markers						
Total fruit and vegetable intake	3.80	0.20	3.59	0.51	0.412	0.681
% energy fat	30.30	0.59	31.44	1.60	-0.742	0.459
% energy saturated fat	48.13	0.69	45.57	1.26	1.523	0.130
Child energy expenditure						
Morning screen time	19.24	2.33	20.80	4.32	-0.278	0.781
Afternoon screen time	89.84	5.24	107.60	14.58	-1.317	0.190
Total television time	92.94	5.25	110.80	11.22	-1.388	0.167
Total computer time	16.13	3.19	17.60	7.92	-0.183	0.855
Total screen time	109.07	6.11	128.40	15.10	-1.259	0.210
Total moderate exercise	85.34	6.64	65.99	9.51	1.248	0.214
Total vigorous exercise	47.15	4.28	35.45	6.13	1.170	0.244
Total exercise	132.49	9.57	101.44	13.51	1.389	0.167

Environment factors						
Parenting style						
Authoritarian	2.18	0.05	2.28	0.11	-0.894	0.399
Authoritative	4.12	0.04	4.02	0.09	1.030	0.306
Permissive	1.82	0.04	2.06	0.09	-2.390	0.026*
Child feeding practices						
Perceived responsibility	4.39	0.06	4.49	0.14	-0.645	0.520
Concern for weight	1.83	0.10	2.92	0.30	-4.236	0.000*
Restriction	3.21	0.09	3.58	0.25	-1.573	0.119
Pressure to eat	2.63	0.09	2.46	0.18	0.762	0.448
Monitoring	4.24	0.07	4.39	0.13	-0.837	0.405
Food intake environment						
Perceived adequacy of child's diet	3.82	0.07	3.55	0.22	1.418	0.159
Meal preparation	3.92	0.07	3.86	0.20	0.345	0.730
Perceived food availability	3.95	0.06	3.83	0.11	0.829	0.409
Family meal structure	4.04	0.07	4.07	0.15	-0.181	0.857
TV interruptions to meals	3.03	0.14	2.68	0.34	1.023	0.309
Family food preferences	3.87	0.07	3.70	0.17	1.124	0.264
Family's involvement in meal preparation	3.32	0.09	3.31	0.23	0.021	0.983
Physical activity environment						
Parental physical activity involvement	3.60	0.07	3.63	0.18	-0.165	0.869
Opportunity for role modelling of physical activities	3.75	0.05	3.58	0.12	1.321	0.190
Parental support of physical activity	3.93	0.07	3.86	0.20	0.388	0.699

*p<0.05

9.5 Discussion

This chapter examined the family environment as an influence on children's behaviour and weight. The family environment is a complex construct to define and measure. For this study, the definition of the family environment included parenting style, feeding practices, parents' involvement and support, role modelling opportunities and perceived adequacy, and food preferences and availability. The inclusion of a large range of predictors provided insight into the family environment context in which children develop dietary and physical activity habits.

Foremost, as with all behavioural survey studies, the findings in this study must be considered in the context of their limitations, particularly in regard to the measurement of behaviour. To increase the accuracy of recall, the outcome variables for children's behaviour were reported by parents with assistance from their child. Dietary intake data provides a range of possible outcomes. For this study, fruit and vegetable intake was chosen as the outcome measure for dietary behaviour in children. Fruit and vegetable consumption in children has been associated with healthier overall dietary patterns – higher micronutrient and lower fat intakes (J.O. Fisher et al., 2002). Despite representing only one food group, fruit and vegetable intake is relatively easy to recall and therefore measure, making it a commonly used surrogate to overall diet quality. The important health benefits of fruit and vegetables have been well documented and considerable attention has been given to their consumption in national nutrition guidelines (http://www.gofor2and5.com.au, ; National Health & Medical Research Council, 2003c; National Health and Medical Research Council, 2003) and health behaviour research. There is evidence to support an association between obesity risk (higher BMI z-score or BMI) and low fruit intake in children and low fruit and vegetable intake in adults (Lin & Morrison, 2002).

An authoritarian parenting style is characterised by parental restriction and excessive control (Hubbs-Tait, Kennedy, Page, Topham, & Harrist, 2008), and findings from this study – supported by others – found an association with less healthful behaviours in children. Often in contrast to parents' intentions, excessive control has a negative effect on children's fruit and vegetable intake (J.O. Fisher et al., 2002; Patrick et al., 2005; Wardle & Carnell, 2005). It may also result in children eating in the absence of hunger (Birch, Fisher, & Davison, 2003) and negatively influences their ability to self-regulate intake (Evers, 1997). This study also found a positive relationship between the authoritarian parenting style and screen time, meaning adopting a more authoritarian approach was related to higher television and other screen time in children. At the other extreme, in cases where children instead of parents dominate control, negative consequences have also been reported. This study found the permissive parenting style, whereby the child is allowed to eat whatever they want with little parental structure, was associated with a higher BMI z-score. Authoritative feeding represents a balance between authoritarian and permissive styles, whereby children are encouraged to eat healthy foods and are given some choice about their options. Children with this more structured parenting style have higher fruit and vegetable (Patrick et al., 2005) and lower junk food intakes (Cullen et al., 2000; Gable & Lutz, 2000), and better weight control (Brann & Skinner, 2005; Chen & Kennedy, 2004). Findings from this study also suggest that these children have greater physical activity levels.

Most research to date has focussed on parenting styles in relation to eating behaviours. This study was one of few to examine the effects of parenting styles on activity patterns in children, with significant relationships between activity and sedentary behaviours reported.

There is evidence to suggest that child-parent feeding interactions, commonly measured using the CFQ (Birch et al., 2001), have a significant influence on children's dietary behaviours. This study found a significant relationship between excessive restriction and pressure to eat and lower intake of fruit and vegetables in children. However, literature suggests that the influence of child feeding practices may have negative consequences on children's nutrition in a more broad sense, beyond fruit and vegetable consumption (K. Campbell et al., 2006; J.O. Fisher et al., 2002). Specifically, aspects of feeding practices have been associated with lower micronutrient intake (J.O. Fisher et al., 2002), and consumption of higher energy dense drinks, and savoury and sweet snacks (K. Campbell et al., 2006).

While some research has characterised the family environment in terms of child-parent feeding or general parenting style, less attention has been given to characterising the broader influences such as meal time behaviours, role modelling and providing children with opportunities for healthy behaviours. Campbell has led this area of research in Australia, defining the family food environment and its influence on children's behaviour (K. Campbell, 2004; K. Campbell et al., 2006) . Using Campbell's Family Food Environment scale (K. Campbell, 2004), with an additional measure of food involvement (Bell & Marshall, 2003), a total of seven aspects of the family food environment were examined, with three having a significant association with children's dietary intake. The significant association between parents' opportunities for role modelling, perceived adequacy of their child's diet, and higher fruit and vegetable intake replicate findings by Campbell (K. Campbell et al., 2006), and the reported relationship between food availability and fruit and vegetable intake has been reported elsewhere (Gallaway et al., 2007; Hearn et al., 1998; O'Connor et al., 2009; Pearson et al., 2008). A link between food availability and intake has also been reported in relation to other food groups such as energy dense and salty snack foods (Gable & Lutz, 2000). Children rely heavily on their parents for the provision of food, and intake is related to the food most available in the home (Patrick & Nicklas, 2005). This notion is simple but highly important (Rosenkranz & Dzewaltowski, 2008).

Children may have an innate preference towards sweet foods (Birch, 1999), but the home environment can have a significant influence in the development of food preferences in children (Birch & Fisher, 1998). Family food preferences were negatively associated with parents' BMI and positively associated with parents' nutrition knowledge, showing evidence for an environmental influence on children's food preferences. This is significant because food preferences and dietary intake patterns develop in childhood and are maintained through to adulthood. What happens within the family home early in life, in relation to food availability and the development of food preferences, will have a lasting effect and influence on diet quality and obesity risk in the future.

Parents' perception of their child's dietary adequacy has been associated with unexpected dietary patterns. Campbell and colleagues reported heightened perceptions of adequacy were associated with reduced vegetable intake and increased intake of energy dense snack foods (K. Campbell et al., 2006). Such dietary intake "over-optimism" (Cox et al., 1996) has been reported previously with adults estimating their own fruit and vegetable (Cox et al., 1996) and fat intakes (Lloyd, Paisley, & Mela, 1993). In contrast, this study found parents' perception of their child's diet was often accurate. Heightened perception of adequacy was associated with a higher fruit and vegetable intake in children and also a better diet quality in parents. Recruitment bias may partially explain these findings – that is the heightened health interest and awareness of social bias associated with volunteer samples.

Parent role modelling of appropriate dietary and physical activity behaviour is important to child outcomes (Pearson et al., 2008; Wrotniak et al., 2005). This data, similar to that reported by Campbell (K. Campbell et al., 2006), found that children of families who ate together and enjoyed the family meal time reported higher intakes of fruit and vegetables. Such meal time behaviours provide opportunities for role modelling of healthy behaviour. Furthermore, role modelling of physical activity behaviours was also associated with positive outcomes – a more active, less sedentary behaviour pattern in children. In addition, this data suggests parents' own behaviours directly influence their ability to be role models. Overweight parents participating in low levels of activity were least likely to provide children with the opportunity for role modelling active behaviours.

There has been very little research to describe and measure the physical activity environment within the home. The questions used to measure the physical activity environment in this study were based on previous research measuring the food environment (K. Campbell, 2004) and involvement (Bell & Marshall, 2003). Factor analysis identified three factors: involvement, opportunities for role modelling, and parental support. As mentioned, opportunities for role modelling were associated with children's exercise and screen time. It is interesting to note that all three factors of the physical activity environment were associated with a healthier dietary pattern in children as well. Although this relationship has not previously been reported, there is some evidence for the clustering of healthy behaviours in adults and children (Gubbels et al., 2009; Jago et al., 2004; Jago, Nicklas et al., 2005; M. F. Johnson, Nichols, Sallis, Calfas, & Hovell, 1998). This study reported that parents participating in sufficient exercise consume a diet of higher quality, and children with lower screen times consume more fruit and vegetables.

In summary, this is one of the first studies to examine the relationships between the family food environment and the physical activity environment. Findings show that parents' individual characteristics, such as weight, dietary and activity habits, and knowledge, can influence the environment they create for their children. And in turn, the environment can significantly influence children's behaviour. The findings have practical and theoretical implications for obesity prevention. It is important that childhood obesity prevention efforts focus on nutrition and physical activity, communicate to parents the importance of creating a supportive healthy home environment, and emphasise that multiple approaches could potentially all be successful. Parents are ultimately in control of the home environment and need to use it as a vehicle for health promotion to their children.

9.5.1 Demographic Variation in Family Environment Measures

Socioeconomic status (SES) (measured in a range of ways) has a well-established influence on dietary behaviours in children (Rosenkranz & Dzewaltowski, 2008). Children from lower SES families are more likely to be overweight and to follow unhealthy behavioural patterns, such as consuming less fruit and vegetables (Vereecken et al., 2004) and more fast foods (Drewnowski & Darmon, 2005), skipping breakfast (Dubois, Girard, & Potvin Kent, 2006), and watching more television (Story & French, 2004). Data from this study supports previous research, reporting a link between SES parenting practices, family environments and behaviour in children. Parents' education and reported income levels were used as indices of SES. Lower education and income levels were associated with a more authoritarian parenting style, which in turn was related to higher screen time and lower fruit and vegetable intake, less opportunity for role modelling of healthy behaviours, lower perceived food availability, and less parental involvement and support for physical activity. SES may be perceived by families as difficult to change and a factor out of their control, however, for health professionals, the socioeconomic context of families must be considered when designing or implementing obesity prevention strategies.

9.5.2 What are the Differences between Healthy and Overweight Children?

To date, there is no behavioural prescription for obesity prevention, partly because research has not been able to identify a pattern of behaviour that protects populations from obesity. It is difficult to differentiate between children by weight status based on their individual behaviour.

This study and the recent Australian National Children's Nutrition and Physical Activity Survey found that overweight children tend to be more sedentary than healthy weight children. It has been reported that overweight children participate in less physical activity (Commonwealth Scientific Industrial Research Organisation (CSIRO) et al., 2008) and have higher screen time than healthy weight children, however, in this study the differences did not reach a level of significance (possibly due to the small sample size).

When classifying children by weight status, as described by the International Obesity Task Force (IOTF), there were some notable differences between healthy weight and overweight or obese children in terms of their environments. Overweight or obese children were significantly more likely to be from lower SES families, and have overweight parents with less nutrition and physical activity knowledge, who displayed a more permissive parenting style. A permissive parenting style means the child has more control than with other styles in terms of what, where and how much they eat (Hubbs-Tait et al., 2008) – characteristics which may increase their susceptibility to weight gain.

This research was able to identify some interesting differences between healthy weight and overweight children, providing evidence for alternative avenues to intervene in efforts to address childhood obesity. Parents' knowledge and parenting style were identified as significant predictors of children's weight status. Both factors may be considered more receptive to change than other parent factors such as weight, activity habits, or household demographics. Finding characteristics that differentiate children based on weight status may indicate opportunities for intervention offering greater likelihood of success.

It has been reported that parents do not accurately perceive the weight status of their children (Carnell et al., 2005), however, this study reported that parents of overweight or obese children did show significantly higher concern for their child's weight compared with parents' of healthy weight children. This finding may reflect a true difference or a recruitment bias towards more health aware parents. Awareness or concern for weight is important because the first step to behaviour change is the recognition of the problem. Parents are unlikely to adopt health promotion messages if they perceive them to be irrelevant to their family's circumstances.

While this study was able to identify a small number of significant differences in the family environments of children based on their weight status, the classification method should be noted. Children were grouped based on the IOTF definitions, but the small sample size meant overweight and obese children were collapsed into one group. Future research in large population samples may reveal additional differentiating characteristics between healthy, overweight and obese children.

While the questionnaires used in this study were based on previous research, such research was extended to include aspects of both food and physical activity environments. There is every chance, however, that these environments have not been measured in their entirety. Further qualitative and quantitative research with parents may inform researchers of aspects of the family home currently not considered or previously measured. New ways of examining parenting, specific to certain dietary behaviours (O'Connor et al., 2009), have been recently developed, which may add to the more traditional measures of parent practices such as child feeding practices (Birch et al., 2001) Our understanding of the family environment as an influence on children's behaviour is still growing, and more research is needed to build evidence to inform successful obesity prevention strategies.

9.6 Conclusion

This chapter provided descriptive statistics about the family home environments of participants in the Healthy Kids: The Family Way study. The findings highlight the complexity of the family food and physical activity environments, and provide much needed evidence that while parents' BMI may independently predict children's obesity risk, it is likely that the shared home environment plays a significant role in the development of children's dietary, activity and sedentary behaviours.

The statistical analysis presented in results up to this point has been descriptive in nature and explored the bivariate relationships between family characteristics and children's behaviours. This process has been necessary to gain an in-depth understanding of the data and interactions, however, the primary aim of this thesis was to develop a model of the interactions between parental behaviour, family home environment factors, and children's energy balance behaviours and weight status. The following chapter presents the development of such a model using exploratory structural equation modelling.

10 CONFIRMATORY FACTOR ANALYSIS AND DEVELOPMENT OF THE OBESITY RESISTANCE MODEL

10.1 Introduction

This chapter outlines the development of a model that describes the family environment and obesity resistance in children. For this study, obesity resistance is defined as the absence of obesity at a time point (BMI z-score) and in the future (change in BMI z-score). The model is based on findings from the results of the Healthy Kids: The Family Way study (presented in Chapters 8 and 9). The predictive ability of the model is tested with respect to children's current weight status and future obesity resistance.

10.2 Method

10.2.1 Confirmatory Factor Analysis

Confirmatory Factor Analysis (CFA) was conducted using AMOS™ 7.0 to confirm or validate the factor structures developed in the previous chapter. While factor analysis determines which questions cluster together to form factors, CFA confirms the factors that cluster together to estimate latent variables. These latent variables are to be included in the proposed obesity resistance model. Maximum likelihood estimation was used to determine standardised regression weights for the factors.

In the model, rectangles denote variables measured and circles denote latent variables which have been developed using factor analysis. It is recommended that multiple fit indices are reported, and therefore the predictive ability of the obesity resistance model was determined using four measures of fit: Relative Chi Squared (CMIN/df), Normed Fit Index (NFI), Comparative Fit Index (CFI) and Root Mean Squared Error Associated (RMSEA). CMIN/df values greater than 1.0 and below 2.0 (Ullman, 2001) are considered good fit (Garson, 2009). NFI and CFI range from 0 to 1.0, with values closer to 1.0 representing very good fit. RMSEA less than 0.06 reflects good model fit (Garson, 2009; L. Hu & Bentler, 1999).

10.3 Results

10.3.1 Family Food Environment Latent Variable

The seven factors identified in the previous chapter were included in the latent variable 'family food environment'. The standardised regression weights and significance values are presented in Table 57. As can be seen, six of the seven factors appear to load significantly onto the latent variable. The variable 'Family's inclusion in food preparation' is non-significant. This factor was removed and the analysis repeated. As seen, in Figure 11 all six factors load significantly onto the latent variable referred to as the 'Family food environment'. This adjustment appears to improve the model fit, as shown by a change in the model estimates (NFI and CFI) and overall chi^2 value.

Table 57 Confirmatory factor analysis standardised regression weights for family food environment

Latent variable	Factors	Factor loadings Std regression weights	Estimate	p value
Model 1[a]				
Family food environment				
	Perceived adequacy of child's diet	0.366	1.00	
	Opportunities for role modelling – meal preparation views	0.639	1.421	0.004
	Perceived food availability	0.552	1.140	0.005
	Opportunities for role modelling of eating behaviours	0.519	1.222	0.006
	Family food preferences	0.498	1.183	0.007
	Food involvement	0.421	13.042	0.012
	TV interruptions to meals	0.303	1.432	0.037
	Family's inclusion in food preparation	-0.004	-0.056	0.972
Model 2[b]				
Family food environment				
	Perceived adequacy of child's diet	0.366	1.00	
	Opportunities for role modelling – meal preparation views	0.639	1.421	0.004
	Perceived food availability	0.552	1.133	0.005
	Opportunities for role modelling of eating behaviours	0.519	1.225	0.006
	Family food preferences	0.497	1.174	0.007
	Food involvement	0.421	13.039	0.012
	TV interruptions to meals	0.304	1.432	0.037

[a] Chi^2=31.213, df= 20, p=0.052; CFI=0.844, NFI=0.711, RMSEA=0.060

[b] Chi^2=21.737, df=14, p=0.084; CFI=0.890, NFI=0.779, RMSEA=0.060

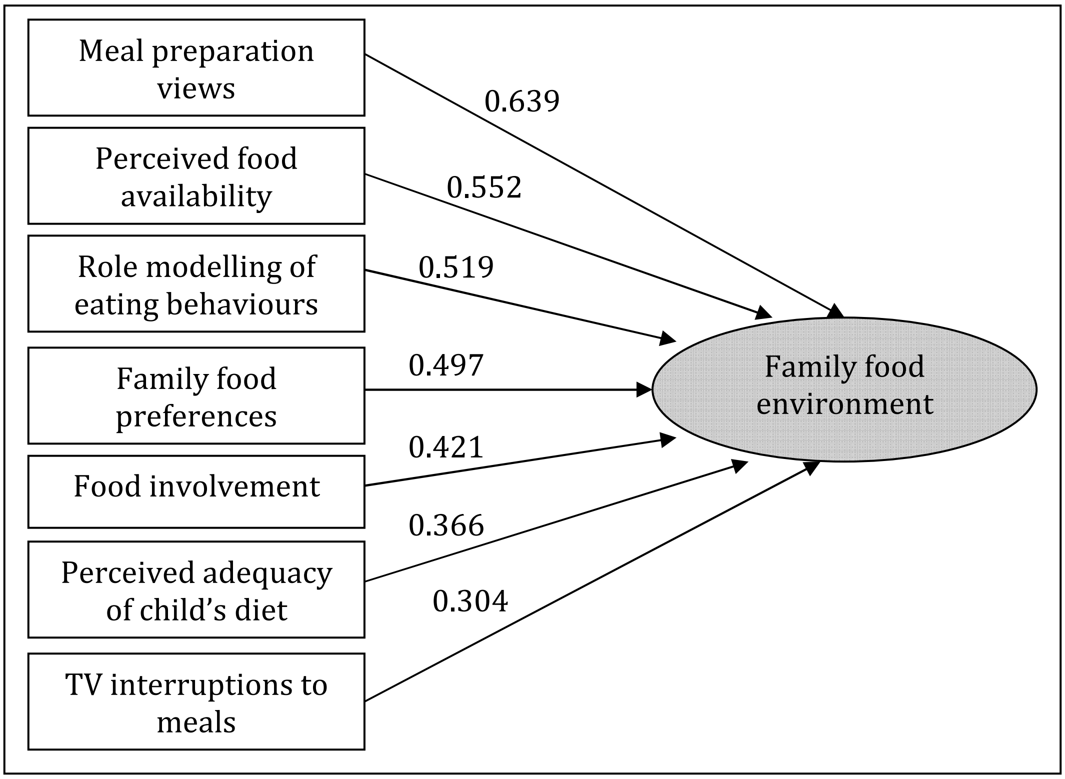


Figure 11 Summary of factor loading for family food environment constructs

10.3.2 Family Physical Activity Environment Latent Variable

The factor loadings for the family physical activity environment are presented in Table 58 and Figure 12. All three factors load onto the latent variable labelled 'Family physical activity environment'. The model fit values are not presented as they are not relevant when there are only three factors.

Table 58 Confirmatory factor analysis standardised regression weights for family physical activity environment

Latent variable	Factors	Factor loadings Std regression weights	Estimate	p value
Family physical activity environment				
	Parental physical activity involvement	0.784	1.00	
	Opportunity for role modelling of physical activities	0.438	0.392	0.049
	Parental support of physical activity	0.422	0.538	0.050

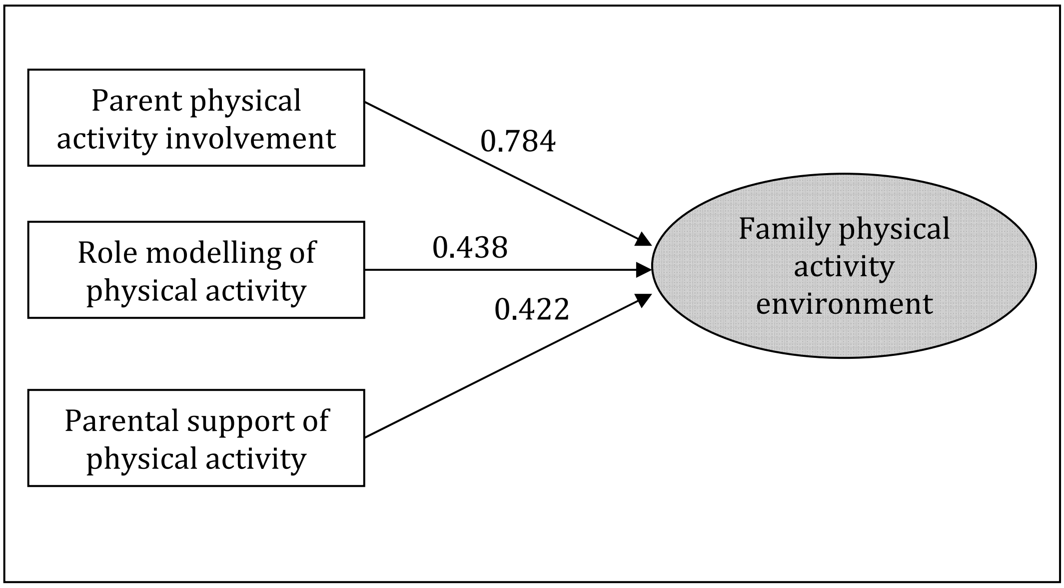


Figure 12 Summary of factor loading for family physical activity environment constructs

10.3.3 Development of the Obesity Resistance Model

The results from Chapters 8 and 9 describe bivariate relationships between factors within the family home environment. The development of the obesity resistance model builds on this knowledge to explore the interactions or the mediating influence of factors measured in this study. Each relationship was explored using structural equation modelling in AMOS™, and the final model represents the model of best fit. Significant relationships are at a p<0.05 level (*) and non-significant relationships are represented by 'ns'.

Relationships between parents' and children's behaviours and the family environment

The predetermined significant correlation between parents' and children's dietary intake appears to be mediated by the latent variable 'Family food environment' (Figure 13).

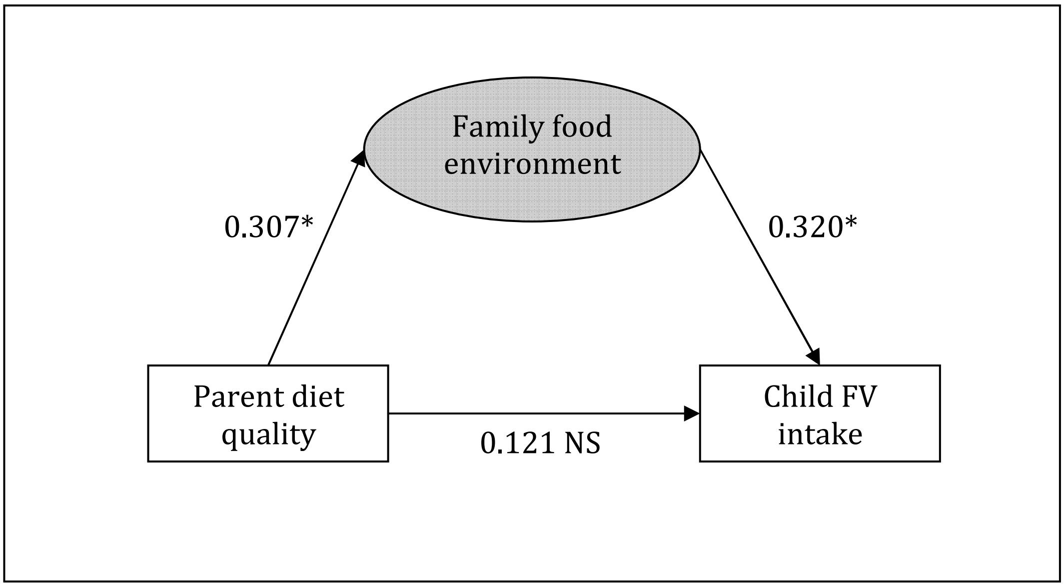


Figure 13 Family food environment mediates the relationship between parents' diet quality and children's fruit and vegetable intake

Chapter 8 describes no correlation between parents' and children's exercise time. There does appear to be a relationship between parents' exercise time and the family physical activity environment, which in turn influences children's exercise and screen time (Figure 14).

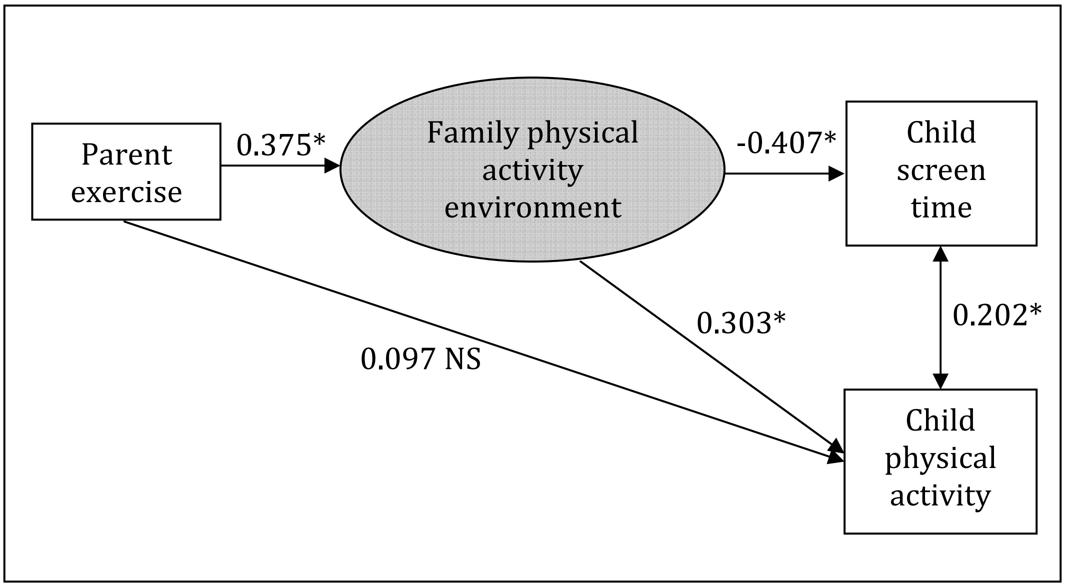


Figure 14 Parental activity and sedentary levels create a family physical activity environment, which supports more physical activity and less sedentary behaviours in children

Relationships between parenting practices, the family environment and children's behaviours

Descriptive statistics suggested that aspects of child feeding practices were significantly correlated with children's dietary intake. Using structural equation modelling to consider the family food environment as an influence in this relationship, it appears that parents' feeding practices influence the environment and the direct relationship with children's dietary intake becomes non-significant (Figure 15).

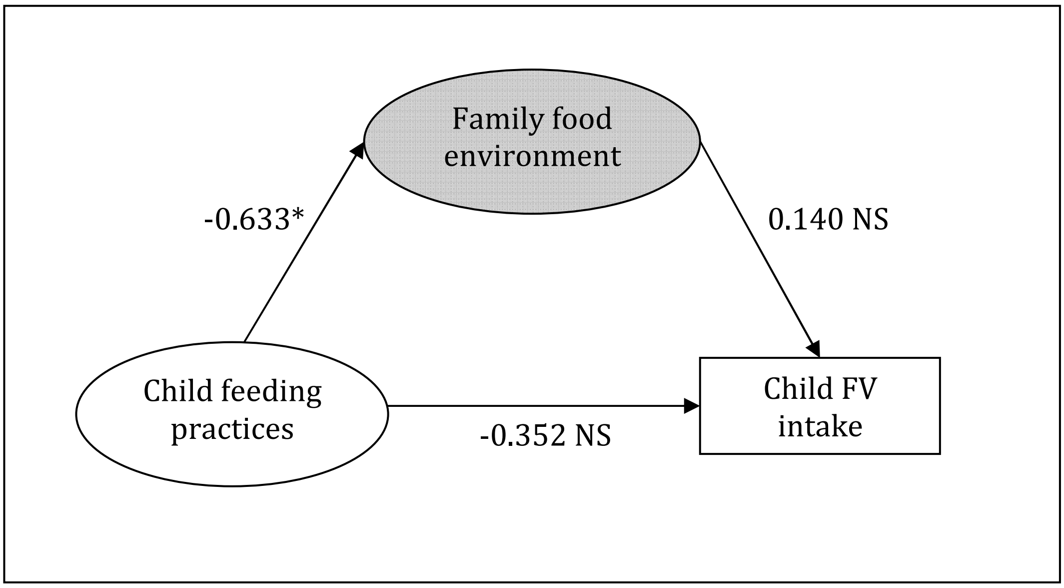


Figure 15 Child feeding practices influence the family food environment and not children's fruit and vegetable intake directly

General parenting style was also found to be correlated with children's intake and energy expenditure behaviours. More complex analysis suggested that the direct relationship between parenting style and children's intake was no longer significant and that parenting style was significantly associated with the food environment, which in turn influenced children's behaviour (Figure 16).

A similar relationship was found between parenting style and the physical activity environment, where parenting style influenced the environment and not children's behaviours directly (Figure 17).

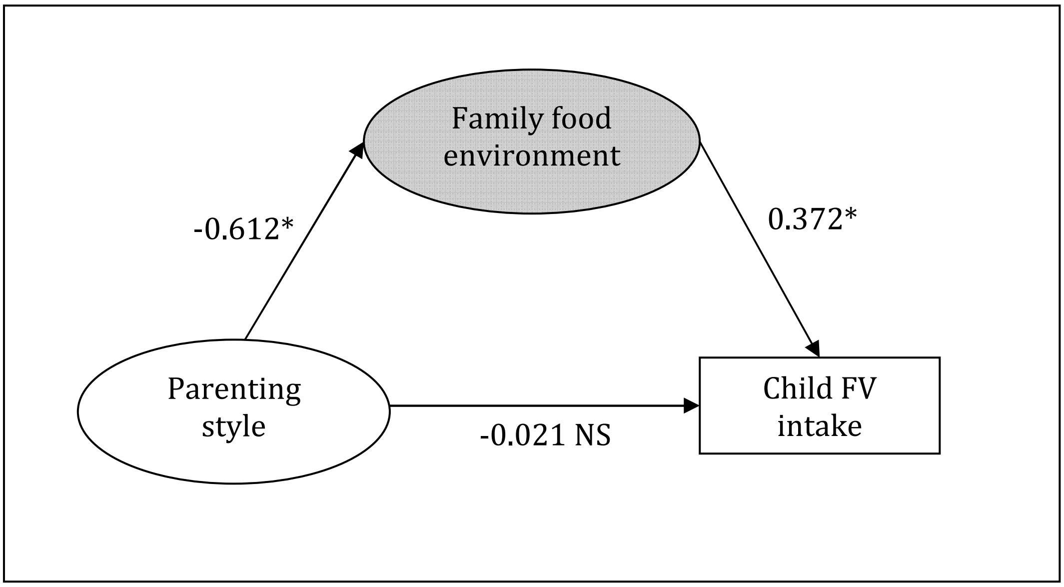


Figure 16 The family food environment mediates the relationship between parenting style and children's fruit and vegetable intakes

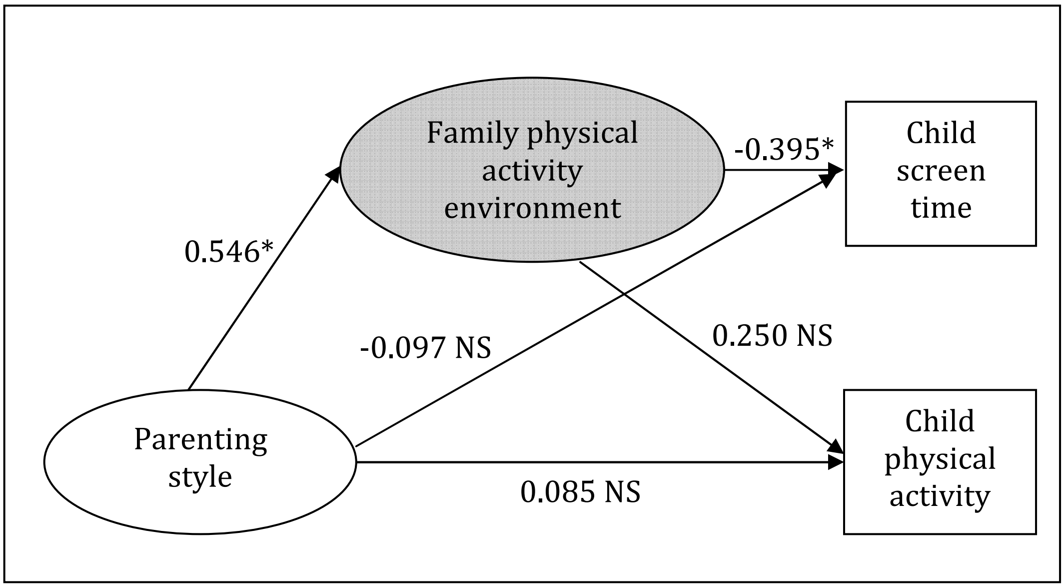


Figure 17 Parenting style indirectly influences children's screen time through the family physical activity environment

The influence of parents' knowledge on parenting practices and the family environment

Previous results found significant correlations between parents' knowledge, their dietary intake, and aspects of the family food environment. Using exploratory structural equation modelling, it can be seen that the relationship between parents' knowledge, their own intake and feeding practices are significant. The direct relationship between knowledge and the environment is not significant, rather knowledge has an indirect influence through parent behaviour (their dietary intake, and parenting and feeding practices) (Figure 18 and Figure 19).

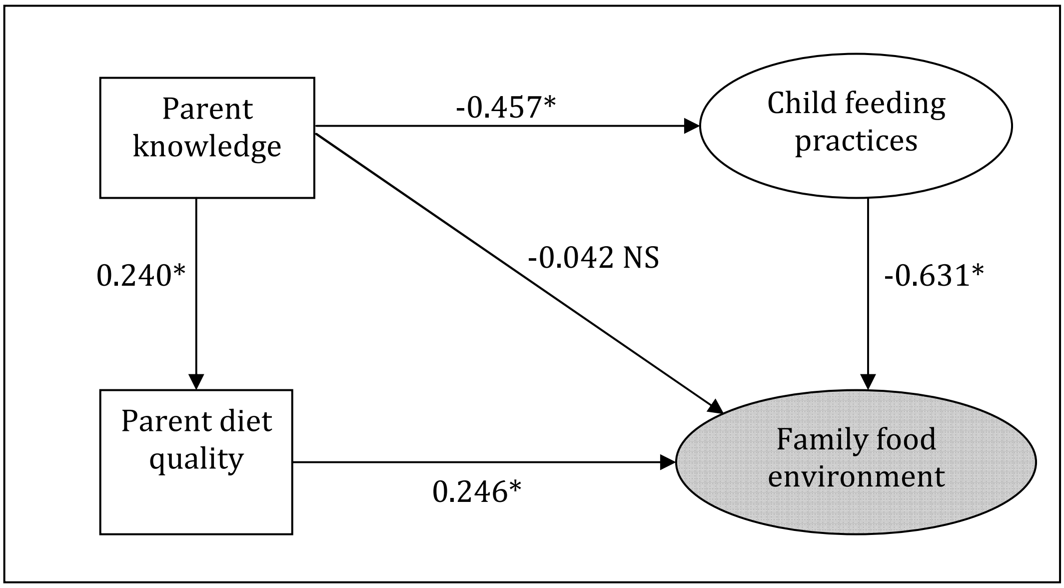


Figure 18 **Parents' knowledge influences their own behaviours (intake and child feeding practices), which in turn influences the family food environment**

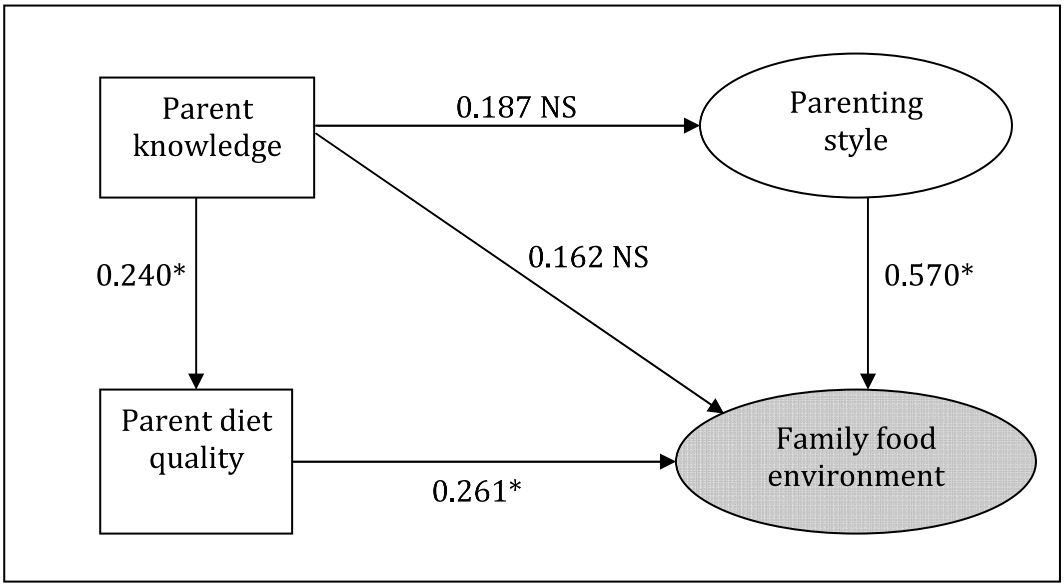


Figure 19 **Parents' knowledge influences their own dietary intake behaviour, which in turn influences the family food environment**

Parents' knowledge does not have a direct relationship with their exercise habits or the physical activity environment at home, however, their exercise habits and parenting style do influence the environment significantly (Figure 20).

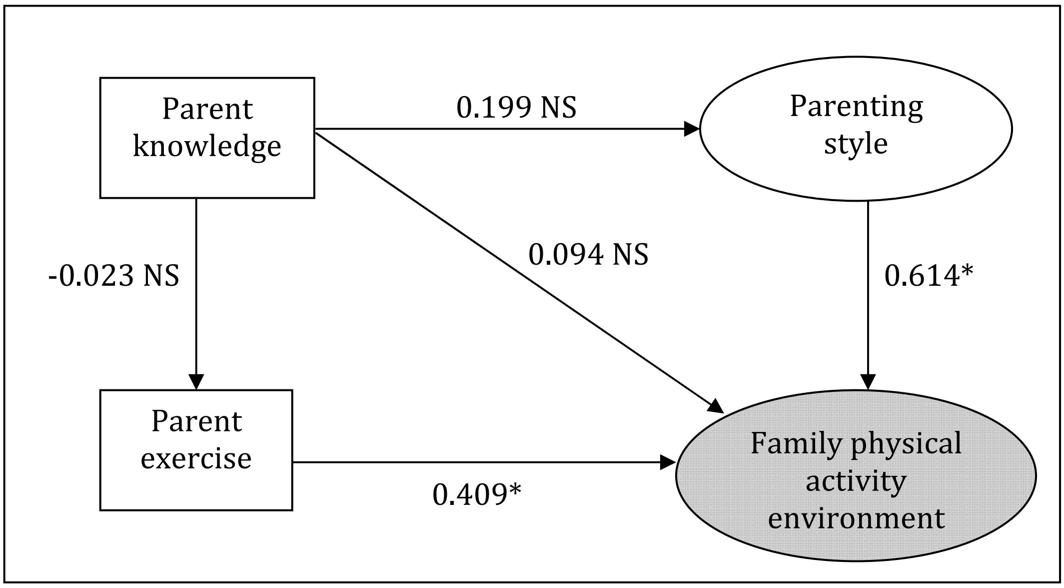


Figure 20 **Parents' behaviours – not their knowledge – influence the family physical activity environment**

In this study, it was found that overweight parents were almost three times as likely to have overweight children, highlighting the strength of parents' weight on children's weight status. Parents' weight status was also found to be a significant predictor of the family physical activity environment, but less of a direct influence on the food environment (Figure 22).

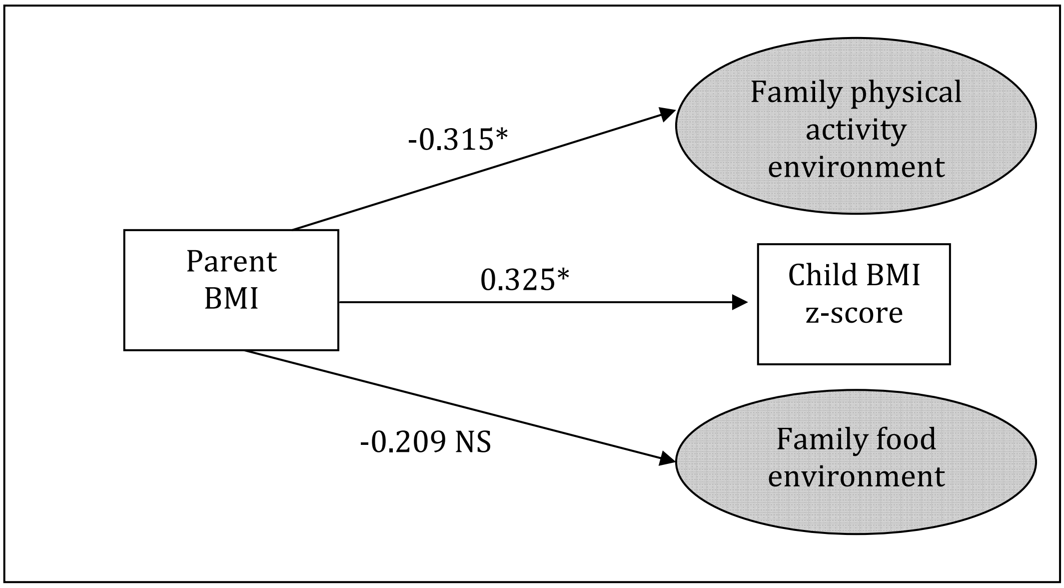


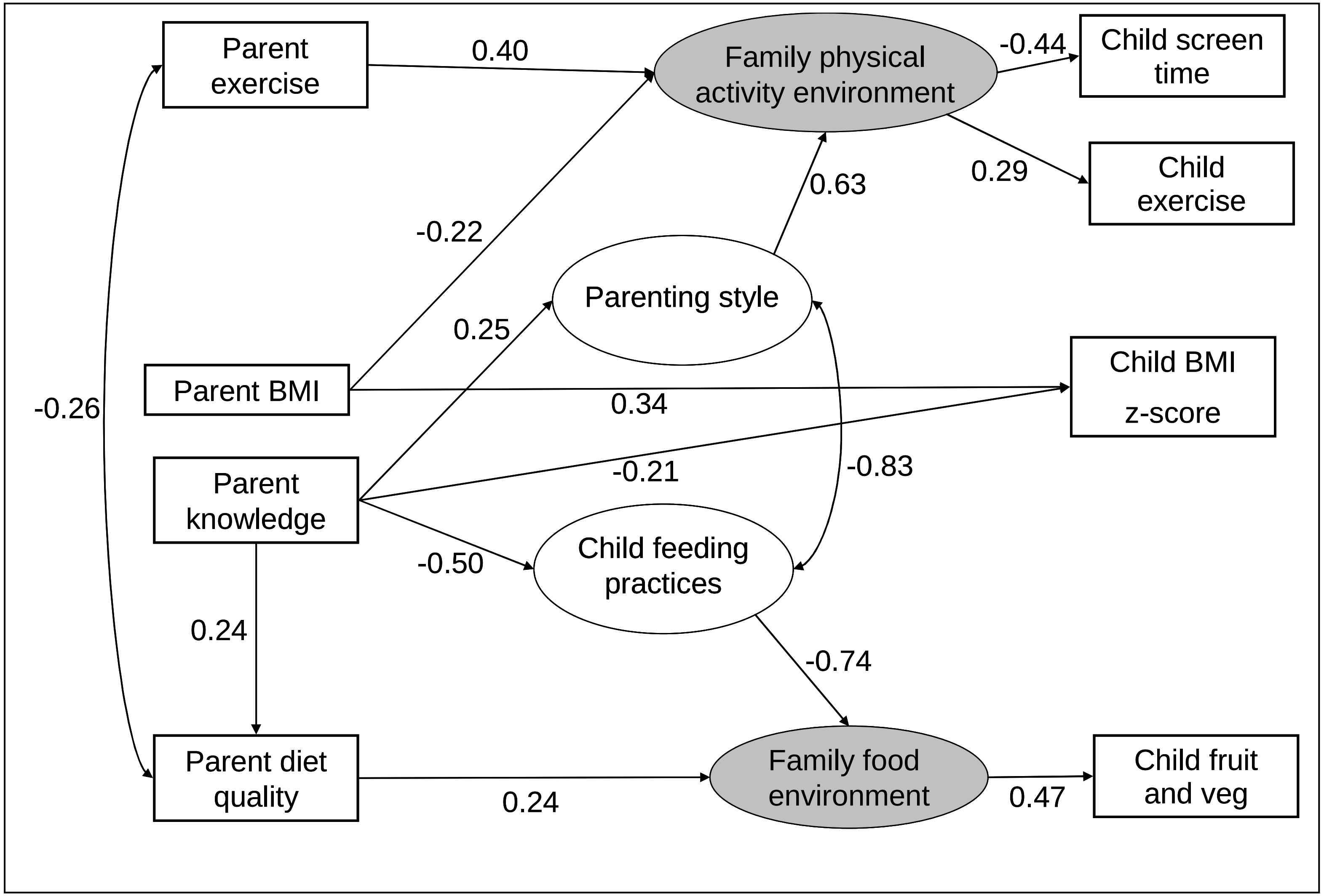
Figure 21 Parents' weight has a direct influence on children's weight status and the family physical activity environment

10.3.4 The Obesity Resistance Model

The significant body of literature reviewed in this thesis, descriptive statistics, and exploratory structural equation modelling of the Healthy Kids: The Family Way data has guided the development of the following model (Figure 22). This model describes the interactions between parental behaviours and family home environment factors, and their relationship with children's weight and dietary and activity behaviours. The model fit values (CMIN/df=1.381, NFI=0.458, CFI=0.741, RMSEA=0.045) suggest the model has an acceptable predictive ability or fit.

The paths can be interpreted as standardised regression weights, and all path coefficients in the model were significant ($p<0.05$). Parents' weight ($\beta=0.34$)

and knowledge (β=-0.21) were found to have a direct relationship with children's BMI z-score. Parents' knowledge directly influenced their general parenting style (β=0.25) and child feeding practices (β=-0.50), which in turn influenced the family physical activity environment (β=0.63) and food environment (β=-0.74) respectively. Other factors to influence the physical activity environment were parents' BMI (β=-0.22) and exercise habits (β=0.40). Parents' knowledge directly influenced their diet quality (β=0.24), which influenced the food environment (β=0.24). The relevant environment variables had a direct relationship with children's fruit and vegetable intake (β=0.47), screen time (β=-0.44) and exercise time (β=0.29) (Figure 22).



Model fit:
CMIN=383.614;
df=291; p<0.001;
CMIN/df=1.381;
NFI=0.458; CFI=0.741;
RMSEA=0.045

Figure 22 Obesity resistance model: A summary of the interactions of family environmental factors influencing children's weight status

10.3.5 BMI z-score Change

One hundred and thirty four children were remeasured at 12 months and a change in children's BMI z-score was calculated.

Figure 23 shows the distribution of the BMI z-score change where a positive value represents an increase in the z-score (indicating a greater than expected weight gain relative to height gain) and a negative value represents a decrease in BMI z-score (suggesting a less than expected increase in weight relative to height). A value of zero represents an expected change in BMI z-score (that is a change in weight that is about expected relative to the change in height, for a child's age and gender). The mean change in z-score over 12 months was 0.06 (SD=0.314).

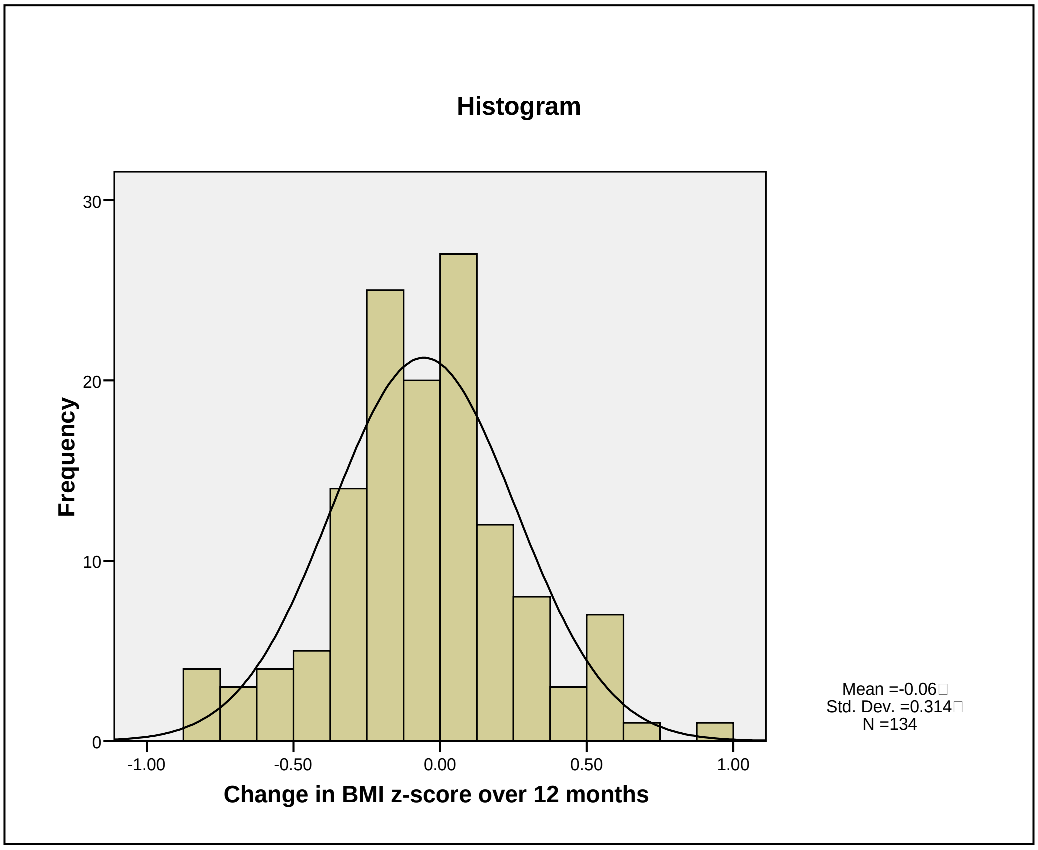


Figure 23 Histogram of children's BMI z-score change over 12 months

Waist circumference was also measured at the 12-month follow-up and a change score calculated where a positive score represented an increase in the child's waist circumference. The average waist circumference change in the 12-month period was an increase of 2.06cm (SD=3.72cm). Figure 24 shows a histogram of the distribution of waist circumference change.

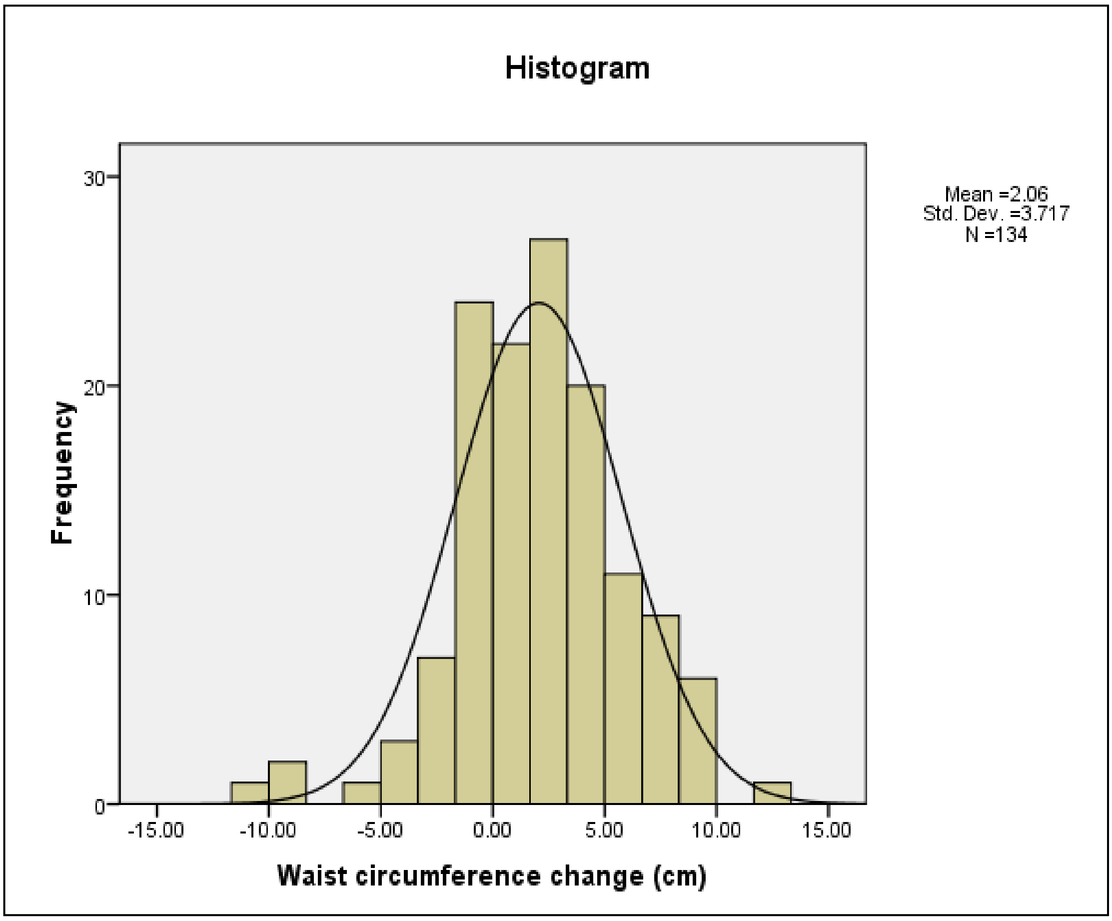


Figure 24 Histogram of waist circumference change over 12 months

10.3.6 Demographic Variation in Body Composition Change

The relationships between the parent and household demographic variables were investigated using the Pearson Product-Moment correlation coefficient for the continuous variables (parents' age and education, household income and number of children, and suburb SES), independent samples t-tests for the dichotomous variables (gender and culture) and one-way analysis of variance for the categorical variables (parents' marital and employment status). There were no significant influences of any household or parent demographic variables on the change in children's BMI z-score or waist circumference.

10.3.7 Predictive Ability of the Obesity Resistance Model for Weight Status Change

The obesity resistance model was retested to determine the statistical fit in predicting BMI z-score change in children over a 12-month period. The changes in BMI z-score were very small over the 12 month period, forcing the model to differentiate between very small numbers. The relationship between parents' knowledge and children's BMI z-score became non-significant (Model 1=-0.21; Model 2: 0.045) and the relationship between parents' BMI and children's change in BMI z-score also become non-significant (Model 1=0.34; Model 2=0.024). The overall model fit was slightly weaker with an increase in NFI to 0.434 and a decrease in CFI to 0.711 and RMSEA to 0.046. The proposed model predicts current behaviour and weight status better than future obesity risk.

The obesity model was also tested for predictive ability in waist circumference and change over 12-month in children with less significant results and a weaker goodness of fit. The waist circumference data was not adjusted for age and gender due to the lack of reference data available and appropriate cut offs.

10.4 Discussion

The proposed model was based on an extensive review of literature. It is comprehensive in nature and describes the complex role of the family home environment as an influence on children's behaviour and weight status. The structural equation modelling examined the predictive nature of the model in terms of children's current weight and weight change, or obesity resistance. Two factors were found to influence children's weight directly – parents' weight and parents' knowledge – while the majority of factors were found to have an indirect influence through the creation of the family home environment.

Studies have shown a strong familial trend in weight status – overweight parents are more likely to have overweight children. This study provided further support, with larger regression weights than previously reported (Birch & Fisher, 2000) for this direct association. The proposed model also presented evidence of an indirect influence that parents' weight may have on the family home environment, through the creation of a supportive physical activity environment. The second direct link between parent and child suggested in this model is the association between parental knowledge and child BMI. Higher nutrition and physical activity knowledge in parents was associated with a healthier weight status in children. Maternal knowledge has been associated with healthier diets in children (Variyam et al., 1999) but to the researcher's knowledge this association with weight has not been reported previously. This finding is of potential significance as knowledge is considered a relatively malleable individual characteristic, and with the current availability of information and misinformation through sources such as the internet willing parents are able to independently seek to improve their health knowledge. The challenge for health professionals and others is to communicate credible, accurate information in an effective and appropriate way. Knowledge was also found to influence parent's own behaviour, such as their parenting and feeding practices as well as their dietary intake; which in turn indirectly influenced children's behaviour through the creation of the family environment. These findings provide much needed support for knowledge as a determinant of behaviour; the crux of the nutrition education framework. At a population level nutrition knowledge of individuals is most amenable to policy intervention (Variyam et al., 1999) and therefore such findings support population level nutrition education campaigns.

Some aspects of the food environment have been associated with various dietary patterns in children such as vegetable intake, sweet and savoury snack foods and high energy drink consumption (K. Campbell et al., 2006). Using a single outcome measure, fruit and vegetable consumption, these data were also able to provide support for the importance of the family food environment on children's dietary intake. The tool used to measure the food environment was based on work by Campbell (K. Campbell, 2004; K. Campbell et al., 2006) and included an additional aspect of the food environment, parental food involvement (Bell & Marshall, 2003). Confirmatory factor analysis showed food involvement loaded well with the other six constructs from Campbell's food environment tool (K. Campbell, 2004). It is recommended that future research considers parental food involvement in the definition of the food environment. As acknowledged by Campbell the current definition of the family food environment is not all inclusive and further work is required to improve the measurement of this multifaceted construct labelled the family food environment. The growing evidence of the home environment warrants its inclusion in research examining children's health behaviour, and future work will substantiate its importance in obesity prevention.

The proposed model extends and builds on previous literature using statistical modelling by considering the expenditure side of the energy balance equation with its attempt to measure aspects of the physical activity environment. Like the family food environment, the physical activity environment was found to have a significant influence on children's activity and sedentary behaviours. A supportive family home was associated with children spending more time in active rather than sedentary behaviour. Parent's own activity habits and their adopted parenting style were significant factors in the creation of a home environment supportive of healthier activity habits in children.

It is well accepted that parents and children's weight are related but how parent's weight may also indirectly influence behaviour is less well understood. The proposed model is unique in showing the direct relationship parent's weight has on the home environment. The model suggests that overweight parents are less likely to provide an environment supportive of physical activity in children. It is important that health professionals are aware and understand that the implications of overweight and obesity in parents goes beyond the genetic predisposition for overweight in their children. These data contribute new knowledge to the philosophy of parent's as role models and it is vital parents acknowledge and accept this challenge. It has been estimated that parents, most commonly mothers (Wansink, 2006), as the nutritional gatekeeper of the home directly or indirectly control 72% of the food consumed by their children (Wansink, 2006). The proposed model highlights some of what these direct and indirect influences might be and the strength of their influence. It is essential parents have insight into the significant role they play in the development of behavioural patterns in their children, and the importance of establishing a healthy pattern early in life.

General parenting styles has previously been included in models of the family environment as part of child feeding (Rosenkranz & Dzewaltowski, 2008) or left out all together. While a relationship exists between feeding practices and general parenting style (Hubbs-Tait et al., 2008), this study has shown the unique importance of each parenting practice in influencing different aspects of the family home environment. Parenting styles and feeding practices are both an integral part of the family dynamic influencing the dietary and physical activity environments of children. General parenting style appears to be more influential in the creation of the activity environment and feeding practices influential in the creation of the food environment within the home. For the development of successful obesity prevention interventions parenting styles and feeding practices must be incorporated and considered as separate yet equally important influences on children's home environments.

"Nutrition behaviours and attitudes are rarely individually based, but are influenced directly and indirectly by family, peers and society at large" (Achterberg & Clark, 1992), therefore the inclusion of a range of family home environment factors within one model allowed the direct and indirect relationships between factors within the home environment to be explored. The proposed model shows the complex network of direct and indirect interactions within the family home, and highlights some relatively unexplored targets for obesity prevention interventions such as parent's knowledge, general parenting style and the physical activity environment. The findings will contribute new ideas to inform obesity prevention strategies in future interventions. The proposed model may provide researchers with confidence to explore obesity prevention using a range of different approaches and provides knowledge that the accumulation of indirect effects will be beneficial in promoting healthy behaviours in children. The indirect effects between factors within the home have not been described, in as much detail, previously. It has been widely advocated that obesity is a complex problem that requires multidisciplinary approaches and solutions (American Dietetic Association, 2006). The proposed model provides some evidence to describe and support this statement.

The multidisciplinary approach suggested by the significant interactions within the model may be used to inform the tailoring of interventions to individual families or sub groups of the population. For example three paths were found to influence the physical activity environment: parent's weight status, their own activity habits and parenting style. With this knowledge an intervention designed to change the home environment could potentially be tailored to target a particular behaviour suited to the family circumstance or alternatively allow parents the liberty of selecting their preferred target behaviour within the defined intervention framework. In the absence of a successful approach to obesity prevention interventions alternative and possible more flexible delivery approaches need to be considered.

The primary intention of this study was to include all of the known family home environment factors, which have been identified through single component interventions, into one model to allow the opportunity to explore the network of interactions. While parent's knowledge and BMI were the only two direct influences, there were many indirect pathways between parent's behaviours, parenting styles, the home environment and children's behaviour. This inclusive approach has allowed for these interactions to be realised.

Reviews are critical of approaches which test a single intervention component; yet uninformed "kitchen sink" approaches (Birch & Ventura, 2009) lack efficacy. The relative simplistic research underpinning practice in this area has resulted in few studies showing effectiveness capable of reversing population level increases in obesity (Birch & Ventura, 2009). Research models will benefit from including both diet and physical activity (Baranowski, 2004), and studies are needed that "are designed to disentangle the relative importance and effects of targeted antecedent behaviours in pediatric obesity [prevention and] treatment" (Oude Luttikhuis et al., 2009). The obesity resistance model proposed presents the relative importance of factors within the home environment and their effects on children's dietary and physical activity behaviours and weight. The structural coefficients within the model represent the strength of the paths that need to be considered. The strength of these relationships may assist prioritising intervention components, to predict the likelihood of success or to direct resources to maximise the effectiveness of an intervention. The model provides further support for multi-component interventions for obesity prevention (American Dietetic Association, 2006; Summerbell et al., 2005).

It is generally difficult to predict or account for human behaviour; previous models account for less than 30% of the variance in human behaviour (Baranowski et al., 1999). Interventions are designed to change behaviour but inferences are often made from models of current behaviour without evidence of effectiveness of their ability to predict behaviour change. This may explain why obesity related behaviour change intervention efforts to date have been largely unsuccessful (Birch & Ventura, 2009; Summerbell et al., 2005). This study attempted to predict behaviour change, but the observed changes in children's BMI z-score were small over the relatively short study period, forcing the model to differentiate between very small numbers. As a result the proposed model predicts current behaviour and weight status better than future obesity risk. It is recommended that the proposed model is tested in a longitudinal study on a larger sample to determine its predictive ability over an extended period. A recent Australian longitudinal study has examined the associations between the family environment and children's weight status (Macfarlane et al., 2009). This study found a few significant associations, one being eating dinner while watching television and change in BMI z-score, over a three year period (Macfarlane et al., 2009). This study used a number of key questions to capture the family environment, however, in limiting its questioning may have underrepresented the complexity of the home environment. This limitation aside, this Australian research is one of few to examine the family environment longitudinally; an important area of research to confirm cross sectional associations.

Nutrition behaviours and lifestyle habits are the result of long established patterns; and too often interventions are short, unable to show large effect sizes and forced to conclude more time is needed to show effectiveness. The Cochrane Review into intervention for the prevention of obesity in children (Summerbell et al., 2005), suggests longer term longitudinal studies are needed to show change in outcomes of interest. The authors of this review also acknowledge the complexity of obesity and its determinants, and challenge the design of future studies to recognise this and design appropriate interventions in order to change children's behaviour and obesity risk (Summerbell et al., 2005). The proposed model recognises the complexity of obesity but was unable to predict a change in obesity risk in children.

The physiological explanation that weight gain is a balance of "energy in and energy out" is widely stated however few epidemiology research studies are able to prove the direct relationship. While aspects of the family environment independently predicted children's behaviour and weight, this study lacked sufficient power to show dietary intake and energy expenditure behaviour directly predicted current weight or weight change. One example, conducted by Jago and colleagues (2005), using a longitudinal design, was able to show television viewing to be predictive of BMI from age three to age six (Jago, Baranowski et al., 2005). Despite television viewing being the only significant predictor, this study measured aspects of children's diet, physical activity and sedentary behaviour and tracked weight status over three years. More studies using this type of study design, multifaceted and longitudinal weight tracking, are needed to learn of the predictor of obesity risk or obesity resistance. Larger scale, longitudinal studies are needed to provide scientific support for targeting these prerequisite behaviours in interventions. It is also important for interventions to show sizable effectiveness to impact on population level obesity trends (Birch & Ventura, 2009).

Using structural equation modelling allowed many factors to be included in the model, to explore the interactions between factors and the predictive nature of the model for the outcomes of interest – children's behaviour and weight. This model was based on previous research and guided loosely by psychological theory. The model presented is of acceptable fit but it must be noted that this does not imply that other models may yield equivalent or better results. Fit indices rule out bad models but do not prove good models. All measures tend to overestimate goodness of fit when the sample size is small, although the comparative fit index (CFI) and root mean squared error associated (RMSEA) are thought to be less affected by sample size (Fan, Thompson, & Wang, 1999). A CFI of 0.90 is generally considered a good fit, however these cut offs are arbitrary and a more salient criterion is to compare goodness of fit between existing models. In the absence of other structural equation models of similar complexity, the CFI of 0.741 in this study is considered acceptable. The few studies in this field to use structural equation modelling have reported better model fit (Birch & Fisher, 2000; J.O. Fisher et al., 2002) but included less variables. It is thought models with fewer factors will have higher apparent fit than models with more factors (Garson, 2009). The path coefficients reported in the proposed obesity resistance model were of similar magnitude to previous studies (Birch & Fisher, 2000; J.O. Fisher et al., 2002). Structural equation modelling appears to be appropriate for the multifaceted problem of obesity and future research should progress this type of analysis to improve model's goodness of fit and predictive ability, and further our understanding of the complex network of factors influencing children's obesity-related behaviours and obesity risk.

10.4.1 Limitations of the Obesity Resistance Model

The obesity resistance model is based on a recruitment strategy, primarily volunteers, which achieved a relatively low response rate. The likely direction and magnitude of bias associated with a sample of this nature needs to be considered and any generalisation of the findings to the wider population needs to be made with caution. The majority of the parent sample were women and the significant role of women in food provision and likely transfer of nutrition habits from mother to children (Stafleu et al., 1996) may have influenced the strength of paths between factors. The role of fathers may be different to mothers (Bogaert et al., 2003) and future research may test path coefficients and the predictive nature of the model with male and female parent figures.

Previous studies have shown that those from economic disadvantaged backgrounds are least likely to participate in social research (Turrell & Najman, 1995) but their ability to report dietary information is similar to that of other population groups (Baranowski et al., 1991). The preliminary descriptive statistical analysis (Chapter 8 and 9) found consistent relationships between demographic characteristics (mainly education and income) and children's behaviour. The dichotomous nature of the demographic variables made it difficult to include them in the obesity resistance model using structural equation modelling. While the sample size of this study was a limiting factor, future research in a large and diverse sample should test the model for statistical fit in samples of differing socioeconomic backgrounds. It is important to understand obesity resistance at a population level; but it is feasible different population groups have slightly different health priorities, reflected in the resulting strengths of path coefficients. This information may be useful to health professional to tailor interventions to population groups.

Because of time constraints, resources and a conscious decision to minimise participant burden, the family environment was not remeasured at follow up. Thus, the proposed model of obesity resistance is essentially a measure of how the family environment (as measured 12 months prior) predicts BMI z-score change in children 12 months in the future. To further develop the proposed model and its ability to predict behaviour change, the family environment should be measured on an annual basis with anthropometry of children and their parents. While the aim of this study was to explore the change in obesity risk in children without direct intervention, behaviour change as a result of merely participating in the research process must also be considered. Of particular interest will be carefully controlled longitudinal research in diverse population samples testing the transformation of this proposed theoretical model into one which can predict behaviour change and therefore make inferences on casual relationships.

The proposed model adds to researchers understanding of the determinants of obesity in children. Alone it will not address the increasing problem of obesity and the preference for children to choose an energy dense, sedentary lifestyle. The model will be of most value if used to inform obesity prevention intervention in a family setting. Interventions that change the environment to enable children to choose a healthy diet and active lifestyle are lacking (Summerbell et al., 2005). Epstein has been at the forefront of longitudinal family based behavioural interventions targeting obesity in children (Epstein, 1996; Epstein, Valoski, Wing, & McCurley, 1994). By tracking children over a 10 year period, he has identified some key criteria of successful intervention – treat both parents and children, include both nutrition and physical activity components, and use the family to support behaviour change in children. The proposed model provides theoretical support for this work of Epstein and some explanation of how these key factors may interact. One recent longitudinal Australian study has examined the associations between the family environment and children's obesity risk (Macfarlane et al., 2009); but more interventions, similar to the extended longitudinal nature of Epstein's work, are needed to improve knowledge of the aetiology of childhood obesity and inform interventions which are effective in reversing current obesity trends. Intervening early in life within the family home will impact on children's health in the short and long term; and essentially children's long term health underpins the future wellbeing of Australia.

10.4.2 Conclusion

The obesity resistance model presented describes the family home environment as an influence of children's dietary and activity behaviours and obesity risk. It is more comprehensive than previous models and gives much needed consideration to both sides of energy balance, expenditure and intake. The findings provide evidence of the complexity of obesity and improve our understanding of the interactions between aspects of the family home. The proposed model should be used to inform intervention design and provide focus for future obesity preventive efforts. Teaching parents effective strategies to establish or improve the home environment is critical in healthy behaviour development and obesity prevention in children.

11 CONCLUSIONS AND IMPLICATIONS FOR FUTURE OBESITY RESEARCH

The main aim of this thesis was to answer the question "Why are some people not obese despite living in an obesity promoting environment?" (Jain, 2005). By focusing that question on children, and their family home environment, this research has gained an understanding of the family home environment and revealed potential opportunities for intervening within this setting in efforts of obesity prevention in children. The focus on children is imperative because the treatment and prevention of obesity in adults is problematic, making the prevention of obesity in children a public health priority.

The family environment is an important obesity prevention setting because habits develop early in life predominantly within the family home. Whilst previous research has recognised the importance of the family environment, individual, school and community approaches have been dominant possibly because of the perception that family homes are difficult to access. This has limited progress in the understanding of this setting. Prevention efforts have targeted a range of behaviours in children including dietary patterns, physical activity and sedentary behavioural habits, and the determinants of these behaviours. Within a family setting, the determinants of children's behaviour include parental characteristics such as weight status and knowledge, parent's dietary intake and exercise habits, their practices such as parenting styles and feeding practices, and the other measures of the environment in which children reside. Literature reviews acknowledge the complexity of the family home environment (Rosenkranz & Dzewaltowski, 2008) and the need for multi component approaches to prevention (American Dietetic Association, 2006; Summerbell et al., 2005); however, characterisation of the complexity of the family home, in both exploratory or intervention research, was identified as lacking. Therefore the primary objective of this thesis was to provide a comprehensive insight into the family environment as a setting for obesity prevention efforts. The proposed model included an unequalled number of potential determinants (factors) and explored the ability of an exploratory model to predict children's current weight and obesity resistance. A recent

Cochrane Review into the treatment of childhood obesity states that "studies are needed that are designed to disentangle the relative importance and effects of targeted antecedent behaviours in pediatric obesity [prevention and] treatment" (Oude Luttikhuis et al., 2009). The analysis of the relationships between factors (coefficient paths) within the model provided a much needed understanding of the relative importance of factors within the home environment. This research contributed valuable scientific knowledge to the understanding of family home; knowledge that informs future obesity prevention efforts.

Knowledge underpins behaviour and is required for behaviour change however scientific evidence linking knowledge to behaviour has been inconsistent. In a review of the existing literature it was identified that limitations in the measurement of knowledge may partially explain the lack of support for this relationship between knowledge and dietary intake behaviour. Modifications to an existing comprehensive measure of general nutrition knowledge and a validation exercise within a heterogenous Australian community setting has provided other researchers with a valid and reliable assessment tool to measure nutrition knowledge. The questionnaire's ability to differentiate between groups of different knowledge levels is important for its use in the future.

Using the validated tool an exploratory study assessed the nutrition knowledge levels of a South Australian community sample. Analysis revealed that some of the basic nutrition guidelines, such as eat more fruit and vegetables and less fatty foods are reaching the community but detailed knowledge of the nutrient content of foods, diet-disease relationships and using knowledge to make healthier food choices is poor. Gaining an insight into the community's level of understanding in regards to nutrition or health messages in general has practical and theoretical implications for health promotion. Population groups of lowest knowledge and common areas of misinformation may be targeted by nutrition education campaigns in the future; and if deficiencies in knowledge lead to poor dietary behaviour, then efforts to increase knowledge may have significant health benefits for individuals and population groups.

Indeed, nutrition knowledge was shown to be a significant independent predictor of dietary intake and diet quality in adults. Greater nutrition knowledge was found to be associated with a healthier dietary intake pattern namely, more fruit, fibre and folate and less saturated fat. Nutrition knowledge accounted for more variance in overall dietary quality than any single marker of intake. These data suggest some of the inconsistent evidence for this relationship between nutrition knowledge and dietary intake behaviour has been due to methodological rather than theoretical issues. Among factors affecting dietary patterns, nutrition knowledge of individuals is the most amenable to policy intervention (Variyam et al., 1999). Therefore evidence linking knowledge with behaviour provides invaluable support for nutrition education campaigns as population level behaviour change strategies.

A significant outcome of this thesis was the validation of the general nutrition knowledge questionnaire for use in the Australia community. Whilst this tool is more comprehensive than others in its assessment of nutrition knowledge, it is recognised that in its current format it may not measure all aspects of knowledge important to intake. Continual refinement and development of the tool to maintain its relevance to intake and consistency with new scientific knowledge will be important for sustained use in future research.

The variety of the food supply and complexity of food patterns means measuring dietary intake behaviour presents unique challenges. Single nutrient or food group analysis has dominated previous study outcomes however that approach omits the synergistic nature of whole dietary patterns. Population surveys in the United States of America have used measures of whole diet (the Healthy Eating Index) for over a decade but similar approaches in Australia were lacking. A key component of this thesis was the modification of the Healthy Eating Index to be consistent with Australian dietary guidelines and its application to the interpretation of dietary intake. It allowed for analysis of dietary intake beyond single nutrient or food groups. This research provided a valuable insight into the measurement of diet quality and the demographic variation in diet quality within an Australian community sample. The value of those results is that they demonstrate a need to apply this approach at a population level. With a review of the Australian nutrition guidelines imminent, this research has shown there is a need to integrate an evaluation component, such as the Healthy Eating Index, into such a nutrition education materials. Specifically, the challenge for researchers will be to develop assessment tools to evaluate the effectiveness of the new guidelines, at an individual (or household) level; that impacts on knowledge, appropriate food choices and dietary intake patterns.

Demographic characteristics influence nutrition, activity and obesity risk in individuals and families. Throughout this thesis demographic factors were shown to affect nutrition knowledge, dietary intake and activity patterns, and the behaviours of parents which define the family home environment. Independent of an individual's economic circumstance, nutrition knowledge was shown to have a significant influence on the healthiness of their diet. This has implications for intervention design and public health campaigns. Including nutrition education or knowledge in all interventions targeting dietary behaviour is important if not essential; and tailoring interventions to different population groups may provide additional benefits.

The importance of knowledge as a determinant of behaviour was further demonstrated by the findings of the Healthy Kids: The Family Way study. This 12 month longitudinal study measured the home environments of South Australian families with primary school-aged children. The significant negative path coefficient in the obesity resistance model suggested that parents with lower knowledge had children at greater risk of obesity. Parents' weight status was identified as a direct predictor of children's obesity risk, adding to the evidence from previous studies, while the importance of their nutrition and physical activity related knowledge has not been reported previously.

The family study and resulting obesity resistance model revealed a number of avenues through which intervention could target parents as the agent of behaviour change and obesity risk in their children. This is an important consideration for intervention design as this approach circumvents criticism that childhood obesity interventions targeted at the children have the potential for negative consequences on self esteem and other unintended negative impacts. Prevention strategies which target parent's weight status, their health related knowledge and parenting style may directly influence children's weight. Other than parent's body weight, these factors to date have not been a strong focus of obesity prevention efforts and provide important areas for future research to pursue.

A permissive parenting style allows children to control what, where, and how much they eat (Hubbs-Tait et al., 2008) and has been associated with negative health outcomes in children. In this study parents of overweight or obese children adopted a significantly more permissive style compared to parents of healthy weight children. Parenting style is considered a malleable characteristic and this evidence suggests parents should be encouraged to adopt a more balanced approach to parenting where they are responsible for providing food and activity opportunities and choices for their children who then make decisions within the boundaries set by parents. This research supports previous literature recommending this division of responsibility, colloquially termed "parent provides, child decides" (Satter, 2005), as it was one characteristic of the family home that differentiated healthy and overweight children. Parenting style and general parenting skills may be a limiting yet fundamental key to the implementation of behaviour change in children. It is recommended that teaching parents about their general parenting styles and the implications of their adopted style is a useful strategy to include in family based obesity prevention efforts in the future.

The notion that obesity is a result of an imbalance between energy consumed and energy expended is well accepted and therefore how influences within the family environment impact on both sides of the energy balance equation is important. Previous research has primarily focussed on the family food environment and therefore an important strength of this thesis was the additional inclusion of the physical activity environment into the model of obesity resistance in children. In characterising the physical activity environment this study was able to show that the influences of the home environment on children's energy expenditure behaviours are similar to findings reported within the food domain. A supportive physical activity environment within the home promoted more active and less sedentary behaviours in children. This reported significance of the family physical activity environment and children's behaviour is unique to this study.

The Healthy Kids: The Family Way study used existing literature from the nutrition domain to develop and factor analyse a measure of the physical activity environment. Although the goal was to measure three aspects of the family physical activity environment: parental involvement, support and role modelling opportunities, there may be other aspects of the environment important to children activity habits not measured by this tool. Importantly, this study has initiated measurement of the physical activity environment within the home and future research may further develop these aspects through exploratory on potential predictors of physical activity to further the understanding of the family environment as a whole.

A complete understanding of the complex interactions that make up the family home environment is critically important to understanding the relevance of this environment to obesity prevention. The proposed model provides a previously unexplored insight into the interaction between factors within the home environment. The model described the complex network of relationships between parent behaviour (diet quality and activity), parent characteristics (BMI and knowledge), parent practices (parenting style and child feeding practices), the home environment (the food and physical activity environments) and children's behaviours (intake, activity and sedentary) and weight status (BMI z-score). As previously mentioned, parent characteristics, such as parent BMI and knowledge, were found to have a direct influence on children's weight status. Parent knowledge also had a direct influence on their parenting practices. It is interesting to note that parent's behaviour and practices were influential in creating the family home environments. And finally the model suggests that the family environment had the most significant influence on children behaviour. These findings make a significant contribution to the scientific literature surrounding the family environment and influences of health behaviour in children.

It is unquestioned that children behaviour develops within the family home environment and is continually shaped directly by parents' behaviour and indirectly through the interaction between parent behaviour and the home environment. Studies which show direct correlations between parent and child intake, food preferences or activity habits contribute some part of this relationship to the shared family home; that is the indirect influences of children learning behaviours through parental role modelling, availability or opportunity and other aspects of the environment. The proposed model was able describe the direction and strength of some these aspects of the shared environment and how these factors mediate this previously observed relationship between parent and child behaviour. This gain in understanding of the indirect influences on children's behaviour provides some insight into the complexity of the family home environment. It is fundamental to the success of future obesity prevention efforts that the complexity of the family setting is acknowledged and models such as the one presented in this thesis guide the development of intervention content.

Another important aspect of this thesis is the attempt to predict obesity resistance in children. While previous models have reported variable success in predicting current behaviour, few predict behaviour change. Accounting for behaviour change is difficult yet essential as it is the objective of all obesity prevention interventions. It is important that future research learns from the limitations of this study and attempts to measure the parent and child behaviour as well as the complexity family environment at multiple time points. Such research will allow a more in depth understanding of how changes at the environment level influence changes at the individual level; that is change in children's behaviour and obesity risk. It is important that future research strives to explain behaviour change. Such knowledge will contribute to the development of successful obesity prevention interventions, which to date remain elusive.

This thesis builds on existing research and contributed significant knowledge to the scientific literature. The extensive literature review identified gaps in research, for example in the measurement of nutrition knowledge, addressed this in the validation of a comprehensive measurement tool and provided support for the theoretical foundation that knowledge is a determinant of behaviour, when previously evidence had been inconsistent. Evidence which provides additional support for the use of public health nutrition education campaigns to change behaviour at a population level. The discussion of diet quality has implications for the use and interpretation of dietary intake data collected in the future and hopefully at a population level in Australia.

Due to the complex nature of obesity it is important that research is guided by theory or models. As yet no satisfactory theory accounts for the complexity of determinants of children's weight status. The proposed model, while limited to the family setting, provided a comprehensive insight into the network of interactions within the home. While it is acknowledged that the model is exploratory in nature and would benefit from future work to test its predictive ability in large populations and translation to intervention; it builds significantly on previous research. The use of structural equation modelling allowed many aspects of the family home environment to be considered in unison as predictors of obesity risk in children. Translation into a model predicting behaviour change will make this model most useful in the design of obesity prevention interventions and in its ability to contribute to the reversing current population trends.

The multi factorial nature of obesity remains a challenge for researchers and behaviour change requires collaboration between individuals, their family and the broader community environment. Of these environments the family home is most dominant in establishing a healthy behavioural pattern in children. It has been estimated that up to three quarters of children's intake is directly or indirectly controlled by the "nutritional gatekeeper" of the home (Wansink, 2006), which tends to be the mother. The knowledge gained from this thesis advances the literature and our understanding of the family home environment as a setting in which to influence children's behaviour and obesity risk. At the crux of the proposed obesity resistance model are the relationships described that comprise the complexity of the family environment.

In summary, this research has shown that at an individual level knowledge can influence food choices and dietary pattern; and at the family level a multi-dimensional approach is appropriate. The challenge remains to design a community intervention which impacts on obesity trends at a population level. Continued efforts to prevent obesity in children must be a national priority as it will contribute to the future health of Australia.

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