INFLUENCES OF SOCIOECONOMIC STATUS, DIETARY FACTORS AND PHYSICAL ACTIVITY ON OVERWEIGHT AND OBESITY OF AUSTRALIAN CHILDREN AND ADOLESCENTS

BY

Zaimin Wang

Bachelor of Medicine, Master of Medicine, Master of Professional Studies (Food and Nutrition Planning)

A thesis submitted for the Degree of Doctor of Philosophy in the Centre for Health Research, Queensland University of Technology

March 2004
ABSTRACT
The increasing prevalence of overweight and obesity in young people is a major global public health concern, especially in developed countries. In Australia, studies in 2001 have suggested that 20% of boys and 21.5% of girls aged 7-15 years were overweight or obese, while in 1985 the figures were 10.7% and 11.8%, respectively. In the short-term, overweight and obese children and adolescents suffer from both adverse physical and psychological consequences. The most significant long-term consequence of childhood obesity is its persistence into adulthood, along with numerous associated health risks. A number of studies have shown that there is an association between being an overweight child and subsequent adulthood obesity.

In general, childhood overweight and obesity is a multifactorial disease and its development is due to multiple interactions between genes and environment. A number of risk factors such as socioeconomic status, dietary patterns, and physical activity have been frequently identified as contributors to its development. However, the results of recent studies provide conflicting evidence. The statistical limitations also make it difficult to compare the studies on childhood obesity between countries. In addition, existing research in Australia that examines the contribution of different risk factors to childhood obesity is limited. There are no published data on the relationship between overweight/obesity, dietary patterns, and physical activity/inactivity in Australian children and adolescents. This study examined the influences of household income, dietary factors, physical activity/inactivity and ethnicity on overweight and obesity among Australian children and adolescents. It also explored the relationship between self-reported weight and height to actual weight and height in older Australian adolescents in order to clarify the accuracy of self-reported data among Australian youth.

Data from the two national cross-sectional surveys, the 1995 Australian National Health Survey (NHS) and the 1995 National Nutrition Survey (NNS) were analysed to explore the influences of household income, intake of energy and fat and percentage of energy from fat on childhood obesity. The study focused on 1585 children and adolescents aged 7-15 years. These data were also used to examine the relationship of self-reported weight and height to measured weight and height in older adolescents. Additionally, another cross-sectional survey among a group of
Australian primary school children from a multi-cultural school in southern Brisbane was undertaken as well as providing indicative data on the relationship of overweight/obesity to physical activity levels and ethnicity, and to provide a protocol on the methodology and practicality of measuring physical activity level in such a school setting.

The results suggested that boys from households with low incomes were more likely to be overweight or obese compared with those from households with higher incomes. Having parents, especially mothers, who were overweight or obese increased the risk of children being overweight or obese. The results do not provide evidence that there are statistically significantly differences in the average intake of energy and fat and percentage of energy from fat between non-overweight and overweight or obese boys and girls. The correct classification of weight or obesity from self-reported height and weight by Australian older adolescents was about 70%, bias in reporting weight and height is higher among overweight or obese older adolescents than non-overweight counterparts.

In addition, preliminary, indicative data from the pilot study on the relationship between body mass index (BMI) and physical activity in 10-12 year old Australian school children from a multi-cultural school revealed that the average daily physical activity level (PAL) was 2.3 Metabolic Equivalents (METs) when the PAL was measured using self-reported activity diary. The proportion of light, moderate and heavy PAL was 2.9%, 20.4% and 76.7% in children, respectively.

Additionally no ethnic differences in the prevalence of overweight /obesity was found. There was no statistically significant difference in average daily TV view times between non-overweight and overweight or obese boys and girls. The average daily number of steps measured using pedometer in the weekdays was 16,505 in boys and 12766 in girls. Most of boys (94.0%) have a medium and over level of steps taken daily while nearly one-third of the girls had not reached the minimum level in the number of steps for optimal health.

However it must be noted this school-based study was a small cross-sectional survey in a single school. The results should be viewed as indicative, not generalisable.
The study does not provide any longitudinal data on physical activity patterns and the trends in relationship to body mass index. In spite of the limitations of this study, it did provide some preliminary data on PAL and its relationship to overweight/obesity among young Australian schoolchildren from diverse cultural backgrounds. Most importantly, this pilot study has provided a protocol on the methodology and practicality of measuring physical activity levels of children using self-reported activity diaries and pedometers in a multicultural school setting.

A number of strategies for the prevention and treatment of childhood overweight and obesity are discussed. In future studies, a population-based and randomly selected sample would ensure findings that are more representative of general Australian children, and the longitudinal studies would help to define the association between the risk factors and childhood obesity, as well as enabling conclusions on causality to be drawn.

**KEYWORDS:** body mass index, overweight, obesity, socio-economic status, diet, physical activity/inactivity, children, adolescents.
PUBLICATIONS BY THE CANDIDATE ON MATTERS RELEVANT TO THE THESIS

JOURNAL ARTICLES


MANUSCRIPT

Wang Z, Patterson CM, Hills AP (2002) Preliminary study on the relationship between body mass index and physical activity in 10-12 years Australian children from a multi-cultural school (This manuscript will be developed submitted for publication as a protocol)

CONFERENCE PRESENTATIONS

- Poster presentation. 33rd Public health association of Australia Annual Conference, Sydney.
- Poster presentation, Australian Society for the Study of Obesity 10th Annual Scientific Meeting, Gold Coast, Queensland.

- Oral presentation. The Australian Health and Medical Research Congress, Melbourne.
- Poster presentation in Queensland Health and Medical Meeting, Brisbane.


- Poster presentation. The Australian Health and Medical Research Congress, Melbourne.
- Poster presentation in California Childhood Obesity Conference, San Diego, California (2003).

OTHER MAJOR PUBLICATIONS BY CANDIDATE

BOOKS


PAPERS IN REFEREED JOURNALS


Wang Z. (1995) Malnutrition, the challenge to the people all over the world (Literature reviews). *Shandong Preventive Medicine* 12, 37-39


STATEMENT OF AUTHORSHIP

The work contained in this thesis has not been previously submitted for a degree or diploma at any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

Signature: ______________________________
Date: ______________________________
ACKNOWLEDGEMENTS

I would like to thank many people who had an important role in the completion of this thesis. First of all, the greatest thanks and appreciation to my supervisors, Associate Professor Carla Patterson and Associate Professor Andrew Hills, for their capable and experienced professional guidance. At all times throughout my candidature they have maintained diligence, interest and enthusiasm for my research. As a student from non-English speaking background, I have been very lucky to be generously instructed by my supervisor team, not only academically, but also linguistically and culturally. To Carla Patterson, my principal supervisor, I would like to thank for her significant amount of time spent on her professional guidance on completing my thesis. I am grateful to Andrew Hills for his capacity as an experienced research in looking over my project. It has been an honour for me to establish a strong personal and professional relationship with both of them.

I am grateful to my wife, Yuan Liu and my daughter Fifi Wang, for their patience, encouragement and emotional support by me throughout.

Special thanks to Katrina Giskes, for her generous assistance with setting up the secondary data sets and helpful advice on my research progress.

I am also grateful to those people who spent their time in assistance with my data collection. They are: Trish Gould, Katrina Giskes, Yifu Deng, Yuan Liu, Jenny Zhang and MingXia Zhu.

I would also like to thank Dr. Diana Battistatta, Dr. Gavin Turrell for their statistical advice and helpful comments on my earlier manuscripts.

A thank you also to the many people who assisted with proof reading my language expression.

I would also like to acknowledge all my colleagues in the Centre for Health Research for their advice and assistance with research and personal friendship.
# TABLE OF CONTENTS

## CHAPTER 1: INTRODUCTION AND BACKGROUND

- 1.1 PREFACE
- 1.2 OUTCOMES OF CHILDHOOD OBESITY
- 1.3 RISK FACTORS CONTRIBUTING TO CHILDHOOD OBESITY
- 1.4 AIMS
- 1.5 CONTENTS OF THE THESIS
- 1.6 SIGNIFICANCE OF THE THESIS

## DEFINITION OF TERMS

## CHAPTER 2: OVERWEIGHT AND OBESITY IN CHILDREN AND ADOLESCENTS: A REVIEW OF THE LITERATURE

- INTRODUCTION
- 2.1 FACTS AND FIGURES
- 2.2 IMPLICATIONS OF OVERWEIGHT AND OBESITY
- 2.3 INDICATORS USED IN DEFINING OVERWEIGHT AND OBESITY
- 2.4 MEASUREMENTS OF PHYSICAL ACTIVITY
- 2.5 AETIOLOGY OF OBESITY IN CHILDREN AND ADOLESCENTS
- 2.6 STRATEGIES FOR THE PREVENTION AND MANAGEMENT OF CHILDHOOD OBESITY
- 2.7 SUMMARY

## CHAPTER 3: METHODOLOGICAL BACKGROUND

- 3.1 INTRODUCTION
- 3.2 SECTION 1: METHODOLOGY OF THE 1995 AUSTRALIAN NATIONAL HEALTH SURVEY AND NUTRITION SURVEY (MANUSCRIPTS 1-3)
- 3.2.1 OVERVIEW OF THE TWO NATIONAL SURVEYS
3.2.2 SAMPLING PROCEDURES FOR THE NHS AND THE NNS…………… 61
3.2.3 RELIABILITY AND VALIDITY OF 24-HOUR DIETARY RECALL……62
3.2.4 QUALITY ASSURANCE PROCEDURES……………………………63

3.3 SECTION 2: METHODOLOGY OF CROSS-SECTIONAL SURVEY
AMONG 10-12 YEARS OLD AUSTRALIAN CHILDREN………………..63
3.3.1 SAMPLING ISSUES ……………………………………………………..63
3.3.2 DEVELOPMENT AND PILOTING OF THE SURVEY TOOL………..64
3.3.3 ETHICAL CLEARANCE………………………………………………..64
3.3.4 QUALITY ASSURANCE PROCEDURE……………………………..64

CHAPTER 4: ASSOCIATION BETWEEN OVERWEIGHT OR OBESITY
AND HOUSEHOLD INCOME AND PARENTAL BODY MASS INDEX IN
AUSTRALIAN YOUTH: ANALYSIS OF THE AUSTRALIAN NATIONAL
NUTRITION SURVEY, 1995…………………………………………………..66

ABSTRACT…………………………………………………………………….67
4.1 INTRODUCTION…………………………………………………………..68
4.2 METHODS…………………………………………………………………69
4.3 RESULTS……………………………………………………………………71
4.4 DISCUSSION………………………………………………………………77
ACKNOWLEDGEMENTS……………………………………………………..81
REFERENCES……………………………………………………………………82

CHAPTER 5: THE RELATIONSHIP BETWEEN BMI AND THE INTAKE
OF ENERGY AND FAT IN AUSTRALIAN YOUTH –A SECONDARY DATA
ANALYSIS OF AUSTRALIAN NATIONAL NUTRITION SURVEY, 1995…85

ABSTRACT………………………………………………………………………86
5.1 INTRODUCTION…………………………………………………………..88
5.2 METHODS…………………………………………………………………89
5.3 RESULTS……………………………………………………………………92
5.4 DISCUSSION………………………………………………………………97
ACKNOWLEDGEMENTS……………………………………………………102.
REFERENCES………………………………………………………………103
APPENDIX B: QUESTIONNAIRES USED IN PILOT STUDY ……………..194

APPENDIX C: INFORMATION SHEET AND CONSENT FORMS………..201

APPENDIX D : ETHICS CLEARENCE APPROVAL LETTER……………..204

APPENDIX E: PARENTAL QUESTIONNAIRE…………………………….205

REFERENCES………………………………………………………………….212
LIST OF TABLES

TABLE 2.1: PREVALENCE OF 'OVERWEIGHT' AND 'AT RISK OF OVERWEIGHT' IN AUSTRALIAN CHILDREN AGED 9 TO 15 YEARS INCLUDED IN THE 1988 AUSTRALIAN HEALTH AND FITNESS SURVEY ..................17

TABLE 2.2: PREVALENCE RATES FOR OBESITY AND OVERWEIGHT IN SELECTED AUSTRALIAN CHILDREN .......................................19

TABLE 2.3: EARLY CONSEQUENCES OF CHILDHOOD OBESITY .........................23

TABLE 2.4: LATE CONSEQUENCES OF CHILDHOOD OBESITY .........................23

TABLE 2.5: BMI CUT-OFF POINTS USED IN CHILDHOOD WEIGHT CLASSIFICATIONS .................................................................28

TABLE 2.6: COMPARISON OF COMMON METHODS USED IN MEASURING PHYSICAL ACTIVITY LEVELS IN CHILDREN: ADVANTAGES AND DISADVANTAGES ........................................34

TABLE 4.1: PROPORTION OF BOYS AND GIRLS IN EACH BMI CATEGORY ......72

TABLE 4.2: RESULTS OF LOGISTIC REGRESSION ANALYSIS: THE PREVALENCE AND ODDS RATIOS OF OVERWEIGHT/OBESITY FOR DIFFERENT LEVELS OF HOUSEHOLD INCOME .....................74

TABLE 4.3: RESULTS OF LOGISTIC REGRESSION ANALYSIS: THE PREVALENCE AND ODDS RATIOS OF OVERWEIGHT/OBESITY FOR CATEGORIES OF FATHER'S BMI .............................................75

TABLE 4.4: RESULTS OF LOGISTIC REGRESSION ANALYSIS: THE PREVALENCE AND ODDS RATIOS OF OVERWEIGHT/OBESITY FOR CATEGORIES OF MOTHER'S BMI .............................................76

TABLE 5.1: BMI (BODY MASS INDEX) CATEGORIES AND NUTRIENT INTAKES OF GIRLS AND BOYS AGED 7-15 YEARS (MEAN ± SD) .........................93


XVII
TABLE 5.3: COMPARISON OF ENERGY AND OF FAT INTAKE AND OF PERCENTAGE ENERGY FROM FAT BETWEEN DIFFERENT BMI (BODY MASS INDEX) CATEGORIES IN AUSTRALIAN BOYS USING ONE-WAY ANOVA (ANALYSIS OF VARIANCE) (MEAN± SD)………………………………………………………………..95

TABLE 5.4: COMPARISON OF ENERGY AND OF FAT INTAKE AND OF PERCENTAGE ENERGY FROM FAT BETWEEN DIFFERENT BMI (BODY MASS INDEX) CATEGORIES IN AUSTRALIAN GIRLS USING ONE-WAY ANOVA (ANALYSIS OF VARIANCE) (MEAN± SD)………………………………………………………………..96

TABLE 6.1: CHARACTERISTICS OF MALE AND FEMALE PARTICIPANTS……..122
TABLE 6.2: BMI AND THE PROPORTION OF BOYS AND GIRLS AGED 10-12 YEARS IN EACH BODY MASS INDEX CATEGORY……………..123
TABLE 6.3: PHYSICAL ACTIVITY LEVEL (PAL) AND TV VIEWING TIME OF BOYS AND GIRLS AGED 10-12 YEARS…………………………125
TABLE 6.4: PHYSICAL ACTIVITY LEVEL (PAL) AND TV VIEWING TIMES OF BOYS AND GIRLS FROM DIFFERENT CULTURAL BACKGROUNDS………………………………………………………………………………………………126
TABLE 6.5: COMPARISON OF PHYSICAL ACTIVITY LEVEL (PAL) AND TV VIEWING TIME BETWEEN DIFFERENT BMI CATEGORIES IN BOYS AND GIRLS USING ONE-WAY ANOVA………………………..127
TABLE 6.6: AVERAGE NUMBER OF DAILY STEPS IN DIFFERENT CATEGORIES FOR BOYS AND GIRLS………………………………….128
TABLE 6.7: AVERAGE NUMBER OF DAILY STEPS AND METS……………….128
TABLE 6.8: THE CORRELATION BETWEEN THE STEPS AND THE PHYSICAL ACTIVITY LEVEL MEASURED USING AN ACTIVITY DIARY IN BOYS AND GIRLS ………………………………………………………129
TABLE 7.1: NUMBERS OF ADOLESCENTS AGED 15-19 YEARS IN THE
TABLE 7.2: THE DIFFERENCES BETWEEN SELF-REPORTED WEIGHT/HEIGHT AND MEASURED WEIGHT/HEIGHT IN AUSTRALIAN ADOLESCENTS……………………………………………………………………..150

TABLE 7.3: THE DIFFERENCES BETWEEN MEASURED WEIGHTS AND REPORTED WEIGHTS BY WEIGHT CLASSIFICATION………………153

TABLE 7.4: CHARACTERISTICS OF ADOLESCENTS WHO UNDER-REPORTED OR OVER-ESTIMATED THEIR WEIGHT BY MORE THAN 5 KG …………………………………………………………………………..154

TABLE 7.5: DISTRIBUTION OF MEASURED AND SELF-REPORTED BMI GROUPS (%)…………………………………………………………………….155
LIST OF FIGURES

FIGURE 2.1: AN ECOLOGICAL PARADIGM FOR UNDERSTANDING FACTORS INFLUENCING OBESITY ...............................................................39

FIGURE 7.1: DIFFERENCE AGAINST MEAN FOR WEIGHT (BOYS AND GIRLS). 151

FIGURE 7.2: DIFFERENCE AGAINST MEAN FOR HEIGHT (BOYS AND GIRLS). 152
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABS</td>
<td>Australian Bureau of Statistics</td>
</tr>
<tr>
<td>ASSO</td>
<td>Australian Society for the Study of Obesity</td>
</tr>
<tr>
<td>BMI</td>
<td>Body Mass Index</td>
</tr>
<tr>
<td>EI</td>
<td>Energy Intake</td>
</tr>
<tr>
<td>FFQ</td>
<td>Food Frequency Questionnaire</td>
</tr>
<tr>
<td>METs</td>
<td>Metabolic Equivalents</td>
</tr>
<tr>
<td>NHS</td>
<td>National Health Survey</td>
</tr>
<tr>
<td>NNS</td>
<td>National Nutrition Survey</td>
</tr>
<tr>
<td>NHMRC</td>
<td>National Health and Medical Research Council</td>
</tr>
<tr>
<td>PAL</td>
<td>Physical Activity Level</td>
</tr>
<tr>
<td>QUT</td>
<td>Queensland University of Technology</td>
</tr>
<tr>
<td>SEIFA</td>
<td>Socioeconomic Indexes For Areas</td>
</tr>
<tr>
<td>SES</td>
<td>Social Economic Status</td>
</tr>
<tr>
<td>TEE</td>
<td>Total Energy Expenditure</td>
</tr>
<tr>
<td>UK</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>USA</td>
<td>United States of America</td>
</tr>
</tbody>
</table>
1.1 PREFACE

Obesity or being overweight is a modern epidemic with considerable consequences. The epidemic is a significant contributor to the increased prevalence of severe articular dysfunction, non-insulin-dependent diabetes, cardiovascular complications and hypertension. The proportion of the population who are either obese or overweight has reached 50% in the USA, and has been rapidly increasing in Western Europe, reaching 30% in 2000 (Guesry, 2000). In Australia, recent national representative data showed that 45% of men, and 29% of women were considered to be overweight, with a further 18% of both men and women being classified as obese. For Australian adults aged 45 and over, the overall rate of overweight or obesity was found to be between 65-75% (McLennan et al., 1997). The obesity epidemic is now also affecting younger populations. This factor induces a further risk of progression to adult populations because once the disease is established, it is very difficult to curtail (Jebb et al., 2000).

Childhood and adolescent obesity is a serious, increasingly prevalent problem in the Western world, including Australia (Allan, 1998); (Flegal, 1999); (Hill et al., 1998); (Rosner et al., 1998) (Booth et al., 1999, 2001, 2003). Almost one-quarter of children in the United States are currently obese; a dramatic increase of over 20% in the past 30 years (Troiano et al., 1995). In the 1990s, 30% of Australian school children were estimated to be overweight (Australian Bureau of Statistics, 1994). However, there was no strong evidence to support this figure. Secondary data analyses of the 1995 Australian National Nutrition Survey (NNS) revealed that the prevalence of overweight or obese Australian children and adolescents aged 7-15 years was between 20%-25% (Magarey et al., 2001). There is also evidence that Australian children are becoming fatter with increased adiposity prominent in very young school children (Wake et al., 1999).

1.2 OUTCOMES OF CHILDHOOD OBESITY

Overweight and obese children and adolescents are at a higher risk of long-term mortality and morbidity, as well as facing the rise of immediate negative effects on physiological and psychological well being (Cashel et al., 2000); (Felts et al., 1996);
The most significant long-term consequence of childhood obesity is its persistence into adulthood, along with numerous associated health risks (WHO, 1997).

An ideal index of health outcome would predict early morbidity or mortality from chronic diseases. However, because obesity in children is rarely associated with immediate morbidity or mortality, the likelihood that obesity will persist into adulthood may have to be used as such an indicator (Bellizzi et al., 1999).

Recently, the NHMRC has summarised the health consequences of childhood obesity (NHMRC, 2002). For example, childhood and adolescent obesity that persists into adulthood confers increased adult morbidity and mortality risks, as well as being associated with morbidity in childhood. In addition, the high prevalence of obesity appears to be contributing to the increasing prevalence of Type 2 diabetes in children and adolescents from certain ethnic groups. Obese children and adolescents suffer from an increase in other medical morbidities that impairs their current health, such as obstructive sleep apnoea, hepatic steatosis, slipped capital femoral epiphyses, and the polycystic ovarian syndrome (Wabitsch, 2000). Further more, obese children and adolescents exhibit impaired psychosocial functioning, with the impairment being greater in females and increasing with age. Finally, a significant proportion of children and adolescents use unhealthy dietary practices for weight control, and these practices are more common in those who are overweight and who are female (NHMRC, 2002).

A number of studies have shown that there is an association between being overweight in childhood and adulthood obesity. For example, the risk of developing adult obesity (BMI > 28) in children aged >9 years who are obese (defined as BMI above the 95th percentile of weight in the second National Health and Nutrition Examination Survey (NHANES II) is up to 80% at age 35 years of age (Guo et al., 1999). The persistence of obesity is more likely when its onset is in late childhood or adolescence and when the obesity is severe (WHO, 1997). This study also found that the odds ratio of being overweight in adulthood for those with childhood BMI values at the 95th percentile were around 1.3-6.1 and 1.4-4.9 times as great as for those with BMI values at the 75th percentile for males and females, respectively (Guo et al.,
Whitaker et al (1997) found that obesity in older children is an increasingly important predictor of adult obesity, regardless of whether or not their parents are obese. The limited longitudinal studies reviewed also revealed that obese children are at greater risk of becoming obese adults. Although only a small proportion of obese adults were obese as children, childhood obesity, particularly during the second decade of life is an increasingly strong predictor of adult obesity (Livingstone, 2000). The relative risks are greatly magnified for extremely overweight children and adolescents and if one or both parents are obese.

There is a need to obtain more information on the morbidity and mortality subsequent to childhood obesity. Such evidence would help the management of primary and secondary prevention for overweight or obesity.

1.3 RISK FACTORS CONTRIBUTING TO CHILDHOOD OBESITY

Many studies have identified a number of risk factors such as genetic or environmental factors – some of them relatively easy to modify and some not-as contributing to the prevalence of overweight and obese children and adolescents (NHMRC, 2002). In general, obesity is a multifactorial disease and its development is due to multiple interactions between genetics and environment. In general terms, the macro-environment determines the prevalence of obesity in a population. The microenvironment, along with biological and behavioural influences, determines the presence of obesity in an individual. Further studies on the contribution of genetic factors and the role of their mechanisms in the development of childhood overweight / obesity are still needed, although a number of practical and social barriers to such research currently exist (NHMRC, 1997).

Weight gain is the result of an imbalance between energy intake (EI) and total energy expenditure (TEE), but the mechanism of this imbalance remains unclear. Whether those who are overweight or obese eat more than their lean counterparts has been extensively investigated and no easy conclusion can be drawn from many of the reported studies (NHMRC, 1997). To date, the dietary emphasis has been on total energy intake and the proportion of macronutrients. Many studies have failed to show a correlation between individual energy intake and adiposity. Despite there being a wealth of data on energy intake and overweight or obesity in children and
adolescents, no definite conclusions can be made about the contribution of food intake to the increasing prevalence of overweight and obesity. Unfortunately, Australian-based studies are limited regarding this research issue.

The most likely environmental factors contributing to the current obesity epidemic are a continued decline in daily energy expenditure that is not matched by an equivalent reduction in energy intake (Hill, 1999). This trend suggests that decreases in physical activity are a major contributing factor. Unfortunately, basic descriptive epidemiological data of physical activity for adolescents are lacking (Sallis et al., 1996) (Livingston, 2000), although Luepker et al suggested that physical activity among youth has declined over the past several decades (Luepker, 1999). In Australia, Booth et al. (2002) examined the physical activity levels among New South Wales high school students and found that the majority of boys and girls were adequately active. However, there has been no collection of representative Australian population data on the physical activity levels of children since the schools survey by the Australian Council for Health, Physical Education and Recreation (ACHPER) in 1985 (Pyke, 1987). It appears likely that Australian children display similar characteristics to American children and that they become more physically inactive as they progress from childhood through adolescence and into young adulthood. However, as yet there is insufficient conclusive evidence from local research to confirm or disprove this trend (NHMRC, 1997).

Some determinants or influences on being overweight/or obese include socioeconomic status (SES), parental weight and ethnicity. Although an inverse relationship between SES and body mass index is well documented, there are limited studies focusing on the paediatric population (Booth et al., 1999). Occupation, education and income may be the most frequently used SES indicators in the health studies. Each indicator is thought to represent different concepts relating SES to health, and each is inter-related with the other.

Parental overweight or obesity is one of the most important health risk factors in the development of childhood overweight and obesity. Parental obesity more than doubles the risk of adult obesity among both obese and non-obese children less than 10 years of age (Whitaker et al., 1997). In a multicultural society, the life style of
immigrants is affected not only by their ethnic or cultural origins but also by their residential environments. This is particularly obvious among young migrants. The influence of ethnicity on health risk factors is also a public health concern in multicultural societies. Data from the USA confirm that there are differences in the fatness of children and adolescents that reflect the ethnic origins of their parents. Increased risk of obesity is apparent in native and Hispanic Americans when compared with white Americans (Dwyer et al., 1998); (Malina, 1993); (Greaves et al., 1989). However, only one Australian study conducted in New South Wales Schools revealed that children and adolescents from European and Middle Eastern background were more likely to be overweight and obese than those from English-speaking or Asian backgrounds (Booth et al., 1999).

Body mass index (BMI), which is derived from weight and height, is one indicator that frequently used to measure overweight/obesity in adults and youth. In clinical practice, these anthropometric measures are often obtained individually. In large-scale population survey, self-reported heights and weights are often used in place of actual measurement to assess the health and nutritional status of people. Numerous studies have focused on the accuracy and reliability of self-reported weights and heights in adults, however, a limited number of studies have reported on these for the adolescent population.

1.4 AIMS
In considering the above background which is more extensively discussed in the following literature review, a number of gaps in evidence were identified, and the overall aims of this thesis were to:

- Provide baseline data on factors including the contribution of household income and diet to the development of overweight and obesity in Australian children and adolescents.
- Provide a protocol for measurement of physical activity and its relationship to overweight/obesity in children in a multicultural school.
- Discuss possible strategies for future studies in order to prevent and treat childhood obesity.
The specific objectives of the research were to determine:

1. Whether there are socioeconomic differences in the prevalence of overweight or obesity among Australian children and adolescents, and whether there is an association between parental overweight or obesity and childhood obesity.

2. If there are differences of energy and fat intakes between non-overweight and overweight or obese Australian children and adolescents.

3. To develop a practical protocol for measuring physical activity levels and a number of factors potentially related to overweight/obesity in children in a multicultural school.

4. Whether self-reported weights and heights are reliable in place of actual measurements to predict the overweight and obesity among Australian older adolescents, as well as determining the direction and magnitude of this reporting bias.

These objectives were determined by analysing data from the 1995 Australian National Nutrition Survey (NNS) and Health Survey (NHS) (specific aims 1, 2, 4), and a cross-sectional survey with Australian school children aged 10-12 years old from a multicultural state school in south Brisbane (specific objective 3).

1.5 CONTENTS AND STRUCTURE OF THE THESIS
This thesis is presented in publication style. Following this introduction, Chapter 2 critically reviews the literature relating to childhood overweight/obesity, in which the contribution of possible risk factors is examined.

An overview of the methods of the Australian National Nutrition Survey (NNS) and the National Health Survey (NHS) in 1995, and the cross-sectional survey among Australian school children in south Brisbane is provided in Chapter 3. The methods issues discussed in Chapter 3 are those not dealt with (or only discussed in minimum details) in the Methods sections of each of the manuscripts.
Three manuscripts, ie Chapters 4, 5 and 7, are presented in the original publication styles for the journals in which they have been published. The manuscript in Chapter 6 will be submitted for publication shortly. Each manuscript addresses the individual objectives of the overall study in terms of the specific results and discussion of these. The referencing style of each manuscript has been altered to be consistent with that of the thesis. As each manuscript is designed independently for the journals, there is some repetitiveness in their introduction, methods and discussion sections.

The first manuscript (Chapter 4) examines the association between overweight/obesity and household income, and parental body mass index among the Australian youth population, and has been published in *Asia Pacific Journal of Clinical Nutrition*. The relationship between body mass index and the intake of energy and fat in Australian children and adolescents is analysed in the second manuscript. This manuscript has been published in *Nutrition & Dietetics*. The third manuscript is the protocol of a study on the relationship between body mass index and physical activity in children aged 10-12 years who attend an Australian multi-cultural school. It also provides a preliminary examination of ethnic differences in the prevalence of overweight/obesity and physical activity/inactivity levels among Australian young children. This pilot study also aims to provide baseline data on the methodology and practicality of measuring physical activity levels in children. The fourth manuscript compares the accuracy of self-reported weights and heights with measured weights and heights among Australian older adolescents, and has been published in *Australian and New Zealand Journal of Public Health*. The studies in Chapter 4, 5 and 7 have been based on the secondary data analyses of the 1995 Australian National Nutrition survey (NNS) and National Health Survey (NHS). The cross-sectional survey in Chapter 6 is an independent study by the candidate.

Chapter 8 summarises the study findings across the four manuscripts, and discusses conclusions in relation to the overall aims of the study. This Chapter further discusses the study limitations, directions for future research, and the public health implications of the research.

Tables and figures are provided in the text to facilitate reading. The references for each of the manuscripts are presented at the end of their corresponding chapters. A
complete reference list (including references cited in the manuscripts) is provided at the end of the thesis.

1.6 SIGNIFICANCE OF THE THESIS
The rapidly increasing prevalence of overweight/obesity in adult and young people is of major public health concern in Australia. Overweight/obesity have been identified as key risk factors of preventable morbidity and mortality due to many diseases particularly hypertension, cardiovascular disease and non-insulin-dependent diabetes mellitus. As the health, psychological and economic costs of overweight and obesity are very high, effective general prevention of overweight including among young people, is essential. This thesis investigates some of the risk factors contributing to childhood obesity, and its aims are consistent with the goals of the strategic plan for the prevention of overweight and obesity launched by National Health and Medical Research Council in 1997 (NHMRC, 1997) as well as the recent NHMRC draft national clinical guidelines for weight control and obesity management in children and adolescents (NHMRC, 2002). The significance of this research is summarised in the following points:

- **Food and nutrition is a significant public health issue**
Primarily, the diet-related diseases that are of greatest public health significance in Australia include chronic, preventable, non-communicable, ‘life-style related’ conditions associated with inactivity and over-consumption of food (Lester, 1994). Recent studies have quantified the burden of disease in Australia by calculating the number of Disability Adjusted Life Years (DALY) for specific conditions and risk factors, and nutrition is estimated to be responsible for at least 10% of the total DALY. These are manifested primary through obesity (4.7%), inadequate consumption of vegetables and fruit (2.8%) and high blood cholesterol (2.1%) (National Public Health Partnership, 2001).

One of the priority objectives of the Australian National Food and Nutrition Policy was to establish ongoing program of food and nutrition monitoring and surveillance in Australia. The National Health and Medical Research Council (NHMRC) developed an initiative called “Acting on Australia’s Weight” to focus on healthy eating and regular moderate physical activity for all as well as on the healthy growth
of children (NHMRC, 1997). When comparing the dietary patterns of Australian children between 1985 and 1995, the overall energy intake was found to increase in ten-year intervals while the percentage of energy from the fat decreased in 1995 (English et al., 1989) (McLennan et al., 1997). However, the relationship of these changing dietary patterns in relation to children being overweight has not been explored. Thus, it is important to undertake more studies on dietary patterns and their relation to overweight /obesity in children and adolescents. NHMRC has recommended that high quality studies examining the amount and type of fat in the diet of children and adolescents are needed (NHMRC, 2002). This thesis examines the contribution of nutrient intake to overweight /obesity in children and adolescents, thereby addressing this significant public health issue (See details in Chapter 5).

- Social inequalities and cultural differences are a public health research priority area

Overall, Australians enjoy good health by international comparisons. However, there are still significant differences between different groups in the population, and social inequalities have been shown to produce health inequalities (Australian Institute of Health and Welfare, 2000). There are overwhelming inequalities in the health of Australians by all measures of socioeconomic status (National Health Strategy, 1992). The influence of the “social determinants of health” (with an emphasis on socioeconomic position) on nutritional health outcomes, as well as information on some nutritionally disadvantaged groups in the Australian population, such as people from non-English speaking background, are important issues in the implementation of such program in Australia (Lester, 1994). When comparing Australian studies into health inequalities with international research, Turrell et al (1999) revealed that most data sets have not been compiled to specially examine socioeconomic variables, and the current measures used for this in Australia are limited in scope, inconsistently recorded and poorly reported.

Although there was no published nationally representative data examining the ethnic differences in childhood overweight or obesity, some Australian studies at the State level suggest that children from certain ethnic backgrounds, such as European and Middle Eastern backgrounds may be at greater risk of obesity (Booth et al., 2001), and a recommendation regarding the requirement for more evidence on ethnicity is
stated (NHMRC, 2002). This document also states that evidence regarding a relationship between socio economic status and overweight /obesity in children is sparse. The recent NHS and NNS did not have comprehensive representative data on people of different ethnic or cultural backgrounds, especially young Australians from non-English speaking backgrounds (NESB). Thus, it is important to explore such issues to determine whether needs are different.

This thesis examines the association between socioeconomic status, ethnicity and childhood obesity, which will contribute to the research into the impact of social inequalities and ethnic or cultural differences in childhood overweight /obesity in Australia (see details in Chapter 4 and in Chapter 6)

- **Increased understanding of the role of physical activity/inactivity in the development of childhood obesity**

  No representative Australian population data on the physical activity levels of children have been available since 1985. Therefore, there is an urgent need for a better understanding of the physical activity levels of Australian children (NHMRC, 1997). In 2002, NHMRC reinforced this need by making three research recommendations regarding physical activity: 1) the relationship between physical activity and body fatness needs to be better understood in physiological terms, 2) an understanding of how children and adolescents are active should aid in the prescription for obesity management, and 3) that physical activity energy expenditure should be assessed (NHMRC, 2002). This thesis provides a protocol through a pilot study for measuring physical activity levels among a group of Australian school children aged 10-12 years of age. In addition, this study also provide some preliminary data on the relationship between physical activity levels and childhood being overweight /obese based on the cross-sectional survey undertaken by the candidate (see details in Chapter 6)

- **Guidance on weight and physical activity measurement in children**

  The NHMRC has recommended that BMI should be used as the standard measure of overweight /obesity for 2-18 year old in Australia, and that the international cut-off points developed by Cole et al (2000) should be used in population and clinical
research (NHMRC, 2002), so that there is potential to provide ongoing baseline data. Currently, in many states in Australia, school nurses collect anthropometric data at the individual level, but aggregated data do not appear to be published, and the question of whether it is necessary to measure height and weight, or if self-reported data can be used as a reliable measure of childhood obesity remains unanswered. This thesis analysed the data from the NHS and NNS to clarify the accuracy of self-reported weight and height in older Australian adolescents. The study also compares the self-reported bias between overweight or obese and normal adolescents. The findings in this thesis have useful implications for health research when using self-reported weight and height by adolescents (see details in Chapter 7).

Measuring physical activity at the population level is difficult as it still largely depends on self-report in the form of a diary, or frequency of various levels of intensity of physical activity. There are few data on the validity of such measures when compared with using motion monitors such as heart monitors and pedometers. In this thesis, some analyses have been undertaken for comparing a pedometer and self-reported diary for measuring physical activity in children. These data provide some initial evidence for the validation of self-reported physical activity data (see Chapter 6). The physical activity level measurement used in the cross-sectional survey among Australian children can be used later to develop a standard physical activity record method.

- **Guidance for future nutrition and physical activity promotion projects**

This thesis will strengthen the evidence available from Australian studies on an association between socioeconomic status, dietary patterns and physical activity levels and the prevalence of overweight/obesity in children and adolescents. The development of physical activity-management guidelines need to be based on the evidence related to positive health outcomes.

In terms of knowledge, attitudes, skills and behaviours, a health promoting school approach (WHO, 1996) provides an additional process for changing, reinforcing and maintaining behaviours, as well as formal curriculum, it involves informal curriculum. This approach systematically co-ordinates curriculum, teaching and
learning, school organisation, ethics and environment; and partnership and services of the school. This reinforces the concept of a multi-sectoral approach where messages and activities reinforce rather than compete (Glanz et al., 1997).
DEFINITION OF TERMS

Adolescents – This term is used to define different age groups by different authors. The Australian Nutrition Survey 1995 (ABS) classified 12-18 year olds as adolescents. For secondary data analysis in this study (Chapter 4, 5), the term children and adolescents was used as the age groups studies were 7-15 years; Chapter 7 refers to 15-19 year old as adolescents.

At risk of being overweight – If body mass index (BMI) is greater than or equal to the 85th percentile and less than 95th percentile.

Body mass index (BMI) - is a measure of a person’s weight in relation to their height, calculated as weight in kilograms divided by height in metres squared.

Children - those aged 2-11 years used in the Australian Nutrition Survey 1995 by Australian Bureau of Statistics. The term children used in this study was noted as above the term adolescents.

Energy expenditure - is an estimate of the energy costs of physical activity derived from reports, observation or indirect objective assessments of people’s activity levels.

METs (metabolic equivalents) - is a unit used to estimate the metabolic cost (oxygen consumption) of physical activity. One MET is defined as the energy expenditure for sitting quietly, which for the average adults is 1 kilocalorie body weight in kg⁻¹hr⁻¹ or 3.5 ml of oxygen body weight in kg⁻¹min⁻¹. METs are used as an index of the intensity of activities (Armstrong et al, 2000).

Physical activity - is any bodily movement produced by skeletal muscles that results in energy expenditure (Armstrong et al, 2000).

Physical inactivity - is conceptualised in population surveys as no reported physical activity (Armstrong et al, 2000).
CHAPTER 2: OVERWEIGHT AND OBESITY IN CHILDREN AND ADOLESCENTS: A REVIEW OF THE LITERATURE

INTRODUCTION
Childhood and adolescent obesity is currently a public health epidemic in most of the Western world, including Australia (Allan, 1998); (Flegal, 1999); (Hill et al., 1998) (Rosner et al., 1998); (Booth et al., 2001); (Magarey et al., 2001). The proportion of the population classified as either being overweight or obese reached 50% in the USA and has been rapidly approaching 30% in Western Europe (Guestry, 2000). Almost one-quarter of children in the United States are currently obese; a dramatic increase of over 20% in the past 30 years (Troiano et al., 1995). In 1990s, 30% of Australian school children were estimated to be overweight (Australian Bureau of Statistics, 1994). However, there was no strong evidence to support this figure. Magarey et al. (2001) and Booth et al (2001) in the recently published studies based on secondary data analyses of the 1995 Australian National Nutrition Survey (NNS), revealed that the prevalence of overweight /obesity in Australian children and adolescents was between 20%-25%. Increased adiposity is also reported as being very prominent in very young school children (Wake et al., 1999).

The most significant long-term consequence of childhood obesity is its persistence into adulthood, along with numerous associated health risks, and unlike childhood obesity, adulthood obesity is always associated with high morbidity and mortality subsequent to cardiovascular disease, hypertension and diabetes (WHO, 1997). A number of studies have reported an association between being overweight in childhood and adulthood obesity (Guo et al., 1999) (Hill et al., 1998) ;( Kelly et al., 1984); (Muramatsu et al., 1988); (Whitaker et al., 1997).

Overweight and obese children and adolescents are at a higher risk of long-term mortality and morbidity, as well as facing immediate risks to their physiological and psychological well-being (Cashel et al., 2000); (Felts et al., 1996); (WHO, 1997). Therefore, both effective prevention and treatment for overweight / obese children is essential. Overall, while there is evidence that the prevalence of overweight /obesity is increasing in many developed countries, the statistical limitations, as well as different definitions of overweight, make it difficult to compare the prevalence or
rates of change between countries (Jebb et al., 2000). In addition to this, studies differ in the way they assess overweight / obesity. Some relied on measures of weight and height, whereas others relied on self-report.

In general, no commonly acceptable standard has emerged, as a wide variety of definitions of childhood obesity are currently in use (Cole et al., 2000). This review includes studies of childhood overweight or obesity in different counties, the health implications of overweight /obesity, aetiology of childhood obesity, and prevention and treatment of this epidemic. It also includes a review on the concept of the definition of overweight/obesity, and measurement of some risk factors related to childhood obesity. It should be noted that most literature in this Chapter focused on children and adolescents aged 7-15 years. However as can be seen through the review, definitions of age groups for children and adolescents vary and standard age grouping for comparison are not set.

2.1 FACTS AND FIGURES
This section reviewed the studies on childhood obesity in different countries over the past 30 years, and presents some facts and figures relating to the prevalence in childhood obesity based on national and local data.

2.1.1 Studies in Australia
To date, there are only two nationally representative sets of prevalence data on childhood obesity available in Australia. In 1985, a nationally representative survey of school children aged 7-15 years was conducted by the Australian Council for Health, Physical Education and Recreation (ACHPER) (Pyke, 1987). Of more than 8000 randomly selected Australian school children aged 7-15 years, 4190 girls and 4302 boys had both height and weight measured. These data were only collected from school children living in the capital cities, and therefore the sample is not truly representative.

The results of 1985 data were analysed using different classifications systems by Harvey et al (1993). The original results suggested that 8.9 -10.7% of boys and 8.7-9.1% of girls were classified as ‘overweight’ using 85th percentiles of age and sex specific distributions of BMI. However, these data were re-analysed by Harvey using
another classification system and the results revealed that 5.3% of children were ‘overweight’, and a further 10 per cent of children were ‘at risk of being overweight’ (see Table 2.1 below). However, these large differences were due to using different definitions of overweight / obesity in children and adolescents, and without consensus concerning a classification of overweight in Australia, the clear statement of what the prevalence of overweight in children and adolescents in absolute terms is unable to be made.
Table 2.1. Prevalence of 'overweight' and 'at risk of overweight' in Australian children in 1985

This table is not available online. Please consult the hardcopy thesis available from the QUT Library

Source: National Health and Medical Research Council, 1997
While the difference in the prevalence is not great, it does highlight the importance of adopting a standard system.

The Australian National Nutrition Survey (NNS) was conducted between February 1995 and March 1996 using a sub-sample of respondents in the National Health Survey (NHS) (McLennan, 1996); (McLennan et al, 1997). Sampling for the NNS was based on a multi-stage sample of households, including urban and rural areas across all States and Territories of Australia. A total of 22,562 individuals aged two years or over was selected from the NHS to participate in the NNS. The results were analysed by Magarey et al. (2001), and the prevalence of overweight or obese children and adolescents in 1985 and 1995 was also compared using new international BMI cut-off points (Cole et al., 2001). The overall prevalence of overweight or obesity was 20% boys and 21.5% girls aged 7-15 years old in 1995. In 1985, the figures were 10.7% in boys and 11.8 in girls in the same age group. Thus, there is some evidence to suggest that the proportion of Australian children who are overweight or obese is increasing.

Besides these two national data sets, there are several data sets collected at a state level. Estimates of the prevalence of overweight or obesity in Australian children vary widely, largely because they have been based upon different standards in the definition of overweight. Table 2.2 summarises some of the published prevalence data in Australia.
Table 2.2. Prevalence rates for overweight and obesity in selected Australian children

* Source: Baur L. University of Sydney, personal communication, 1995

Additionally, in some States and Territories, data on height and weight are collected by school nurses. Unfortunately, no published findings from such collections were found in recent literature.

In a most recently published data analyses by Booth et al. (2003), data from five independent Australian population surveys were analysed. They included the Australian Youth Fitness Survey 1969, the Australian Health and Fitness Survey 1985, the South Australian schools Fitness and Physical activity Survey 1997 and the Health of Young Victorian Survey 1995. The results of these analyses revealed that
the prevalence of overweight among young Australians aged 7-15 years old increased by 60-70%, obesity increased 2-4 fold, and the combined overweight and obesity categories doubled from 1969-1997. Although all data in this study were recently reanalysed using published BMI cut-off points (Cole et al., 2001), the limitations of a comparison between these data should be noted, as these five independent surveys were not specially designed for comparison (Booth et al., 2003)

Although there are limitations in the available data on the prevalence of overweight or obesity in Australian children and adolescents (both at state and national levels), the results do suggest that the prevalence is increasing.

2.1.2 Studies in the USA
Since 1960, overweight and obesity in the USA have increased across all ages, genders, and racial/ethnic groups, and the prevalence in the obese category has increased by about 10% (Grundy et al., 1999). The number of US children who are currently overweight has increased by 6% in the last decade to more than 20% (Allan, 1998). Dietz (1998) has reported that obesity now affects one in five children in the United States. National-wide data from the National Health and Nutrition Examination Survey (NHANES) in the US revealed that 11% of young people from 6 to 17 years of age were overweight in 1988-1994 (using sex-and age-specific 95th percentile cut-off points of revised NCHS/CDS growth chart in the US, compared to about 4% in 1963-1965 (Troiano et al., 1998).

The threat of obesity appears greater than ever for US children and adolescents. All indicators point to the likelihood that the current generation of children will grow into the most obese generation of adults in US history, and there is every expectation that the next generation of children is likely to be fatter and less fit than the current generation (Hill et al., 1998).

2.1.3 Studies in other countries
Data on the prevalence of obesity in European countries has been made available through a number of studies, however comparison and the ability to define such trends are difficult due to differences in definitions of overweight or obesity. Some European studies have suggested that European children and adolescents are
becoming taller, and are therefore, heavier than before (Livingstone, 2000). However, while some studies show proportionately greater increases in weight than stature, others demonstrate a nearly proportional increase in both, while others have observed an increase only in weight or stature (Livingstone, 2000). The frequency of overweight and obesity in childhood and adolescence is about 11% in Western Europe with large variations from country to country (Guestry, 2000).

The available prevalence data show complex patterns varying with time, age, sex and geographical region. The overall pattern suggests that prevalence rates in young children are relative low compared to adolescents (Livingstone, 2000). Gender differences in the prevalence of obesity in Europe are inconsistent between countries. Some studies in Italy, Finland and Austria revealed that the prevalence was the highest in boys (Livingstone, 2000); (Elmadfa et al., 1993), while other studies conducted on Italian and Spanish sub-populations demonstrate the opposite trend (Maffeis et al., 1998); (Moreno et al., 1998). The highest rates of obesity are observed in the Eastern European countries, particularly Hungary, and the southern European countries of Italy, Spain and Greece (Livingstone, 2000). In contrast, northern European countries tend to have lower rates and these are broadly comparable across countries. The reasons for these differences are unclear, but suggest that independent of genetic differences, environmental variables such as social demographics, diet and physical activity patterns are extremely powerful predictors of obesity, which operate in complex ways, both within-and-between countries (Livingstone, 2000).

Unfortunately, because few studies on childhood obesity in Europe have made direct cross-country comparisons using the same reference norms, relative changes in adiposity between countries are difficult to evaluate (Livingstone, 2000). Monitoring secular trends in the prevalence of obesity in European children and adolescents is severely hampered due to a lack of longitudinal data. More recent data from a four-year longitudinal study of 112 pre-pubertal Italian children showed that a high prevalence of obesity (defined as relative BMI>120%) at age 8 years (22.3%) did not change significantly at 12 years (19.8%).
Takada et al (1998) stated that the prevalence value of obesity in Japanese children aged 10 years was 5.5% in 1977 and increased to 8.8% in 1992 (obesity was defined as the index of real weight - standard weight/ standard weight >20%). In a cross-sectional study conducted among 457 Japanese children aged 10 years during 1992 - 1994, Takada et al (1998) found that the prevalence of obesity in Japanese children aged 10 years was 14.1%. There is very limited literature on paediatric obesity in Sweden, Britain, the Netherlands and Canada.

Overall, while the prevalence of childhood overweight or obesity is increasing in many developed countries, the comparisons of figures and trends between countries remains difficult.

2.1.4 Summary
The literature reviewed above suggests that Australian children are becoming fatter, although the cited data have some limitations. Mention of this work should take precedence over trends in other countries. More comprehensive studies in the USA revealed that the threat of obesity is greater than ever for children and adolescents. There are limited studies on childhood obesity in other Western countries such as European countries and Japan.

2.2 IMPLICATIONS OF CHILDHOOD OVERWEIGHT OR OBESITY
Childhood obesity in Western society is a major public health concern because of its significant immediate, as well as later-life health consequences. Possible adverse effects of childhood obesity are summarised by Wabish (2000) in Tables 2.3 and 2.4 by a number of authors (Bellizzi et al., 1999); (Livingston, 2000).
Table 2.3. Early consequences of childhood obesity

<table>
<thead>
<tr>
<th>Early consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical appearance</td>
</tr>
<tr>
<td>Psycho-social impact</td>
</tr>
<tr>
<td>Orthopaedic</td>
</tr>
<tr>
<td>Metabolic disturbances</td>
</tr>
<tr>
<td>Nightly hypoventilation and sleep apnea syndrome</td>
</tr>
<tr>
<td>(associated with Neuro cognitive defects)</td>
</tr>
<tr>
<td>Immune system and infections</td>
</tr>
<tr>
<td>(higher prevalence of bronchitis and upper airway</td>
</tr>
<tr>
<td>infection)</td>
</tr>
<tr>
<td>Skin alterations</td>
</tr>
<tr>
<td>(skin infections, acne, striae distensae, and wound</td>
</tr>
<tr>
<td>healing problems)</td>
</tr>
<tr>
<td>Physical handicap (decreased physical mobility leading</td>
</tr>
<tr>
<td>to decreased physical activity)</td>
</tr>
<tr>
<td>Increased blood pressure and hypertension</td>
</tr>
<tr>
<td>(and increased left ventricular mass)</td>
</tr>
<tr>
<td>Liver steatosis cholecystolithasis</td>
</tr>
</tbody>
</table>

Table 2.4. Late consequences of childhood obesity

Source: Wabitsch, 2000

As one of the most important consequences of childhood obesity is its persistence into adulthood, the latter along with many associated health risks, such as cardiovascular diseases, hypertension and diabetes, a number of studies have focused on the relationship between childhood obesity and adulthood obesity (Livingstone, 2000). Assessing the relationship between overweight in childhood and overweight in adulthood is difficult and has been hampered by differences in study design, representativeness of study populations, the age at which obesity is initially assessed and the length of the follow-up period, the measurement of obesity and the criteria
used to define overweight and obesity, and the availability of longitudinal studies. (Livingstone, 2000).

In spite of these limitations, a number of studies have shown that there is an association between being overweight in childhood and adult obesity. Overall, the persistence of obesity is more likely when its onset is in late childhood or adolescence, and when the obesity is severe (WHO, 1997). In Australia, one study provides evidence for this relationship. Kelly et al. (1984) collected the height and weight of 928 young people in Busselton, Western Australia over a period of 11 years. This study found that although most obese young adults were not obese in childhood, 50% of those who were obese between the age of 9 and 14 years were still obese when examined in young adult life, and were at greater risk of becoming obese adults than their non-obese peers. Most subjects who subsequently became obese young adults were significantly heavier than their non-obese peers from 6 years of age onwards.

Several studies from the USA support this association. For example, Guo and Chumlea (1999) reported that the risk of developing adult obesity (defined as BMI > 28) in children aged > 9 years who are obese (defined as BMI above the 95th percentile of weight in the second NHANES survey is up to 80% at age 35 years. They also revealed that the prediction is excellent at age 18 years, good at age 13 years, but only moderate at ages less than 13 years. For 18 years olds with BMIs above the 60th percentile, the probability of being overweight at age 35 years is 34% for men and 37% for women. Guo and Chumlea (1999) also found that the odds ratio of being overweight in adulthood for those with childhood BMI values at the 95th percentile were around 1.3-6.1 and 1.4-4.9 times as great as for those with BMI values at the 75th percentile for males and females, respectively. Whitaker et al (1997) found that obesity in older children is an increasingly important predictor of adult obesity, regardless of whether the parents are obese.

In brief, the literature suggests that childhood BMI values correlate with BMI values in adults. The limited number of longitudinal studies demonstrated also that obese children are at greater risk of becoming obese adults. Although only a small proportion of obese adults were obese as children, childhood obesity, particularly
during the second decade of life, is an increasingly strong predictor of adult obesity (Livingstone, 2000).

2.3 INDICATORS TO DEFINE OVERWEIGHT AND OBESITY

There are several definitions of overweight and obesity in children and adolescents used in the literature. Overweight is often described as excess body weight while obesity is defined as a condition where a pathological excess of body fat is present in an individual (Bellizzi et al., 1999); (Wabitsh, 2000).

It must be recognised that there has been a lack of consistency regarding how overweight or obesity are defined in children and adolescents. However, the area is obfuscated by the inconsistent use of widely recognised definition. These factors represent a significant limitation in attempts to compare studies. As mentioned at the outset of this review and reinforced in national documents (NHMRC, 1997, 2002), one of the real challenges is to standardise the measurement of overweight and obesity in children and adolescents. The absence of a consensus on a definition or a classification of overweight in children and adolescents has been a major barrier to communication both among health professionals and subsequently between health professionals and the public. Recently, international BMI cut-off points have been introduced to identify and define the overweight and obesity in children and adolescents (Cole et al., 2001).

Adiposity is the amount of fat in the body; expressed either as total fat mass (in kilogram) or as a fraction (percentage) of the total body. Overweight describes excess body weight (Bellizzi et al., 1999). Obesity is defined as a pathological excess of body fat which is present in an individual (Wabitsh, 2000). Overweight and obesity develop when there is a discrepancy between energy intake and energy output. It should be noted that there was a very small percentage of secondary obesity (for example, those whose obesity resulted from an underlying disease or condition such as congenital chromosomal defects, Downs Syndrome, Klinefelter Syndrome and Prader-Willi syndrome ) in childhood, all these primary obesity scenarios can easily be diagnosed by their specific clinical features (Wabitsh, 2000).
To date, a range of indicators have been used to define being overweight and obesity among children and adolescents. Weight and height are the most common indicators, as they are routinely measured in the clinical setting and included in medical records to evaluate the health status of children. Numerous other methods are also used as to assess fatness. Goran et al. (1998) undertook a recent review of methodologies used in obesity and nutrition research in children. Some of the more frequently used body composition techniques in children are densitometry (underwater weighing), DXA (Dual energy x-ray absorptiometry), skinfold measurements and anthropometry, and bioelectrical impedance analysis (BIA). For population screening of obesity, the anthropometric measures of height, weight and/or skinfold thickness, of which triceps and subscapular are the most usual, remain the most feasible and practical. The following sections summarise some of the indicators used to identify being overweight and obesity.

### 2.3.1 Weight and height

Body weight is reasonably correlated with body fat but is also highly correlated with height (Bellizzi et al., 1999).

Although weight may be one indicator of fatness, children of the same weight but of different heights can have widely varying levels of adiposity. Some of the common cut-off points used involving weight and height are as follows:

- 85th percentile of weight-for-age commonly used to classify those "at risk" of overweight (Himes et al., 1994); (Lazarus et al., 1995)
- 95th percentile weight-for-age used as a cut-off for obesity (Himes et al., 1994).
- 120 per cent of a standard or reference weight used to estimate the prevalence of overweight (NHMRC, 1997)

Weight and height may be reasonable indicators of reliable fatness if their cut-off points were based on specific age and gender and if the standards of cut-off points were derived from a reliable and representative population.

### 2.3.2 Body mass index (BMI)
BMI, which is Weight adjusted for height, is a useful index and is widely used to assess reliable adiposity in adults (Bellizzi et al., 1999). While the use of BMI is accepted as a reliable tool for measuring obesity in adults, there has been a reluctance to use it with children and adolescents, largely because BMI increases with age (NHMRC, 1997). Lazarus et al. (1996) demonstrated that BMI was an excellent indicator of body fat measured by dual X-ray absorptiometry in subjects aged 4 to 20 years. Himes et al. (1994) reviewed the strong correlations that have been shown in adolescents between BMI and blood pressure, blood lipids and lipoproteins, and also the direct associations between increase in BMI in adolescents and subsequent elevated BMI, blood lipids and blood pressure in young adulthood.

- Relationship to fatness
In adults BMI is largely independent of height and for this reason is widely used as an indicator of both under-and over-weight and in some studies of children and adolescents (McLennan, 1998, 1998) (Hills & Byrne, 1998) (Lazarus et al., 1995). BMI has been proposed as a simple and valid measure for monitoring fatness in adults (Schreuder & Martorell, 1999). Pietrobelli et al. (1998) found that BMI was strongly associated with TBF (total body fat) and %BF (percent of body weight as fat) for boys and girls aged 5-19 years, respectively. The results support the use of BMI as a fatness measure in groups of children and adolescents although interpretation should be cautious when comparing BMI across groups that differ in age or when predicting a specific individual's TBF or %BF.

- BMI cut-off points
Although BMI is also currently used as a measure of body fatness in children and adolescents, there have been a number of BMI standards used in the definition of overweight and obesity. For example, in the 1995 Australian National Nutrition Survey, two sets of reference values have been used in place of the BMI categories in children and adolescents (McLennan, 1998). One is an international reference value for persons aged 6-24 years and another is an Australian reference value for people aged 7-15 years. BMI was divided into four categories that is Low BMI for age (if BMI is less than 5th percentile reference value for their age and sex); Acceptable BMI for age (if BMI is greater than or equal to 5th percentile and less than 85th percentile); at risk of overweight (if BMI is greater than or equal to the 85th...
percentile and less than the 95\textsuperscript{th} percentile). Table 2.5 summarises some frequently-used BMI cut-off points.

Table 2.5. BMI cut-off points used in childhood weight classifications

<table>
<thead>
<tr>
<th>Weight classifications</th>
<th>Cut-off point (Percentiles)</th>
<th>Cut-off point (BMI scores)</th>
<th>Authors/date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-14 years</td>
<td>• BMI ≤ 15\textsuperscript{th}</td>
<td></td>
<td>Malina et al., 1998</td>
</tr>
<tr>
<td>7-15 &amp; 6-24 years</td>
<td>• BMI &lt; 5\textsuperscript{th}</td>
<td></td>
<td>McLennan, 1998</td>
</tr>
<tr>
<td>Normal weight</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-14 years</td>
<td>• 15\textsuperscript{th} &lt; BMI &lt; 85\textsuperscript{th}</td>
<td></td>
<td>Malina et al., 1998</td>
</tr>
<tr>
<td>7-15 &amp; 6-24 years</td>
<td>• 5\textsuperscript{th} ≤ BMI &lt; 85\textsuperscript{th}</td>
<td></td>
<td>McLennan, 1998</td>
</tr>
<tr>
<td>At risk of overweight</td>
<td></td>
<td>85\textsuperscript{th} &lt; BMI &lt; 95\textsuperscript{th} ≤ 30</td>
<td>Himes &amp; Diez, 1994</td>
</tr>
<tr>
<td>7-15 &amp; 6-24 years</td>
<td>• 85\textsuperscript{th} &lt; BMI &lt; 95\textsuperscript{th}</td>
<td></td>
<td>McLennan, 1998</td>
</tr>
<tr>
<td>Overweight</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17 or 18-21 years</td>
<td>• BMI ≥ 95\textsuperscript{th} &gt; 30</td>
<td></td>
<td>Himes &amp; Diez, 1994</td>
</tr>
<tr>
<td>7-15 &amp; 6-24 years</td>
<td>• BMI ≥ 95\textsuperscript{th}</td>
<td></td>
<td>McLennan, 1998</td>
</tr>
<tr>
<td>2-18 years</td>
<td>age &amp; sex specific BMI value</td>
<td></td>
<td>Cole et al., 2000</td>
</tr>
<tr>
<td>Obesity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-18 years</td>
<td>age &amp; sex specific BMI value</td>
<td></td>
<td>Cole et al., 2000</td>
</tr>
</tbody>
</table>

As a wide variety of definitions of childhood obesity are in use and no commonly-acceptable standard has yet emerged (Cole et al., 2000), trends in childhood obesity are difficult to quantify or to compare internationally. A workshop on childhood obesity convened by the International Obesity Task Force (IOTF) agreed on a novel
approach to the establishment of cut-off points to identify degree of overweight among children and adolescents (Dietz et al., 1998). The IOTF agreed that the paediatric percentiles identified in late adolescence by a BMI of 25 and a BMI of 30 (kg/m²) should constitute the cut-off points for identification of childhood overweight. That is, the BMI centile curves that passed through BMI of 25 and 30 (kg/m²) at age 18 are used to define the overweight and obesity in children and adolescents aged 2-18 years, respectively (Cole et al., 2000). However, there are some important limitations to this approach. Firstly, because the relationship between BMI and percent fat has only been examined in a small number of countries (the reference population was from the international survey of six large nationally representative cross sectional growth studies from Brazil, Great Britain, Hong Kong, the Netherlands, Singapore, and the United States), caution is required when the identified BMI cut-offs points are used to assess the prevalence of obesity in other populations. Secondly, caution is required when using mostly cross-sectional data to infer longitudinal patterns of growth (Dietz et al., 1998). Nevertheless, the proposed cut-off points, which are less arbitrary and more internationally based than current alternatives, should help to provide internationally comparable prevalence rates of overweight and obesity in children (Cole et al., 2000).

- Advantages
BMI has a number of advantages over other available measures of adiposity
(a) BMI is easily calculated from measures in either kilograms and meters or pounds and inches
(b) BMI that is derived from measures of height and weight, provide more reliable measures of fatness in populations than measures such as triceps skinfold thickness. It is reproducible and valid (Bellizzi et al., 1999).
(c) Recent studies have improved our understanding of the validity of the BMI as a measure of adiposity in paediatric populations (Daniels et al., 1997); (Pietrobelli et al., 1998).

- Disadvantages/limitations
BMI is not a perfect measure in children because it covaries with height, and therefore it does not give a direct measure of adiposity (Bellizzi et al., 1999); (NHMRC, 1997). The major shortcoming of this index is its inability to distinguish
muscle from fat, and the instability of the index in the growing individual. (Lazarus et al., 1995). BMI may not be as sensitive a measure of body fatness in children and adolescents who are particularly short or tall for their age or have an unusual body-fat distribution. It may also misclassify children and adolescents who have highly developed muscles. Further, there are racial differences in the relationship between the true proportion of body fat and BMI, and appropriate cut-off points may vary as results (Must et al., 1991).

- Usage
Through the analysis of height and weight data from children in the United States, United Kingdom, Japan, and Singapore, Franklin et al. (1999) found that the use of BMI appears to be satisfactory for adolescents aged ≥16 and links well with the use of BMI for adult. He suggested that the use of BMI as an indicator of adiposity appears acceptable for children aged 6-7 and 17-18 years.

Currently, in Australia, NHMRC, 2002 recommends:
- The international reference developed by Cole et al. (2000) should be used in population and clinical research.
- BMI-for-age percentile charts should be used in clinical practice and in non-health care settings; a BMI above the 85th percentile being indicative of overweight and a BMI above the 95th percentile being indicative of obesity.
- The Centers for Disease Control and Prevention BMI percentile charts are recommended for use until Australian BMI standards are developed.

2.3.3 Comparison of self – reported and measured weight and height
Most population-based studies of overweight or obesity among youth use the BMI derived from measured weight and height. However, the question of whether is it appropriate to collect self-reported data instead of measured weight and height in large-scale population surveys remains. Many studies on the accuracy of self-reported data has focused on adults, however, little research has examined the correlation between self-reported and measured weight and height in children and adolescents. Giacchi et al. (1998) investigated a sub-sample of 140 secondary school students in Siena, Italy, and found that both males and females under-reported their
weight and over-reported their height, such that underestimation of the overweight prevalence was in the order of about 8% for both genders. For both weight and height, the correlations between self-reported and measured values were over 0.90. Strauss (1999) found that correlations of self-reported and actual weights and heights in adolescents ranged from approximately 0.85 to 0.95. Since self-reported weights and heights are easily obtained, they are appropriate to utilise in surveys in order to provide a reliable assessment of obesity related behaviours. The shortcomings of self-reported weight and height in children and adolescents are firstly, that they are not reliable for tracking weight changes in longitudinal surveys, and secondly, that they are not recommended for use in studies of obesity-related morbidities. Finally, self-reported weights and heights are not recommended for identifying individuals as "being overweight" as young people were more likely to under-estimate their weight and over-estimate their height (Strauss, 1999).

The National Health Survey (NHS) and National Nutrition Survey (NNS) in 1995 in Australia provide a potential possibility to explore the accuracy of self-reported weight and height in Australian older adolescents. A comparison of self-reported and measured height, weight and BMI in Australian adolescents is addressed in Chapter 7 of thesis. Unfortunately, there is no data on self-assessed height and weight among children and adolescents less than 15 years in the NHS (McLennan, 1998). To date, there is very limited Australian literature that has compared self-assessed and actual weight classifications in young children. Further study is needed to focus on such a group in order to compare the discrepancy between self-reported and measured body weight and height in the paediatric population.

### 2.3.4 Other measures

Densitometry is based on estimating body composition from measurement of total density. The most widely used approach is to measure body volume by underwater weight and determine density by dividing body mass by body volume. If total body density and the specific densities of fat and fat-free mass are known, an equation can be generated for converting body density to percentage of body fat based on the Archimedes principle (Siri, 1961). The density of fat-free mass is known to be influenced by factors such as age, gender, and ethnicity (Lohman, 1986).
Current limitations for applying densitometry to the paediatric population include practical problems and theoretic considerations. The technique requires climbing into a large tank of water, emptying the lungs by maximal exhalation, and sitting still underwater for several seconds. Thus, from a practical standpoint, testing adherence is extremely difficult for young children (Goran, 1998). Recent developments using air rather than water displacement for measurement of volume (Dempster et al., 1995) may be more practical for paediatric populations. Such a device, called the BodPod (Dempster et al., 1995) has been developed, and it produces an alternative method for measuring body volume that is simpler, quicker, and more practical than hydrostatic weighting.

2.3.5. Summary
Among a number of indicators used in defining overweight and obesity in children and adolescents, The BMI remains one of most frequently used indicators in the evaluation of childhood overweight or obesity, although there is still no globally accepted BMI cut-off point. However, the recent BMI cut-off points for obesity in children and adolescents aged 2-18 years proposed by Cole et al. (2000) allow an international comparison of the prevalence of overweight and obesity in childhood and adolescence.

2.4 MEASUREMENT OF PHYSICAL ACTIVITY
2.4.1 Terminology
• Physical activity
  - any bodily movement produced by skeletal muscles those results in energy expenditure" (Caspersen et al., 1985).
• Components of total energy expenditure
  - basal metabolic rate, which typically encompasses 50% to 70% of total energy expended
  - the thermic effect of food, which accounts for another 7 - 10%
  - physical activity, the most variable component is comprised of activities of daily living (bathing, feeding, and grooming, for example), sports and leisure, and occupational activities (Kriska et al., 1997).
• Exercise
Exercise is a subset of physical activity, it is defined as planned, structured and repetitive bodily movement undertaken to improve or maintain one or more components of physical fitness (Armstrong et al., 2000). In the 1995 NHS, exercise refers to physical exercise undertaken for recreation, sport or health/fitness purposes during the two weeks prior to interview (McLennan, 1996).

- Leisure-time physical activity refers to an individual's discretionary time, or time left after completion of work, travelling, domestic chores and personal hygiene (Armstrong et al., 2000).
- Moderate exercise

The ABS (1996) defined moderate exercise as exercise or other activities (undertaken for recreation, sport or fitness) that caused a moderate increase in the heart rate or breathing of the respondents or it refers to the physical activity requiring 3-4 times as much energy as at rest or intensity of 3-4 Metabolic Equivalents (METs), e.g. brisk walking (Armstrong et al., 2000).

- Vigorous exercise

The ABS (1996) defined it as exercise or other activities (undertaken for recreation, sport or fitness) that caused the respondent to perspire and/or resulted in a large increase in the respondent's heart rate or breathing. The CDC (1991) defined ‘vigorously activity’ as at least 20 minutes of hard exercise that made one breathe heavily and made the heart rate increase significantly at least 3 days per week. The METs were also used to defined the “vigorous exercise”, e.g., METs $\geq 6$ (ABS, 1996) (CDC, 1991).

- Vigorous-intensity physical activity exercise is physical activity requiring 7-9 times as much energy as at rest or intensity of 7-9 METs, e.g. running (Armstrong et al., 2000).

However, it appears to be difficult for young people to report the type and intensity of their physical activities accurately following these subjective definitions (Goran, 1998).

2.4.2 Methods of measurement

Measurement of activity in children is problematic since there is no valid method of assessing activity levels that is feasible for use in large field studies. A number of
different methods have been used to assess activity levels in children, and there is no standard, acceptable technique that has been universally applied (Freedson et al., 1996) (Westerterp, 1999) (Mota et al., 2002). The most common methods of assessing children's physical activity include self-report, direct observation, a variety of mechanical and electronic monitors, and doubly labelled water (Sallis et al., 1993). Each of these methods has advantages and limitations, all of which are summarised in Table 2.6.

Table 2.6. Comparison of common methods used in measuring physical activity levels in children: Advantages and disadvantages

<table>
<thead>
<tr>
<th>Methods</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-reported questionnaire</td>
<td>low-cost, convenience</td>
<td>more subjective</td>
</tr>
<tr>
<td></td>
<td>suitable for large-scale studies</td>
<td>not suitable for children</td>
</tr>
<tr>
<td></td>
<td></td>
<td>under 10 years</td>
</tr>
<tr>
<td>Pedometer</td>
<td>more objective</td>
<td>not accurate if speed is</td>
</tr>
<tr>
<td></td>
<td>light, small</td>
<td>too fast or too slow</td>
</tr>
<tr>
<td></td>
<td>suitable for large-scale studies</td>
<td>not appropriate for ‘wet’ activity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>difficult to control in weekend</td>
</tr>
<tr>
<td>Heart rate monitors</td>
<td>more objective</td>
<td>expensive</td>
</tr>
<tr>
<td></td>
<td>high reliability and validity</td>
<td>not suitable for large-scale studies</td>
</tr>
</tbody>
</table>

2.4.2.1 Questionnaires

Self-reports are the most commonly employed procedures to measure physical activity and can involve recall or diary methods and can be interviewed or respondent-based (Kohl et al., 2000). The strengths of self-reports are ease of administration, convenience, the ability to characterise activity historically and low cost (Freedson et al., 1996).

Quantification and description of physical activity in the questionnaire should consider all aspects of 1) type and purpose of physical activity (eg, recreational or obligatory, aerobic or anaerobic, occupational or household; 2) intensity (degree of vigour or metabolic cost); 3) efficiency; 4) duration (average number of minutes per session performed during a particular time frame (typically 1 week, month, or year);
5) frequency (average number of sessions per given time frame) and 6) specific energy cost of the activity performed, each activity expressed in "METs (metabolic equivalents)-hours per week" or kcal/kg/wk (Goran, 1998) (Kriska et al., 1997).

The major difficulty with the questionnaire approach is that it relies on the ability of the subject or the parent to recall behavioural information accurately and it is also difficult to translate qualitative information on physical activity (for example, playing for 30 minutes) to quantitative data (for example, Kcal per exercise session) (Goran, 1998). The source and type of physical activities observed in children are very different from those in adults (for example, there is no occupational activity and different types and intensities of habitual activity). There is also very limited information available on the specific energy costs of different activities in children (Goran 1998). Baranowski (1988) suggested that children are able to recall only 50% of the previous week's physical activity. Very few questionnaires, if any, have been developed specifically and validated for use in children (Goran, 1998). Very few studies have ever compared the reliability and validity of different types of physical activity self-report measures with children of different ages.

Among different methods for the assessment of physical activity, five methods namely, monitoring, direct observation, indirect calorimetry, doubly-labelled water, or direct calorimetry, may be used to validate self-report methods, and the findings reviewed by Kohl et al. (2000) revealed that for self-report techniques, data from younger children suggested generally lower test-retest repeatability than with data from older children and adolescents. It has been demonstrated that children under 10 years of age cannot recall activities accurately and are unable to quantify the timeframe of activity (Baranowski, 1988).

Sallis et al. (1993) examined the reliability and validity of standardised self-reported physical activity in children and adolescents and found that the 7-day Physical Activity Recall (PAR) interview was a reasonably reliable and valid method for the assessment of physical activity in children as young as 10 -11 years of age. However, both reliability and validity improve with age and repeated 24-hour activity recalls may be more valid for children than 7-day recalls. Kriska et al. (1997) suggested that for the time frame of physical activity surveys, assessment over a short time period is
less likely to reflect usual behaviour, as activity levels may vary with seasons or as a result of illness or time constrains. To obtain the best estimate of physical activity levels, some questionnaires have included assessment over both a short and a long time period. Mota et al (2002) used a week self-administered questionnaire in 109 children aged 8-16 years old, and found that the reliability R was 0.91. The study conducted by Bouchard et al (1985) suggested that the 3-day activity record is a procedure suitable for the estimation of physical activity in population survey. Aarson et al. (1995) developed a questionnaire to assess the physical activity of adolescents during leisure time doing the past year. Four multiple questions were used to assess hard and light exercise over the past 2 weeks, daily television watching and competitive athletic participation. The questionnaire was found to be both reproducible and indirectly valid in assessing the habitual activity patterns of adolescents.

In recent times, some researchers have developed multimedia tools and computer networking in physical activity recall questionnaire in children. Recently, Ridley et al. (2001) have fully exploited these features in their computer delivered multimedia 1-day physical activity questionnaire (CDPAQ). They suggested that the multimedia features of CDPAQ might assist children in remembering and characterising physical activity. Recently, Mota et al. (2002) developed a study to validate a self-reported questionnaire in a Portuguese pediatric population (aged 8-16 years). The weekly activity questionnaire was significantly correlated with the Computer Science and Application, e.g, \( r = 0.30 \). The findings suggested that the reliability of a ‘Weekly Activity Checklist’ was acceptable.

Overall, the choice for use of a particular method of activity assessment among children and adolescents depends largely on the design of the study and the age of the participants. The available data reviewed by Kohl et al (2000) suggested low to moderate validity for self-report and monitoring measures of physical activity. However, some other evidence suggested that one-week recall is appropriate for children, as it can represent habitual physical activity, and the self-reports should not be used with children younger than 10 years (Sallies, 1991); (Sallis et al., 2000); (Mota et al., 2002).
In summary, the literature reviewed has suggested that the self-report questionnaire is the most feasible tool used in population surveys of children and adolescents. However, the results on the reliability of self-report questionnaires are inconsistent. Greater effort toward developing a consistent standard of measure and improving the accuracy of physical activity assessment among children and adolescents is required. The limited ability to recall all episodes of activity, accurate reporting of duration and intensity, lack of motivation to persist with the task, and illegible written responses are the most frequent problems in self-report childhood physical activity surveys (Goran, 1998). To ensure the validity and reliability of measuring physical activity levels in children, the period of recall should be at least one-week (including weekends) and repeated in different school terms or seasons if possible.

2.4.2.2 Motion sensors
Motion sensors, such as pedometers, actometers and accelerometers, have been developed to provide more objective information on body movement. Using these mechanical motion sensors for monitoring physical activity levels can eliminate some of the problems associated with subjective reports or may be served as validation criteria for self-report methods, and there are several different types of motion sensors that range in complexity and cost from the pedometer to the triaxial accelerometer (Freedon, 1991); (Freedson et al. 2000). A pedometer is designed to record the number of steps made by an individual. It is worn on the hip and assesses the distance covered by measuring acceleration and deceleration using a lever arm, spring and gear assembly (Montoye et al., 1996); (Freedon, 1991, 2000). The main advantages of pedometers are that they are small and inexpensive (Freedson et al. 2000). However, the application of pedometer is also limited. For example, it is not sensitive to activity that does not involve locomotion, isometric exercise, or activity that involves the upper body (Melanson et al., 1996), and it is not as accurate at very slow or very fast walking speeds (Bassett et al., 1996); (Goran, 1998). The pedometer has not been widely used in a variety of population groups for the assessment of physical activity (Freedon et al., 2000), and there have been limited studies on children wearing pedometers to measure physical activity levels. For example, Eston et al (1998) revealed that a correlation of \( r = 0.78 \) was reported between pedometer steps and oxygen uptake for treadmill walking in children. Recently, an Australian study (Tomson et al., 2003, personal communication) was
conducted to measure the physical activity level in more than 700 school children in Years 1 to 7 in Brisbane, Australia, and found that primary school girls walked an average 11,700 steps a day and boys walked about 14,400 steps. Much evidence needs to be produced regarding the reliability and validity of using pedometers in the measurement of physical activity levels among pediatric population.

The uniaxial accelerometer is a more complex instrument than the pedometer. It measures acceleration in a single plane and can be attached to the trunk and/or limbs to measure acceleration of the trunk and/or limbs (Freedson et al., 2000). The Caltrac accelerometer was one of the first accelerometers to be used. The advanced accelerometer, such as the Computer Science and Applications (CSA), Inc. actigraph, are small and unobtrusive instruments with large memory capacity that allow for monitoring and storage of temporal patterns of activity in relatively small time intervals over a period of days or weeks (Freedson et al., 2000). Both the Caltrac and CSA accelerometers have been widely used in physical activity research involving adults, children, and overweight children. Trost et al (1998) used the CSA in controlled laboratory conditions for children and found that counts were highly correlated with energy expenditure, oxygen consumption, heart rate and treadmill speed. Several other field-based studies also revealed that there was a high correlation between the CSA counts and Vo2 per kg 0.75 or heart rate (Janz, 1994); (Eston et al., 1998). Overall, the uniaxial accelerometers is also appropriate for a wide variety of activities although the pedometer is the simplest, least expensive, and best suited for assessing walking activity (Freedson et al., 2000).

2.4.2.3 Heart rate (HR) and doubly labelled water (DLW) methods
when using HR in the measurement of physical activity levels, the result is more accurate at higher levels of physical activity, because at low levels of physical activity the interpretation of HR data is confounded by the fact that HR responses reflect not only physical activity, but also metabolic status, posture, temperature and emotional status. Moreover, total energy expenditure estimates from HR data provide an acceptable estimation of total energy expenditure of groups (Molnar et al, 2000). Currently, the most acceptable and powerful technique for the measurement of total energy expenditure is the DLW method. DLW method is non-invasive and more likely to obtain a more representative estimate of total energy expenditure.
Unfortunately, its application in large-scale studies is limited by cost and technical complexity. In addition, the results of DLW studies do not provide information concerning the duration spent in activity (Molnar et al., 2000) with the exception of the study by Goran et al (1997) where both DLW and physical activity questionnaires were used.

2.5 AETIOLOGY OF OVERWEIGHT OR OBESITY IN CHILDREN AND ADOLESCENTS

Many studies have identified a number of risk factors as contributors to the increasing prevalence of overweight and obesity in children and adolescents, including the ‘ecological’ equation for understanding factors influencing obesity (NHMRC, 1997).

Figure 2.1. An ecological paradigm for understanding factors influencing obesity (NHMRC, 1997)

Physiological adjustment refers to the metabolic and, in some cases, behavioural changes that follow disequilibrium in fat or energy balance and which prevent excessive fluctuations in body weight. Disequilibrium of fat /energy balance are usually temporary states restored through appetite mechanisms and/or, compensatory physiological adjustments such as changes in metabolic rate or the energy cost of physical activity. Influential factors include extra-and intra-individual factors affecting energy balance; in particular, environmental, biological, and behavioural
factors. The complexity of environmental factors can be broadly categorised into macro-environment (affecting the whole population) and micro-environment (affecting individuals). In general terms, the macro-environment determines the prevalence of obesity in a population and the microenvironment, along with biological and behavioural influences, determines the presence of obesity in an individual.

Biological factors known to influence body fat levels include age, sex, race, hormonal factors (such as puberty, pregnancy and menopause) and a wide range of genetic factors. Behaviours are the result of complex psychological factors, including habits, emotions and cognitions, developed through a background of learning history. Factors including genetic predisposition, nutrition (in all its aspects), and activity are equally important in the aetiology of overweight and obesity (NHMRC, 1997).

In general, obesity is a multifactorial disease and its development is due to multiple interactions between genes and environment. The following sectors discuss factors implicated in the causation of childhood overweight and obesity. These include:

- Genetic factors
- Environmental factors such as food /energy intake and physical activity/energy expenditure, and
- Socioeconomic status, parental obesity and ethnicity factors. As these factors may indirectly affect the development of overweight and obesity through the alteration of dietary habits /behaviours and physical activity patterns, and because limited research is available in this area, in this thesis they were separated from the category of environmental factors.

2.5.1 Genetic factors
Evidence is available to support a genetic influence on obesity in individuals. Children of obese parents have a higher risk of becoming obese than do children of non-obese parents (Lissau et al., 1992); (Maffeis, et al., 1994); (Sorensen, et al., 1992). Stunkard et al. (1986) revealed that adopted children as adults had greater similarity in BMI and other features with their biological parents than with their adopting parents. The genetics of obesity and the various studies of twins, families, adoption and population have been well documented in a reviewed by Bouchard
From this review, it appears that the genetic effects account for some 25% to 40% of obesity in the overall population.

Several single-gene mutations have been shown to cause obesity in animal models, however, the situation in humans is considerably more complex (Commuzzie et al., 1998). Early results from the genome scan in Mexican Americans suggests the existence of a few genes with substantial effects on obesity. However, a large number of genetic loci are likely to be involved, but many of these genes on their own may account for only a small portion of the total phenotypic variance (Commuzzie et al., 1998).

Research into the genetics of human obesity is continuing at a rapid pace. Currently, there are at least three genome scanning efforts underway that have obesity phenotypes as a primary focus and at least three others that should be operational shortly (Commuzzie et al., 1998). Therefore, the ability to fully understand genetic contribution to obesity would ultimately depend on the extent to which the efforts are made in the finding of collaborative gene.

Overall, further studies on the contribution of genetic factors and their role in the development of childhood overweight and obesity are still needed, however, this may present a number of practical and ethical barriers. It should be also noted that while genetic factors may help explain some inter-individual differences in BMI from a population perspective, genetic mutation is unlikely to explain the recent epidemic of overweight and obesity in children.

2.5.2 Environmental factors
Genetic factors explain part of the development of childhood obesity, however several environmental factors also have a significant bearing on the phenomenon. The mix of contributing environmental factors responsible for the development of obesity may vary from country to country and be based on variables such as cultural habits and recreational activity (Wabitch, 2000). This review specially focuses on the influences of food /energy intake, physical activity/energy expenditure and sedentary behaviours.
2.5.2.1 Food / energy intake

The first physiological contact of the child with the environment is in the uterus. The mother's metabolism during pregnancy interacts with the fetus with respect to the development of the metabolic regulatory mechanisms (Barker, 1998); (Parizkova, 1998). After birth, the method of feeding and weaning may theoretically influence the risk of obesity (Maffeiis, 2000) Feeding practices in turn have been reported to subsequently influence children's food choices. In the development of children's food preferences, family lifestyle and food habits play an important role (as mentioned above). Nguyen et al. (1996) revealed that parents' adiposity and fat intake are in many ways associated with their children's adiposity and fat intake, which suggests that familial similarities in food consumption may partially explain familial patterns of adiposity. The attitudes and behaviour of parents, peers, siblings and relatives who live with the children also highly affect children's eating habits. Moreover, parents' encouragement to eat promotes fat gain in their children (Klesges et al., 1991).

Weight gain is the result of an imbalance between energy intake (EI) and total energy expenditure (TEE), but the mechanism of this imbalance remains unclear, and this varies from person to person. Obesity develops due of an excess EI relative to TEE, a reduced TEE relative to EI, or a combination of both (Livingstone, 2000).

Obesity has also been seen as the product of gluttony. It is difficult to know what control eating in different human beings, as it involves many learned responses and basic physiological drives for eating and satiety, as well as psychosocial factors (NHMRC, 1997). However, there are number of methods available to measure what people eat. Generally, it is known that all individuals under-report their intake; the obese by more than those of normal weight (Bandini et al., 1990); (Lightman et al., 1992); (Prentice et al., 1986). It is beyond the scope of this Literature Review to produce a comprehensive review of methods of measuring dietary intake. However, Willett (1998) has critically reviewed a number of methods including food frequency method of measuring food intake including, 24-hour dietary recall and food record methods. In terms of their advantages and disadvantages for studies of individuals and at a population level, a number of recent studies also have addressed specific issues of comparing the use of different methods, especially the use of short
questionnaires for population based surveys (Cook et al., 2001); (Marks et al., 2001); Riley et al., 2001); (Rutishauser et al., 2001). Further details regarding the specific dietary intake methodologies of direct relevance to this study are discussed in section 3.2.3. In terms of measuring food, 24-hour recall is one of the most frequently used in population based studies. It has been generally concluded that the food and nutrient intake from a 24-hour recall method does not represent the usual or average intake of an individual. However, it is more reliable for estimating intakes at a group level, where participants’ under and over estimates of their consumption cancels out and produces a fairly stable estimate of the group’s mean consumption (Carter et al., 1981); (Karvetti et al., 1985); (Boeing et al., 1997); Many studies investigating the validity of 24-hour recalls have found them to have acceptable levels of validity in most populations (Boeing et al., 1997); (Buzzard, 1990); (Karvetti et al., 1985). When comparing with other dietary intake methods, the 24-hour recall has been found to have acceptable levels of concurrent validity with weighed food records, the dietary history method, and FFQs (Boeing et al., 1997) (Karvetti et al., 1985). However, it should be also recognised that 24-hour recall has some limitations. Firstly, as dietary intake varies considerably from day to day, particularly in young people, the 24-hour recall method does not provide an accurate estimate of an individual’s usual food and nutrient intake.

To date, the dietary emphasis on the causes of obesity has been on total energy intake and the proportion of macronutrients. Many studies, however, have failed to show a correlation between individual energy intake and adiposity in children and adolescents. Rolland-Cachra et al. (1986) revealed that no correlation was found between energy intake and individual corpulence (BMI and skinfold thickness) in a population of French children, but a higher proportion of overweight children was found in lower social classes where energy intake is traditionally higher. The authors also found that daily energy intake was not higher in obese compared with non-obese French adults, but obesity was more prevalent in social groups where energy intake is higher (Rolland-Cachra et al., 1990). This suggests that socially determined factors, such as a high-energy diet, are conducive to the development of obesity.

Another (perhaps more important) issue in the aetiology of obesity is the nutritional composition of the diet. Danforth (1985) suggested that the increased incidence of
obesity during this century could be the result of an increase in the consumption of foods high in fat. Studies by Blandell et al (1993) and Lawton et al (1993) have shown that high-fat, low-carbohydrate diets may promote obesity. Consideration of epidemiological studies suggested a strong link between dietary fat and obesity (Lissner and Heitmann, 1995). Kuller (1997) also found that a high-fat intake may increase the risk of obesity. However, the evidence from a study by Prentice (1994) would suggest that over the last two centuries there has not been an increase in the average daily energy intake, but there has been an increase in the intake in the proportion of energy intake from fat. It is unknown whether these data collected in children are still relevant. A recent Australian study (Cook et al, 2001) revealed that energy intake of boys and girls has increased 11% and 15%, respectively from 1983 to 1995; this has arisen due to a 20% increase in both total carbohydrate and sugar.

Why is it difficult to obtain detailed dietary information in children? A number of reasons have been reviewed, and they include: 1) rapid change in food habits and nutrient intake during growth and development; 2) limited ability or motivation to cooperate in the reporting process; 3) limited memory spans; 4) the problem of obtaining correct dietary information from different adults who take care of younger children; 5) unstructured eating patterns; 6) a significant degree of out-of-home snacking; 7) dietary restraint and 8) pre-occupation with body weight (Livingston, 2000).

It is also very important to understand that total energy intake can be either a cause of obesity or the effect of obesity on it. As discussed before, obese subjects under-report energy intake to a greater degree than people with normal weight (Bandini et al., 1990); (Lightman et al., 1992); (Prentice et al., 1986), while “dieting” in certain people has lead to actual reduction in total energy intake. In addition, an increased body mass requires relatively higher energy intake to maintain normal function. The complexity of what is the cause and what is the effect of the relationship of obesity and increased energy intake should not be underestimated. Despite a wealth of data on energy intakes and overweight and obesity in children and adolescents, the results of the contribution of energy intake to overweight/obesity are inconsistent. It would appear that more longitudinal research is needed in order to determine the
contribution of individual dietary components and dietary patterns to childhood obesity.

Food advertisement is also an important aspect affecting the dietary patterns of the paediatric population. Wilson et al (1999) suggested that food advertisements targeted at children generally promote dietary patterns associated with an increased risk of obesity in childhood. An Australian study analysed the content of food advertisements during children’s viewing time, and found that very few advertisements were consistent with dietary guidelines (Hill & Radimer, 1997).

2.5.2.2 Physical activity /Energy expenditure

In terms of the previously described equation on energy balance, physical activity is the major modifiable component of energy expenditure. There are limited national data on levels of physical activity in Australian children and consequently on the suggested decline of physical activity levels. Although Booth et al. (2002) examined the physical activity levels among New South Wales high school student and found that the majority of boys and girls were adequately active, no nation-wide representative Australian population data on the physical activity levels of children have been collected since the schools survey by the Australian Council for Health, Physical Education and Recreation (ACPER) in 1985 (Pyke, 1987). There have also not been any representative longitudinal studies to document the highly probable decline in the level of physical activity from childhood through adolescence and into young adulthood (NHMRC 1997). For example, there were no data on the physical activity levels of Australian adolescents less than 15 years of age in the 1995 Australian National Health Survey (McLennan, 1996). The data from the 1995 NHS do not necessarily indicate accurate levels of total physical activity or of absolute or relative levels of fitness as the respondents aged 15 years or more were only asked whether, during the previous two weeks, they did any ‘walking for sport, recreation or fitness, moderate and vigorous exercise’ (McLennan,1996). A draft report by the NHMRC (2002) continues to highlight this gap in the literature, and make recommendations that further research is required in this area.

It may be that Australian children become progressively more physically inactive as they progress from childhood through adolescence and into young adulthood.
Recently, a meta-analysis was conducted by Tomkinson et al (2003) to test the hypothesis. This analysis compared the results of 55 reports of the performance of children and adolescents aged 6-19 years in 20 countries who have used the 20m shuttle run test (20mSRT). The results revealed that there has been a very rapid secular decline in the 20mSRT performance of children and adolescents over the last 20 years (1981-2000). However, there is still insufficient conclusive evidence to confirm or disprove the decline of physical activity in children and adolescents in Australia, and there is an urgent need for more research on physical activity levels of Australian children and youth (NHMRC, 2002).

Basic descriptive epidemiological data of physical activity levels in children and adolescents are also lacking in the USA (Sallis et al., 1996), although Luepker et al. (1999) suggested that physical activity among youth has declined over the past several decades. Nationally representative data for physical activity among children and adolescents were not collected using comparable methods across surveys, during 1980s and 1990s in the United States (CDC, 1997).

A number of studies in Europe suggest that sedentary behaviour in children today is common and may be related to the development of overweight and obesity (Livingstone, 2000); (Moore et al., 1995); (Raitakari et al., 1994)

Research from other countries also provides some relevant insights. For example, a 14-year longitudinal study conducted in the Netherlands revealed that overall physical activity levels dropped steeply from age 13 to 16 for boys and girls, and less steeply from age 16 to 27 (van Mechelen et al., 1995). However, it should be noted that the method used in this longitudinal study had not been extensively validated.

In relation to physical inactivity, there are many more types of sedentary activities in which children may participate. However, many studies have only focused on television viewing. Some research from the United States and Canada indicating that the average adolescent watches over 20 hours of television per week (Shephard et al., 1986); (Robinson et al., 1993) and young children watch even more. There are two major health-related concerns about television viewing. One is that periods of
inactivity and snacking while watching television are contributing to obesity (Dietz et al., 1985). The other is that if a child watches television for three hours or more per day, there is little time left for physical activity. The literature is conflicting on this point, however data suggests that there is a weak relation between television viewing and physical activity by children (Robinson et al., 1993). There appears to be no national data readily available on the impact of computer activities on leisure time activity.

Sallis et al (2000) evaluated the correlates of physical activity in children and adolescents aged 3-18 years in a review of 108 studies. The results suggested that there were a number of factors significantly affecting the levels of physical activity in young people. For example, variables that were consistently associated with children’s levels of physical activity were gender (male), parental overweight status (inverse), physical activity preferences, intention to be active, perceived barriers (inverse), previous physical activity, healthy diet, program/facility access, and time spent outdoors. The most likely environmental explanation for the current obesity epidemic is that a continued decline in daily energy expenditure has not been matched by an equivalent reduction in energy intake (Hill, 1999), suggesting that decreases in physical activity are a major contributing factor. A number of prospective studies on young children have confirmed that the decreased physical activity is associated with adipose weight gain over time (Klesges et al., 1995); (Maffeis et al., 1998). Berkey et al. (2000) examined the role of physical activity, inactivity, and dietary patterns on annual weight changes in preadolescents and adolescents and found that for both boys and girls, a 1-year increase in BMI was larger in those who reported more time with TV/videos/games. It should be recognised that the association between physical activity and overweight / obesity in children and adolescents was largely drawn from cross-sectional surveys and a cause–effect relationship can not be established based on these surveys. However, while some longitudinal studies did reveal that physical activity levels were associated with children’s BMI or fat gain (Klesges et al., 1995); (Moore et al., 1995), such an association has not been confirmed in others (Beunen et al., 1992); (Davies et al., 1991). Therefore, further longitudinal investigations on representative samples, using uniform protocols, instruments, and criteria for assessing physical activity are required to clarify this relationship and to establish causality.
Overall, limited research evidence supports that children and adolescents appear to undertake less physical activity now than in previous years. The association between physical activity and childhood obesity was largely drawn from many cross-sectional surveys. More longitudinal studies on the relationship of physical activity to obesity are required.

2.5.3 Socio-economic status
As mentioned before (Section 2.3), socioeconomic status, parental obesity and ethnicity may indirectly affect the development of overweight and obesity through the alteration of dietary habits /behaviours and physical activity patterns, in this thesis they were separated from the category of environmental factors. as they may be a complex interaction of environmental and genetic factors.

Although an inverse relationship between socioeconomic status and body mass index is well documented in adults, there are limited studies focusing on children and adolescents, and the results on the relationship between the socioeconomic status of family and childhood obesity were inconsistent (Lissau et al., 1992); (Lissau et al., 1994); (Maffeis et al., 1994).

De Spiegelaere et al. (1998) examined the influence of socioeconomic status on the prevalence, evolution, and incidence of obesity in a retrospective cohort study on 12 and 15 year-old children in Belgium. Children with low socio-economic status had the highest risk both of incidence and of permanence of obesity with these differences in obesity increasing during early adolescence. In Australia, Booth et al.(1999) measured height, weight, waist and hip girths and skinfold thicknesses of students in school years 4, 6, 8 and 10 and found that among boys, there were no differences between the SES tertiles on any of the measures. Among girls, each of the anthropometric measures (except sum of skinfolds) was inversely associated with socio-economic status, with body fatness tending to be lower in the highest SES tertile. The relationship was consistent from childhood to adolescence. The available Australian national data such as the National Dietary Survey of School children in 1985 (English et al., 1989) the NHS in 1995 (McLennan, 1997), and Australia’s
Young People: Their Health and Wellbeing 1999 (Moon et al., 1999) did not explore the relationship of SES to obesity in children and adolescents.

In a longitudinal study on the relationship between being overweight and subsequent educational attainment, marital status, household income and self-esteem in a nationally representative sample of 1039 randomly selected young people who were 16-24 years old from 1981 to 1988, Gortmaker et al. (1993) found that being overweight during adolescence and young adulthood had important social and economic consequences that were more severe for women than for men and greater than those associated with a variety of other chronic conditions during adolescence. However, the study did not provide evidence for the ongoing impact of obesity in children younger than 16 years.

In studies of the implications of differences in socioeconomic status (SES) at the youth population level, parental or family-based measurements of socioeconomic status are used in examining socioeconomic influences on children’s health status. However, there has been no agreement on an ‘optimal’ means of socioeconomic status. Instead, each is thought to represent different concepts relating to SES to health (Galobardes et al., 2001)

Overall, there is little evidence of a pattern between overweight or obesity and socioeconomic status in children and adolescents. As the majority of youth are not in the workforce, the indicators of SES used in the studies on youth population are based on those of their parents.

2.5.4 Parental obesity

Parental overweight or obesity may be one of the most important health risk factors in the development of childhood overweight and obesity.

An Australian study by Tienboon, Rutishauser and Wahlqvist (1994) measured the weight and height of both parents and adolescents from 213 families with an adolescent child aged 14-15 years in Geelong, and revealed that adolescents who rated themselves as slim had parents whose BMI was significantly lower than those of the parents of adolescents who rated themselves as overweight. These results
provide evidence for an association between adolescents' perceptions of body weight and parents' weight for height status.

In the USA, Whitaker et al. (1997) reviewed the medical records of both children and their parents and found that obese children under three years of age without obese parents were at a low risk for obesity in adulthood. Parental obesity more than doubles the risk of adult obesity among both obese and non-obese children less than 10 years of age. However, no further details are available from this study as to why this would be.

In Italy, Maffeis, Talamini et al. (1998) assessed the relationship between diet, body composition, physical activity, parental obesity and adiposity in children at the age of 8 years. Results revealed that parental obesity was the main risk factor for obesity in children at the age of 8 years, as well as four years later.

In Australia, no current literature exists at a national level on the impact of parental obesity on childhood obesity. Data available in the NHS and NNS does, however, provide some current Australian evidence. This is dealt with in Chapter 4 of this thesis, which is entitled, ‘the association between overweight or obesity and household income and parental body mass index in Australian youth: analysis of the Australian National Nutrition Survey’.

2.5.5 Ethnicity
In a multicultural society, the life style of immigrants is affected by not only their ethnic or cultural origins, but also their new residential environment. This is particularly obvious in young migrants. The influence of ethnicity on health risk factors is a significant public health concern in a multicultural society such as Australia. Normally, in a multicultural society, the minority ethnic or cultural background refers to either the subject themselves, or to one parent or grandparent born outside resident country. A description of the patterns of immigration to Australia is beyond the scope of this review, but it is of significance to note that incoming arrivals of significant numbers of immigrants in Australia may lead to new health concerns either because of previous differences in health status and or because of a lack of update of Australian health messages.
In Australia, Lynch (2000) examined 3645 children aged 5 - 12 years during 1994-7 in south-eastern Sydney, in which 59.9% were white (North European), 8.5% Mediterranean white, 7.7% Asian, 7.7% others, and 16.2% mixed. BMI in this group was related strongly to ethnicity and age. Those of Asian ethnicity had the lowest BMI, while those of Mediterranean background the highest. However, there was no discussion on comparison of whether those of non-Australian background had significantly different BMI from their counterparts in the country of origin. Similarly, no data were available on levels of physical activity and dietary intake. Unfortunately, both the 1985 and 1995 national-wide dietary data in Australia do not provide the representative samples of different ethnic or cultural background (English et al., 1989); (McLennan et al., 1998).

Indigenous Australians are another priority population group with regards to health concerns. Aboriginal and Torres Strait Islander people experience a much greater burden of ill health than other Australians (NHMRC, 200b). Almost 40% of Indigenous men were found to be overweight, and a further 26% obese, while for women, the figures were 26% overweight and 31% obese (ABS, 1996); (ABS &AIHW 2001). Further evidence on paediatric obesity in Indigenous people is needed, as well as the significant early development of obesity.

The influence of ethnicity on overweight and obesity may be through the alteration of eating behaviour. For example, a study on diverse racial ethnic student populations assessed adolescents' perceptions about factors influencing their food choices and eating behaviour suggested that parental influence on eating behaviours (including the culture or religion of the family) is one of a broad range of factors influencing such behaviour. The relative contribution of this influence however was not examined (Neumark-Sztainer et al., 1999). Robinson et al., (1995) revealed that cultural factors might influence the susceptibility of American children and adolescents to the effects of television viewing which as previously discussed may have an impact on the childhood obesity. However, this study did not provide evidence for why it may be so. Gordon-Larsen et al. (1999) found that a minority of ethnic adolescents in the US, with the exception of Asian females, have consistently higher levels of inactivity than White groups. Lowest physical activity levels were
found for non-Hispanic black and Asian females although Asian females also have low inactivity and low levels of overweight. A national longitudinal study of adolescent health in young people from various ethnic and racial backgrounds in the US showed that all race and ethnic categories except Chinese and Filipino had higher obesity levels than non-Hispanic whites (Popkin et al., 1998). Again, this study failed to explain how these differences came about. Booth et al (2001) also revealed that there was a higher prevalence of overweight/obesity among students from European or Middle-Eastern cultural backgrounds, although an interpretation was difficult to make due to small numbers in some groups and different definitions used in the different surveys.

In Canada, a study on the early determinants of obesity in multi-ethnic children aged 9 - 12 years revealed that being of European or Central American/Caribbean family origin were independently correlated with obesity in boys, and mother's obesity and father's obesity were independently correlated with obesity in girls. Girls of Asian family origin were protected (O'Loughlin et al., 1998). However, this study did not examine if such correlation still exist among these children’s counterparts in their country of origin.

Overall, although some studies have indicated an influence of ethnicity on childhood overweight or obesity, there are no data on the reasons for such an outcome. A number of important questions remain:
- Is this a genetic or environmental effect or an interaction of both?
- From an environmental point of view, does ethnic or cultural difference affect children's dietary patterns, participation in physical activity or body image and weight-control practices?
- What are the interactions between the ethnicity and a number of other health risk factors on childhood overweight and obesity?

Further studies are needed to provide evidence on how ethnicity may impact on childhood and adolescent overweight and obesity.

2.6 STRATEGIES FOR THE PREVENTION AND MANAGEMENT OF CHILDHOOD OBESITY
Given the extent of the growing problem of childhood obesity, the review now turns relevant prevention guidelines and to prevention and management strategies at a national level in Australia and other Western countries. This is treated briefly in this review to provide a context for future activity and why further research is required.

2.6.1. Initiatives in Australia

Overall, there are limited national data of the extent of childhood obesity in Australia. Early in 1985, the national school survey (Pyke, 1987) provided baseline data of identified problems in Australia but there was not a huge concern about childhood obesity at this time. Originating in other western countries, increasing prevalence of childhood obesity has been considered to be a major global health concern (McLennan, 1997) (Guestry, 2000). Some Australian studies based on the 1995 National data subsequently have also indicated similar problems (Magarey et al., 2001) (Booth et al., 2001). A number of initiatives were selected for discussion in this review because they are related to the prevention and management of childhood obesity. It should note that some of these documents do not include guidelines or strategies specific for children and adolescents which is a limitation. However even when children are not specially mentioned, there is an association between the adult and paediatric population. These initiatives and guidelines include:

- Acting on Australia’s Weight (NHMRC, 1997)
- Eat Well Australia: A strategic framework for public health nutrition 2000-2010 (National Public Health Partnership, 2001)
- National Physical Activity Guidelines for Australian (Active Australia, 2000)
- Dietary Guidelines for Children and Adolescents (NHMRC, 2003)
- Draft National Clinical Guidelines for Weight Controls and Obesity Management in Children and Adolescents (National Health and Medical Research Council, 2002).

The document ‘Acting on Australia’s Weight’ includes a broad range of combined approaches to physical activity and diet through public health action occurring at the level of the macro-environment. This document is important as it has increased the awareness of population overweight and obesity in Australia. It identified the current status of overweight/obesity as well as highlighting the importance of both food intake and physical activity.
Australia has established a National Public Health Partnership to address public health concerns in Australia. Eat Well Australia aims to improve the health of all Australians through better food and nutrition. It has been suggested that key decision makers in relevant sectors should understand the societal implications of the current trends in overweight/obesity in the population, especially among youth and demonstrate a commitment to reversing the trend. For increasing overweight and obesity in the population. This initiative also carries with it the importance of providing evidence for the outcomes of suggested strategies in future.

Although there are no physical activity guidelines specifically for children and adolescents, the current Physical Activity Guidelines for Australians may also help the promotion of physical activity among Australian youth. Notwithstanding the lack of specific guidelines for children, it is difficult to know what level and amount of physical activity is optional for child health and in this instance in relation to the prevalence of overweight/obesity. Among Physical Activity Guidelines, guidelines 1 to 3 stress the importance of all forms of movement, including moderate-intensity physical activity, particularly in those who are currently inactive. Guideline 4 illustrates the added health and fitness benefits that can be gained from higher levels of physical activity or exercise. The guidelines would help to create and foster an environment which supports appropriate physical activity, which would benefit the promotion of physical activity for children and adolescents. It also should be noted that the enthusiasm for the promotion of physical activity should not overshadow the importance of a healthy balanced diet.

In 2002, NHMRC launched draft national clinical guidelines for weight control and obesity management in children and adolescents (NHMRC, 2002). Although it has recognised that the draft treatment guidelines are not for prevention, it has been considered that a significant number of children were already obese, thus a brief description of weight management is necessary. These guidelines have assessed the current scientific evidence and provided detailed evidence-based guidance for assessing and managing overweight and obesity in Australian children and adolescents. However, it is difficult to monitor and evaluate the implementation of individual strategies within different areas without consistent data-collection.
methods. The links of this national strategy with other related public health initiatives, as well as national food and nutrition policy, and many state and territory nutrition policies will be very important for the success of its implementation.

Recently the NHMRC has released a revised Dietary Guidelines for children and adolescents (NHMRC, 2003). These guidelines seek 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. This edition of the guidelines focuses more on food groups and lifestyle patterns, moving away from specific nutrients. Two of the guidelines related to the quantity and quality of the food needed by children and adolescents, the other of these two guidelines deals with appropriate amounts of food for growth while also encouraging children and adolescents to be active.

In addition, The National Obesity Task force in Australia will release a report in late November 2003 (ASSO, October 2003). This report will focus on effective advocacy for improved obesity management and prevention. For example, local action includes improving neighbourhoods for safe, active recreation and active transport by children, while national action will focus on reducing the volume of television food advertising directed at children. Again, like other initiatives discussed previously, without the substantive further support from government and other organisation, these goals will not be achieved.

The initiatives discussed above included an evidence-based review, and a strategic framework and guidelines at the Australian national level to target the overweight/obese population through the implementation of nutrition and physical activity promotion programs. It can be seen there are many strategies at various stages of implementation which have been interrelated to prevent and treat obesity. For example, based on the backgrounds in Acting on Australia’s weight launched by NHMRC in 1997 and reviewed recent studies, Eat Well Australia provide a blueprint for the prevention of chronic diseases in Australia, the implementation of Dietary guidelines for children and adolescents will results in significant health gains for community. Some actions have been taken, for example, some new positions in community and public health for nutritionists have been created and more founding
in the health promotion projects is available. Based on these initiatives, some best practices including creating a social environment for eating and physical activity, and promoting incidental activity have been implemented.

However, the population strategies for preventing overweight and obesity in Australia since then have not been well implemented. The successful implementation of those initiatives would help Australia to create a healthy environment for the prevention and treatment of population obesity especially among children and adolescents. More specific national initiatives such as physical activity guidelines for children and adolescents, and ongoing monitoring and co-ordination of current promotion programs is also needed.

### 2.6.2. Initiatives in other countries

In the USA, the childhood overweight/obesity has been regarded as an emergent public health epidemic. The Government, health, education, business and non-profit leaders have been urged to identify immediate strategies to address the problem. In California, it has been suggested that a state law mandating 200-400 minutes of physical education every 10 days in Grades 1-12 be implemented, and that there be funding for and implementation of a state law outlining elementary school nutrition standards (California Center For Public Health Advocacy, 2003).

The local health departments in the USA should promote healthy nutrition and physical activity as top priorities, and evaluate if there are findings and recommended policy changes accordingly.

There are some clear needs for actions to address the problem of childhood obesity in Europe (Wabitsch, 2000). Actions should be initiated to assist physicians to diagnose obesity in children and adolescents where it occurs and to diagnose potential health risks associated with obesity in an individual. It would be of great advantage to establish a network between hospitals, outpatient clinics, therapists and scientific groups working in the field of childhood obesity within all European countries (Wabitsch, 2000).

### 2.6.3. Summary
Overall, there is a lack of successful public health intervention targeting overweight and obesity prevention in children and adolescents. The current evidence suggests that combating overweight and obesity requires a high degree of sensitivity, long-term commitment, inter-sectoral collaboration and action and environmental modification to make it easy for people, especially youth to be active and eat a healthy diet in their everyday settings.

2.7 SUMMARY

The studies reviewed suggest that childhood and adolescent obesity is a serious, increasingly prevalent problem in the Western world. More comprehensive studies in the USA have revealed that the threat of obesity is greater than ever for children and adolescents. Recent Australian studies have also provided evidence that there are increasing numbers of Australian children who fall into the overweight and obese categories.

As overweight and obese children and adolescents suffer from both physical and psychological consequences in the short-term, and that the childhood obesity increases the likelihood of adult obesity with its associated health risks in the longer term, both effective prevention and treatment for overweight and obese young population are essential.

Many studies have recommended Body Mass Index (BMI) as a measure of adiposity in paediatric populations although it is not a perfect measure. However, it is still difficult to quantify or to compare national or international data of childhood obesity as a wide variety of definitions of childhood overweight and obesity is in use.

Many studies have identified a number of risk factors as contributing to the prevalence of overweight and obesity in children and adolescents, but these studies generally used different research methods, different age groups with consequent inconsistencies in the results. Although it is generally accepted that physical inactivity is a major element in the development of obesity in Western society, few studies have focused on the influences of dietary patterns in combination with physical activity levels on paediatric overweight and obesity. A validated standard
physical activity survey instrument for children and adolescents is lacking, as well as an appropriate method of measuring physical activity in young children.

The Australian Government launched a national population strategy for preventing overweight and obesity in 1997. In 2002, NHMRC also launched draft national clinical guidelines for weight control and obesity management in children and adolescents. The links of this national strategy to other related public health initiatives as well as national food and nutrition policy and many state and territory nutrition policies will be very important for the success of its implementation. Eat Well Australia may provide such a link. It is vital that there are ongoing peer-reviewed reports on monitoring and outcomes of these initiatives.

From this review, there are clearly many areas requiring further research in order to provide evidence for the way we address being overweight and obese in children and adolescents in Australia. From these areas I have identified the following to be the focus of research in my thesis. These areas are:

- As identified in sections 2.5.3, 2.5.4, there are limited SES studies focusing on children and adolescents, and the results on the relationship between the socioeconomic status of family and childhood obesity have so far been inconsistent. There is also a lack of national evidence exploring the impact of parental obesity on overweight and obesity in children and adolescents in Australia.

- Section 2.5.2.1 suggests that despite a wealth of data on energy intakes and overweight and obesity in children and adolescents, the results of the contribution of energy intake to overweight/obesity are inconsistent within the current evidence. There is a need in Australia to provide evidence that explores the relationship of dietary factors such as energy, fat intake and childhood overweight and obesity (see the detailed statements in the relevant sections before.

- Studies reviewed in sections 2.5.2.2 suggested that some longitudinal studies did reveal that physical activity levels were associated with children’s BMI or fat gain, however, such an association has not been confirmed in other longitudinal studies. Therefore, more research on physical activity levels in children and
adolescents, and the relationship of these levels to overweight/obesity are needed.

- Section 2.4.2 reviewed the current methods used to measure physical activity levels in children, and concluded that a greater effort towards developing a consistent standard of measurement and improving the accuracy of physical activity assessment among children and adolescents is necessary. There is limited data on how to undertake such studies especially on the use and validity of different measures of physical activity levels in young children.

- Section 2.3.3 suggested that most population-based studies of overweight or obesity among youth use the BMI, derived from measured weight and height, and there are limited studies on the availability and feasibility of self-reported data instead of measured weight and height in large-scale youth population surveys. Thus, there is a need to generate further research into this area in order to provide evidence on self-reporting bias in young people.

These ideas were the basis for the development of overall and specific aims in the thesis.
CHAPTER 3: METHODOLOGICAL BACKGROUND

3.1 INTRODUCTION
Each manuscript in this thesis provides the details of the relevant methodology for each specific study. This section discusses the methods issues that have not been dealt with or only discussed in minimum detail in those manuscripts. The Chapter is divided into two sections. The first section describes the methods for the first three studies based on the secondary data analyses, while the second section describes the methods for the cross-sectional survey conducted in Brisbane Australia by the candidate. Some further explanation in the published papers is provided to explain why in some instances specific age groups were selected.

3.2. SECTION 1: METHODOLOGY OF THE 1995 AUSTRALIAN NATIONAL HEALTH SURVEY AND NATIONAL NUTRITION SURVEY (MANUSCRIPTS 1, 2 AND 4)

3.2.1 Overview of the two national surveys
The Australian National Health Survey (NHS) was conducted by the Australian Bureau of Statistics (ABS) during the 12 month period January 1995 to January 1996. It aimed to collect information about the health status of Australians, their use of health services and facilities and health-related aspects of their lifestyle. About 13,800 households, representing about 1 in 310 of non-institutionalised populations through Australia were selected in the 1995 NHS. Trained ABS interviewers personally interviewed each member of the selected households aged 18 years or more, and with the consent of parents or guardians, children aged 15-17 years. Parents or guardians were asked to answer questions in respect of their younger children (McLennan, 1996).

Of those respondents to the NHS, a little fewer than 40% (21,200 persons) were also selected to take part in a National Nutrition Survey (NNS). The NNS sought to provide some baseline data and address some of the limitations of previous survey. It is the first Australian survey that includes participants 2 years of age and older and those living in both urban and rural areas in all Australian States and Territories. The NNS collected dietary data from 13,858 individuals using both a 24-hour recall and
Food Frequency questionnaire (FFQ). During the personal interview, children aged 15-17 years were interviewed with their own consent and the permission of a parent or responsible adult. A parent, guardian or close relative was asked to answer on behalf of children aged 0-14 years. This may be considered as a limitation of the data collected for children of this age group as other studies collect data from children themselves. As the NNS was collected in conjunction with the NHS, the nutrition data could be linked with health data for each of the participants (McLennan, 1998).

### 3.2.2 Sampling procedures for the NHS and the NNS

In the NHS, each Australian State and Territory was divided into a number of areas called ‘strata’. Each stratum contained a number of census collections’ districts (CDs), each of which contained approximately 250 houses. In capital cities and other major urban or high-population areas, the sample was selected in 3 stages:

- A sample of CDs was selected from each stratum.
- Each selected CD was divided into groups of dwellings or blocks of similar size, and one block was randomly selected from each CD.
- A systematic random sample of dwellings within each block was selected.

Dwellings on an adjoining properties were not selected (McLennan, 1998).

The NNS sample was a systematically selected sub-sample of CDs from the base NHS CDs. A maximum of two people per household in urban areas and three people in rural areas were selected to participate. These people were randomly selected from the households and included those aged two years or more who were usual residents of the dwelling (that is those who had stayed at the dwelling for any part of the month of interview or the previous month) (McLennan, 1998). Non-Australian diplomatic and service personnel and their dependents were excluded from the survey. Additionally, overseas visitors whose usual place of residence was outside Australia were also excluded (McLennan, 1998).

The data on household income, food and nutrients intake and measured weight and height are available for people aged two years of age and over in the NNS data set while the data on self-reported weight and height are only available for people aged
15 years and over in the NHS data set. The sample between ages of 7-15 years was selected for the analyses in manuscripts one and two. All children and adolescents were categorised into three age groups in the thesis, namely, 7-9, 10-12 and 13-15. A number of factors regarding such categories have been considered. Firstly, with such age division, data on children aged 7-9 years old could be separated from the adolescents aged 13-15 years old. The 10-12 year old group was regarded as a transition group between childhood and adolescence. It is assumed that such age categories may help with identification of children and adolescents separately. In addition, such categories provide analyses which are comparable with several other Australian studies.

3.2.3 Reliability and validity of 24-hour dietary recall
The 24-hour recall data from the NNS were used in this study to estimate the nutrient intakes of participants. It has been generally concluded that the food and nutrient intakes from a 24-hour recall does not represent the usual or average intakes of an individual. However, it is more reliable for estimating intakes at a group level, where participants’ under-and over consumption cancels and produces a fairly stable estimate of the group’s mean consumption (Carter et al., 1981); (Karvetti et al., 1985); (Boeing et al., 1997);

Many studies investigating the validity of 24-hour recalls have found them to have acceptable levels of validity in most populations (Boeing et al., 1997); (Buzzard, 1990); (Karvetti et al., 1985). When comparing with other dietary intake methods, the 24-hour recall has been found to have acceptable levels of concurrent validity with weighed food records, the dietary history method and FFQs (Boeing et al., 1997) (Karvetti et al., 1985).

However, it should be recognised that 24-hour recall has some limitations. For example, as dietary intake varies considerably from day to day, particularly in young people, the 24-hour recall method does not provide an accurate estimate of an individual’s usual food and nutrient intake. Because of such limitation, caution must be exercised in attributing too much credibility to relating such data to current weight profiles in individuals.
3.2.4 Quality assurance procedures
Quality assurance activities were undertaken at a number of steps in the NHS and NNS data collection phase. All changes to the data files as a result of quality assurance activities were done by the ABS prior to its release for use in this study.

Interviewers for the 1995 NHS were primarily recruited from a pool of trained interviewers with previous experience on ABS household surveys. Those selected to work on this survey underwent further classroom and field training and were required to satisfactorily complete study exercise at home. All phases of the training emphasised understanding of the survey concepts, definitions and procedures in order to ensure that a standard approach was employed by all interviewers concerned (McLennan, 1996). Qualified nutritionists were recruited to work as interviewers on the NNS. They were given two weeks of training covering all aspects of data collection. Training included the taking of physical measurements, and practice interviews were undertaken on volunteer subjects, including children and older people.

During the secondary data analyses, the sample size in the subsets of the data (eg children, adolescents) created by the candidate was checked for consistency against the original file of the surveys. Outliers in intakes of all analyses were investigated by going back to the food records in the original file.

3.3 SECTION 2: METHODOLOGY OF THE CROSS-SECTIONAL PILOT SURVEY AMONG 10-12 YEARS OLD AUSTRALIAN CHILDREN

3.3.1 Sampling issues
The study was sampled from one purposively-identified state school with children of culturally-diverse backgrounds. Data obtained from the school showed that nearly two thirds of students were from a minority ethnic or cultural background. Children between the ages of 10-12 years (eg those students enrolled in Grade 6 and 7) were selected to participate on the basis of two considerations. Firstly, physical activity levels were measured using a self-completed questionnaire and by wearing a pedometer. Previous research has suggested that children 10 years of age and under can not recall activities accurately and are unable to quantify the time frame of
activity (Baranowski, 1988). Secondly, the total number of all students in Grade 6 and 7 of the target school was a feasible sample given the time and financial constraints of the study. It was recognised from the power calculations that such a sample would not be sufficiently large to make generalisations.

3.3.2 Development and piloting of the survey tool
A three-day activity diary was designed based on Bouchard’s self-completion diary (Bouchard et al., 1983). The major parts in the revision of Bouchard’s diary included 1) using the exact time each day, for example, starting at 9:00 am ending at 8:00 am the next day rather than just using 0, 1, 2, 3 hours; 2) adding a number of rows for listing activities (see details in Appendix B). As these revisions were based on the feedbacks from the trial study, the validity of the revision was not tested. The questionnaire is written in simple language with clear appropriate instructions on how to complete the diary. The survey schedule and questionnaire were subsequently pilot tested among a single class 6 months before the pilot survey was conducted. The selection criteria of the participants for the trial study included: the subjects study in the same school between Grade 6 and 7, at least one-third of participants are from a minority cultural background, and the class teacher is happy with the arrangement. After the trial study was conducted, class teachers were asked for the feedback regarding the survey schedule and procedure. Participants were asked if they had any difficulty with understanding and answering the questionnaires, and if they had any recommendations regarding how the questionnaire could be improved. The questionnaires that were used in trial study and pilot survey are shown in Appendix A and B, respectively. The principal changes were 1) simplifying the physical activity diary, 2) reducing the information sheet to parents and children, 3) clarifying the consent form and added incentives.

3.3.3 Ethical clearance
Ethical clearance was obtained from the University Ethic Committee of Queensland University of Technology prior to undertaking the trial and pilot study (Appendix D). The information package and consent forms are provided in Appendix C.

3.3.4 Quality assurance procedures
There were 6 staff in the research team. They were trained by the candidate and his supervisor before they were involved in the survey in the target school. The training involved how to present the instructions to the class, and how to measure weight and height in children using the standard procedures. The research staff practised doing the measurements on single subjects until consistent results were obtained. Random checks were made of measures. To increase the recall accuracy of physical activity level data, staff were required to check the activity diary every morning before the new activity diary was distributed. In this check, obvious omissions of data were completed, obvious errors were corrected and the children were asked if they had any questions or areas they were uncertain about. In addition, the completed questionnaires were randomly selected for daily check by the principal investigator (candidate), and the participants were asked to amend the questionnaire if necessary. Similar to the secondary data analyses of the NHS and NNS, outliers in physical activity level were investigated by going back to the original file.
CHAPTER 4: ASSOCIATION BETWEEN OVERWEIGHT OR OBESITY AND HOUSEHOLD INCOME AND PARENTAL BODY MASS INDEX IN AUSTRALIAN YOUTH: ANALYSIS OF THE AUSTRALIAN NATIONAL NUTRITION SURVEY, 1995

Citation:


**Date submitted:** August 2001

**Date accepted:** December 2001

**Contribution of authors:**

The candidate performed all data analysis and wrote the entire manuscript. Other authors contributed to the manuscript in terms of providing feedback on the analyses and initial drafts.
Pages 67-84 are not available online. Please consult the hardcopy thesis available from the QUT Library.

Citation:


Date submitted: April 2002

Date accepted: January 2003

Contribution of authors:

The candidate performed all data analysis and wrote the entire manuscript. Other authors contributed to the manuscript in terms of providing feedback on the analyses and initial drafts.
Pages 86-107 are not available online. Please consult the hardcopy thesis available from the QUT Library.
CHAPTER 6: A PILOT STUDY ON THE FEASIBILITY OF MEASURING PHYSICAL ACTIVITY IN 10-12 YEARS AUSTRALIAN CHILDREN FROM A MULTI-CULTURAL SCHOOL

Citation:

Wang Z, Patterson CM, Hills AP (2003) Preliminary study on the relationship between body mass index and physical activity in 10-12 years Australian children from a multi-cultural school. (This manuscript will be developed and amended for publication).

Contribution of authors:

The candidate performed all data collection and analyses. The candidate also wrote the entire manuscript. Other authors contributed to the manuscript in terms of providing feedback on the analyses and initial drafts.
Pages 109-142 are not available online. Please consult the hardcopy thesis available from the QUT Library
CHAPTER 7: A COMPARISON OF SELF-REPORTED AND MEASURED HEIGHT, WEIGHT AND BMI IN AUSTRALIAN ADOLESCENTS

Citation:


**Date submitted:** April 2002

**Date accepted:** August 2002

**Contribution of authors:**

The candidate performed all data analysis and wrote the entire manuscript. Other authors contributed to the manuscript in terms of providing feedback on the analyses and initial drafts.
Pages 144-165 are not available online. Please consult the hardcopy thesis available from the QUT Library.
CHAPTER 8: GENERAL DISCUSSION

8.1 INTRODUCTION
Each manuscript has its own separate discussion section in which the findings in relation to literature, an interpretation of contributing factors, the limitations of the study and the implications in the public health field have been addressed. This Chapter summarises the findings in the four manuscripts at a more macro level. Methodological conclusions and recommendations for further research are also discussed.

8.2 SUBSTANTIVE DISCUSSION
Firstly, the results of the research undertaken provide further baseline data on overweight or obesity and the contribution of socioeconomic status, parental overweight or obesity and some dietary factors among Australian children and adolescents based on recent national surveys. Additionally, this thesis provides an indication of the accuracy of self-reporting weight and height in older Australian adolescents. Finally, the results provide data of how physical activity/inactivity are associated with overweight and obesity in a group of Australian schoolchildren.

This substantive discussion follows three main themes:
- The influences of socioeconomic status, parental obesity and dietary factors on childhood obesity
- The contribution of measurement of physical activity to the development of childhood obesity
- Implications of self-reporting weight and heights in youth

8.2.1 The influences of socioeconomic status, parental obesity and dietary factors on childhood obesity
When using household income as the measure of socioeconomic status in Australian children and adolescents, the study presented in Chapter 4 showed that the prevalence of overweight or obesity among boys and girls was the lowest in the highest level of household income, and the odds ratio of overweight or obese boys with the highest household income was significantly smaller when compared with those with the lowest household income.
In studies of the implications of differences in socioeconomic status at a population level, three different indicators are used most frequently for studies among adults. These indicators are occupation, education and income, each of which is inter-related with another to differing degrees (Turrell et al., 1994); (Turrell et al., 1999). As the majority of youth are not in the workforce, do not earn significant income and have not finished their education, parental or family-based measurements of socioeconomic status are used in examining socioeconomic influences on children’s health status. There has been no agreement on an ‘optimal’ means of socioeconomic status (SES) instead each is thought to represent different concepts relating SES to health (Galobardes et al., 2001). In other studies a ‘combination index’ such as SEIFA is used to capture the impact of an extensive range of factors. This however limits the understanding of which component is having an impact (discuss later).

However, the use of occupation and education as the indicators of SES in this study would have reduced the available sample of children in the 7-15 year age groups because of the way data were collected in the primary data collection. Consequently, income was the only indicator explored as an indicator of SES and is useful for the following reasons. Firstly, income affects people’s ability to purchase equipment (eg, microwave ovens and resources) to undertake various health behaviours (Galobardes et al., 2001). Additionally, it may provide access to medical care and opportunities for further education. Different levels of personal income provide access to different lifestyle, to prestige or power (Liberators et al., 1988) (Turrell et al., 1994). Therefore, use of household income as an indicator of SES in this study provides an insight to its contribution to the impact of socioeconomic inequality in the development of childhood obesity. Further research is needed to explain how income influences the development of childhood obesity. Social inequalities and their relationship to health outcome have been identified as important issues in Australia for understanding how health outcomes can be improved. However Australian studies in this area are limited (Australian Health Strategy, 1992); (Turrell et al., 1999).

In the NHS, a combination of index for area, SEIFA (socioeconomic index for area), was used to summarise different aspects of the socioeconomic status in an area (McLennan, 1996). The index is calculated by summarising the information from a
variety of underlying social and economic variables, each index using a different set of underlying variables (Castle, 1993). However, there are some limitations of using SEIFA. Firstly, the indices contain only limited aspects of wealth (such as income and expenditure). In addition, the family structure (number of income earners, number of parents, number of dependents etc) is not strongly represented in the indices. Furthermore, access to infrastructure such as schools, community services, shops and transport are not represented by the indices (Castle, 1993). However, most importantly, the indices reflect the socioeconomic wellbeing of an area, rather than that of individuals. Therefore, it is often less appropriate to make inferences regarding a particular individual on the basis of the index.

Chapter 4 also showed that the prevalence of overweight and obesity among children increased with the prevalence of parental overweight or obesity except for the trend with father’s BMI among boys. This study also suggested that parental risk of overweight or obesity was an independent risk factor for childhood obesity. Parental overweight or obesity has been shown to be one of the most important health risk factors in the development of childhood overweight and obesity. Previous studies have revealed that parental obesity increases the risk of adulthood obesity developing from those obese children (Whitaker et al., 1997); (Maffeis et al., 1998). It is assumed that parental genetic predisposition, as well as environmental factors such as family eating habits and lifestyle may influence the development of childhood obesity (Epstein et al., 1990).

Further studies are needed to explore the mechanism of association between parental obesity and childhood obesity, ie to separate the effect of genetic and environmental influences and for example, the influences of parental diet and physical activity on children’s health behaviours. It would be interesting for future studies to determine whether the overweight or obese child’s siblings are more likely to be overweight or obese. Another important relationship is to explore comparisons of the separate roles of fathers and mothers health behaviours on the development of childhood obesity. The study in Chapter 4 suggested that the role of mother’s obesity is greater than that of fathers in the association with the development of childhood obesity. Is this a genetic predisposition? Alternatively, could it be a relatively greater influence through food intake behaviours?
Chapter 5 explored the association between overweight or obesity and the intake of energy and fat, and percentage of energy from fat in Australian youth. The results did not provide evidence that there were statistically significant differences in intakes of these nutrients between non-overweight and overweight or obese Australian boys and girls. Weight gain is the result of an imbalance between energy intake and total energy expenditure. However, many previous studies have failed to show a correlation between individual energy intake and adiposity.

In many studies, it is difficult to draw the conclusion that those who are overweight or obese definitely eat more than their lean counterparts (NHMRC, 1997). When considering the under-reporting issue, many studies have suggested all individuals under-report their intake, and that obese persons under-report more so than their normal weight counterparts (Bandini et al., 1990); (Lightman et al., 1992); (Prentice et al., 1986).

Actually, the study in this thesis based on data analysis from the NNS revealed that overweight or obese Australian boys and girls were more likely to under-estimate their energy intakes than that of non-overweight counterparts. Although the gender differences in under-reporting was not examined due to the limitation of sample size in this thesis, it is generally accepted that females are more likely to have low body image and prefer to under-estimate their dietary intakes (Carroll et al., 1986) (Tiggeemann, 1990); (Paxton et al., 1991); (Huon, 1994); (O’Dea, 1995). It would be important in further studies to examine more comprehensively the influence of food intake under-reporting in studies on the association between nutrient intake and overweight or obesity.

The nutritional composition of the diet, such as fat consumption, rather than the energy intake have been considered as another important issue in the aetiology of obesity. In the total population, the proportion of fat in the food eaten by the population over the last two centuries has increased while there has not been an increase in the average daily energy intake (Prentice, 1994) while Cavadina et al. (2000) suggest that there has not been an increase in consumption of fat in children’s diets over the past 30 years. However, when comparing the dietary pattern of Australian children between 1985 (English et al., 1989) and 1995 (Mclelman et al.,
1997), this study showed the overall energy intake was found to increase in ten-year interval while the percentage of energy from fat decreased in 1995. This is probably due to the an increasing of carbohydrate and sugar but decreasing of high-intensity fat food (Cook et al 2001).

Generally, no definite conclusions can be made about the contribution of food and nutrient intake to the development of overweight or obesity from currently available data. The current study supplements Australian studies in this area, although further research is needed to explore the impact of dietary factors on the overweight and obesity, remembering that intake is only one part of the equation.

Childhood is an important period for the development of some dietary, physical activity and other health behaviours, which may relate to health status in adulthood. Therefore, more comprehensive studies to explore the influences of some health risk factors on the aetiology of childhood obesity are essential. The studies in Chapter 4 and 5 were conducted based on cross-sectional surveys. Longitudinal investigations will help to establish the cause-effect relationships between SES, dietary factors and childhood obesity. Meanwhile, childhood overweight prevention initiatives are urgently needed, such as delivering healthy eating and physical activity messages to children and their families in ways that are engaging, relevant and meaningful to help prevent childhood overweight and obesity and the associated chronic diseases (Elder et al., 2003). Eat Well Australia and the National Health and Medical Research Council have launched national initiatives for the prevention of Australian childhood obesity, and suggested that more high quality studies examining the dietary patterns of children and adolescents are needed (National Public Health Partnership, 2001); (NHMRC,, 2002).

8.2.2 The contribution of physical activity to the development of childhood obesity

The study reported in Chapter 6 was a cross-sectional pilot survey of physical activity levels (PAL) of a group of 10-12 year old Australian children in a multi-cultural school. In considering the comments that follow, it should be recognised that this study is indicative rather than definitive, and provides a models for undertaking a study which would enable to explore the association between PAL and overweight
and obesity. The results in this study suggested that these children were physically active, ie around 94% of boys and girls had moderate or vigorous physical activity levels. This contrasts with many assertions being made about physical activity levels in children. As more better designed studies on physical activity in children become available, it will be interesting to see how the evidence builds for different factors contributing to overweight and obesity in Australian children.

Although this small and non-randomly selected sample size limited the representativeness of the study, there are many positive indicative aspects in this study. Firstly, this pilot study explored the influence of ethnic differences on PAL. In spite of the multicultural nature of Australia, there are few data exploring the impact of ethnicity on health risk factors or outcomes in children. Additionally, this study also explored the validation of self-reported diaries using data collected from pedometers. Furthermore, this preliminary study of measuring physical activity in Australian school children provides a protocol on the methodology and practicality for similar studies in school settings.

The general level of activity found, in spite of the limitations, was contradictory to many previous studies, in which it has been generally accepted that children are becoming more physically inactive than before. For example, the data from the 2001 Youth Risk Behaviour Survey (YRBS) in the United States showed that more than 30% of the youth responding did not participate in either moderate or vigorous physical activity over the previous week, compared to 14% in 1996. However, there are some limitations in this survey. For example there is no validity and reliability data on this instrument and the youth only recall their physical activity in previous week. The decreasing of enrolment in PE in the American students probably provide some explanations for the decline of physical activity. Booth et al. (2002) examined the physical activity levels among New South Wales high school student and found that majority of boys and girls were adequately active. However, there has been no national-wide physical activity data in Australian children and adolescents since the schools–based, by the Australian Council for Health, Physical Education and Recreation (ACHPER) in 1985. Many reports provided in Australia on the increase in overweight in children, highlight the lack of evidence available generally on physical activity levels and participation in children. On the other hand, the results
of the 1999 National Physical Activity Survey in Australian adults have suggested that the participation of physical activity in adults have declined between 1997 and 1999 while the proportion of physical inactivity increased especially for those people aged 30-44 years (Armstrong et al., 2000). However, as yet there is insufficient conclusive evidence from local research to confirm or disprove that Australian children display this similar declining trend physical activity trends as noted among adults.

Furthermore, the limitations of in the methodologies used in the measurement of physical activity make it difficult to compare different studies in Australia and other developed countries. It is vital that more research on physical activity level in Australian youth when undertaken, develop valid and consistent methodologies for measuring physical activity.

Turning to consideration of interaction of physical activity with other factors, studies in the U.S. have outlined some potential factors that may lead to the high prevalence of overweight and physical inactivity (California Center for Public Health Advocacy, 2003). There is evidence that a number of individual, social, and environmental factors are involved in these outcomes in the Unites States. These are:

- Increasing portion sizes of food provided
- Increasing consumption of fast food and soft drinks
- Lack of funding for nutrition and physical activity programs
- Availability of soda and junk foods on school campuses
- Poor physical activity infrastructure in schools and communities
- Limited compliance with physical education requirements in many schools
- Limited access to healthy foods in low-income neighbourhoods, and
- Advertising of junk foods to children and their families.

Similar situations appear to be occurring in Australia although there are no published data summarising the potential causal factors, nor equally importantly the relative impact of such factors. There is sufficient evidence to indicate that the ‘obesiogenic’ environment in many Western countries shows many commonalities. However, there are some differences in demographic, social-economic and cultural or ethnical aspects between Australia, the United States and other western countries.
experiencing similar trends. It is vital that interventions to prevent or treat overweight/obesity note carefully the specifics of environmental influences.

Looking at the subsequent effects of childhood obesity and lack of physical activity leads to some of the following considerations. Physical fitness has a key role in children’s health by keeping the cardio-respiratory system, joints and muscles healthy and strong. Physically-fit children are less likely to suffer from chronic diseases both as children and as adults, and regular physical activity helps to maintain healthy weight and prevent overweight. (California Center for Public Health Advocacy, 2003). Moreover, physically active children are more likely to be physically active adults, with much lower risks for diabetes and heart disease (California Center for Public Health Advocacy, 2003). On the other hand, overweight children face a greater risk of numerous problems, including Type 2 diabetes, high blood pressure, high blood lipids, asthma, sleep apnea, chronic hypoxemia, early maturation, and orthopaedic problems. Overweight children also suffer psychosocial problems, including low self-esteem, poor body image, and symptoms of depression (USDHHS, 2001); (UCB/Coop, 2000).

For girls in particular, poor self-image from being classified as obese follows them into adulthood, resulting in fewer years of completed education, lower family income, and higher rates of poverty, regardless of their initial socioeconomic background (Dietz, 1998). The combination of overweight and physical inactivity results in significant medical and financial resources being expended in the treatment of overweight youth and obese adults (California Center for Public Health Advocacy, 2003). Studies have suggested that medical care costs associated with obesity are greater than those associated with both smoking and problem drinking (Sturm, 2002). The above reports provide a strong case for immediate action on childhood overweight and obesity in the USA.

The Australian government has recognised obesity as epidemic and launched national physical activity guidelines for Australians, and draft national guidelines to promote physical activity in children and adolescents (Active Australia, 2000) (NHMRC, 2002). Therefore, more high quality research into the impact of physical activity on overweight or obesity would provide more evidence and help in the
adoption of appropriate strategies in the future. Further studies on the validity of physical activity measurements using activity diaries is needed. The protocol for the pilot study reported in this thesis, together with identified limits and barriers provides useful practical information in the design of school-based studies.

8.2.3 Implications of self-reported weight and height in youth

Weight and height are the common indicators used in both clinical and public health settings to evaluate the health status of populations for a number of lifestyle diseases. In large-scale adult population surveys, self-reported weight and height are often used in place of actual physical measurements due to the convenience and cost-effectiveness in the data collection. However, studies on the reliability and validity of self-reported data in youth are limited. The availability of both self-reported and measured weight and height among the Australian adolescents aged 15 year-old or over in the Australian National Health Survey (NHS) and Nutrition Survey (NNS) made it possible to conduct the comparison of such data in older adolescents in this study. The results reported in Chapter 7 revealed that the percentage of misclassification of overweight or obesity from self-reported data in 15-19 years Australian adolescents was around 30%, and the bias in reporting weight and height was much higher in overweight or obese youth of both genders.

Much previous research has described that females are more likely to report their physical measurements inaccurately than that in males (Hills et al., 1998); (Pirie et al., et al., 1981); (Cash et al., 1992); (Paltra et al., 1982). However, the study in Chapter 7 did not suggest that there are gender differences in under-reporting bias. This difference may be due to inconsistent age group selection among the different studies.

The current study and many previous studies implied that the self-reported physical measurement data have to be cautiously utilised for predicting overweight or obesity in Australian older adolescents. The self-reported weights and heights are not recommended for identifying an individual as ‘overweight’ (Strauss, 1999). In addition, the accuracy of self-reported weights and height may be improved if adolescents were encouraged to measure themselves using the reliable estimates prior to completing the self-reported questionnaires. However, it is important that
this activity is not reinforced to the extent that it leads to young people becoming obsessive about body image, e.g. encouraging consistent weighing. The bias in self-reporting weight and height in children and adolescents younger than 15 years of age also needs to be reported.

8.3 RECOMMENDATIONS FOR THE PREVENTION AND TREATMENT OF CHILDHOOD OBESITY

Well-documented evidence has clearly indicated that the overweight or obesity in children and adolescents is an increasing trend and cannot be ignored. This epidemic demands an investment in the primary and secondary prevention of obesity and overweight in young people. Primary prevention aims at establishing a healthy, active lifestyle and keeping children and adolescents within a healthy body weight range that is considered to be healthy (Zwiauer, 2000). Constant availability and affordability of palatable and energy-dense food in the affluent society of the Western World demands preventive strategies to ensure appropriate energy intake.

For those children and adolescents who are already obese, secondary prevention is necessary. The secondary prevention aims at long-term weight maintenance and normalisation of body weight and body fat. Eating and exercise behaviour of obese children needs to be modified, as well they need to establish new, healthier behaviour and lifestyle. However, there have been many studies that have documented the failure of treatment for obesity to achieve long-term success in adults as well as in children (Garner et al., 1991); (Kayman et al., 1990). In addition, the health consequences associated with obesity over a long period may not be fully reversible by weight loss (Pi-Sunyer, 1993).

The findings in this thesis may provide some insight into factors which need consideration when initiatives are launched for the prevention of childhood overweight and obesity. Examples include:

- Relevant nutrition and physical activity programs would be more effective if their priority target groups were more inclusive of low-income families and/or overweight or obese parents. As many studies suggested, the current food advertisement has an inverse effect on the dietary patterns of the paediatric
population (Wilson et al 1999, Hill and Radimer, 1997) Thus, promotion of health eating is an important issue in the prevention of childhood obesity).

- Prevention efforts must begin at early age, and persist during adolescence, and into adulthood. More awareness and consciousness of the problem of childhood obesity must be generated in order to lead to effective therapeutic programs. Priority groups include those have familial obesity, especially parental obesity, and those individuals who are at risk of becoming overweight.

- At the population level, more efforts should be made to increase the awareness of positive outcomes of controlled caloric intake and increasing physical activity and energy expenditure. Currently, many negative health messages are delivered to the paediatric population. (Wilson et al 1999, Hill and Radimer, 1997). Thus, local and national action should be taken to promote the implementation of appropriate nutrition and physical activity programs (ASSO, 2003).

- Effective treatment in children may prevent or delay adult obesity. The primary goal of childhood obesity treatment is the regulation of body weight and body fat with nutrition, which nevertheless ensures normal growth and development (Zwiauer, 2000). The treatment components include behavioural approaches, such as changing eating and exercise behaviour; diet and nutrition, such as dietary modification through reduction or stabilisation of total calorie intake, fat intake and modification of the composition of macronutrient intake as well as reconstruction of eating habits; and exercise physical activity. However, there is a need for further research into the evaluation of effectiveness of these treatment components.

8.4 METHODOLOGICAL CONCLUSIONS AND RECOMMENDATIONS
The methodology used in this thesis has been discussed in each manuscript and the methodological background of Chapter 3. Overall, the 1995 National Health Survey (NHS) and National Nutrition Survey (NNS) are two large-scale nation-wide representative studies in Australia. They were conducted on a multi stage area sample of private dwellings such as houses, flats and a list sample of non-private dwellings such as hotels, motels although the NNS sample was a systematically
selected sub-sample from the NHS. This sample selection method ensured a known and equal chance of selection for each person with each stratum and, an equal chance of selection strata with each State in Australia (McLennan, 1996). However, there are limitations of studies based on secondary data analysis from these datasets, and the cross-sectional survey in a small group of Australian school children included in this thesis. Limits include:
- The SES indicators available
- Under-reporting
- Low statistical power
- Reliability of 24-hour recall for dietary intake
- Sample design of the physical activity study
- Data of self-report in adolescents

Although there is no conclusive evidence that either income or occupation, or education was more sensitive as the indicator of SES measurement in detecting health inequalities among children and adolescents, the combination of these SES indicators used in health studies would provide a more accurate and informative picture of relationship between SES and childhood obesity. Examination of the impact of differences in the levels of parental education or occupation on the profile of obese and non-obese children and adolescents was limited by the small sample sizes in the NHS and NNS. Further studies should collect parental occupation, education and income data from all youth participants, because adequate sample sizes using the full range of indicators would help in obtaining a more comprehensive picture of the likely genesis of health inequalities. Thus, it would be interesting to explore whether the impact of SES on overweight/obesity is same as the study in this thesis when using a wide range of SES indicators.

The methodology used in this thesis also highlighted that exploring the differences in nutrient intakes between obese and non-obese children and adolescents should examine the effect of potential underreporting bias. Under-reporting data were not available for children under 10 years old. Gender differences in under-reporting in this study were unable to be examined due to small sample size in each gender group among the youth aged 7-15 years of age. Future dietary surveys should determine the
validity of methods used in examining the under-reporting of young children and use a large sample size.

When exploring the relationship between nutrient intakes and overweight/obesity in children and adolescents in this study, the low sample size in the categories of overweight or obese groups is associated with low statistical power, and hence such relationships cannot be shown statistically. Further studies may overcome this limitation by either utilising a larger sample size that was used in the NNS and/or a longitudinal study to reflect better a cause-effect relationship.

As discussed earlier, the dietary intakes of children and adolescents were estimated based on 24-hour recall method. Where only one day of the intake is used as a measure of dietary intake, it is recognised that individual estimates are unlikely to an accurate representation of usual dietary intake. However, the mean of a one day intake is believed to represent the group mean usual intake for a population as the non-systematic individual errors are presumed to cancel each other out. Overall, the 24-hour recall method has an acceptable level of reliability and validity when it was used for the comparison of dietary intakes in different ages (Boeing et al., 1997); (Karvetti et al., 1985).

Due to the limitation of sample size, conclusions on the relationship between physical activity and overweight and obesity in the pilot study can not be drawn. However, the pilot study of physical activity level in school children has provided a protocol for measuring PAL in young children. Although this study had limited resources and could not afford a larger sample size, a longer data collection, or management of using pedometer over the weekend and or in different seasons, future studies with well-designed and large sample sizes may use a similar data collection methodology and measurement protocols used in this thesis to explore whether the findings remain same.

8.5 RECOMMENDATIONS FOR FURTHER RESEARCH
Many recommendations could be made from this study. Among these recommendations, some priorities are included the following:
- Future studies examining the association between SES, parental obesity and nutrient intakes and childhood obesity need to consider the numbers required in the sample to be able to explore such associations.

The findings in this thesis based on the NHS and NNS and a small cross-sectional survey could be limited in their generalisability to the Australian-wide population. Firstly, the participants in the NNS were recruited from the samples of the NHS. Non-response bias in the NNS possibly under-estimates the magnitude of an association between household income, dietary factors, parental obesity and overweight or obesity in children and adolescents. This is because the samples at the extremes of the SES distribution and of the body weight distribution in the general Australian youth population may be reluctant to participate in such studies (McLennan, 1998). It is also possible that the dietary intake, and self-reported weight and height of participants who volunteered for the NNS are not representative of the Australian children and adolescent population although data were published on how representative the adult population was.

- In future studies, a population-based and randomly selected sample would ensure findings that are more representative of general Australian children. The small cross-sectional survey on the Australian children aged 10-12 years old was limited by recruiting the sample purposely and conveniently. Although there were no age, gender and ethnic differences between non-respondents and actual participants, the children who volunteered to participate may have had higher than average levels of interest in nutrition and physical activity programs. The findings of this cross-sectional survey may not be replicated among other samples of children that have been recruited in different ways due to the limitation of validity and reliability of in this school-based study.

- The research questions of this thesis may be more comprehensive and accurately addressed using a longitudinal study design. The longitudinal studies would help to define the association between the risk factors and childhood obesity as well as enabling conclusions on causality to be drawn. It also could follow these up into adulthood. Such a longitudinal study has conducted in Australia. The data from this study will be available to researcher.
- Updated national-wide nutrition and health data are urgently needed in Australia. The secondary data analyses in this thesis were based on the NHS and the NNS which were conducted in 1995-96, and the findings based on the NNS and NHS in this thesis merely reflected the picture of the population of Australian youth that occurred 7 years ago. Data from the 2001 NHS are not yet available for general use and analysis. Australia should set-up a regular, systematic monitoring and surveillance system to ensure availability of relevant recent data. Considerable work has been completed in adults on the validity of single or short numbers of questions for dietary intake data. This needs to be extended to intake data for children.

- Future studies need to examine simultaneously the impact of both food and nutrient intakes on overweight or obesity, and assess the influence of family eating styles as well.

Studies of differences of dietary intakes between obese and non-obese children and adolescents in this thesis only explored the contribution of some selected nutrient intakes, as well as levels of physical activity, such that the findings are limited in the contribution they can make to help the nutrition –intervention strategies, and to deliver healthy eating messages in terms of foods. Additionally, there is evidence that parents influence food choices and other eating behaviours in their children (National Health and Medical Research Council, 2002).

- Future studies still need to explore some other potential factors, including the relative contribution of genetic and environmental factors that may have an impact on childhood overweight or obesity. For example, are there differences in rates of obesity in children who prefer purchasing foods from school tuckshops or where food is not prepared at home?

As this thesis only considered a limited number of risk factors that may contribute to the development of childhood overweight or obesity it should be understood that the association is likely to be more complex than this, and include many additional influences that were not considered.
APPENDIX A: QUESTIONNAIRES USED IN DEVELOPMENT STUDY

Code___________

The investigation of body image perceptions, weight-control practices and physical activity levels in Australia schoolchildren

November, 2001
Preface

The questionnaires aim to investigate a variety of your attitudes and behaviour about how body is viewed and what weight-control practices are used as well as physical activity levels using three-day dairy.

They include:

- **Section One**  Demographic data
  It is about your name, gender and ethnic background. You need to answer all questions

- **Section Two**  Body image perceptions, weight-control practices
  You need to answer all questions

- **Section Three**  Three-day activity daily
  Please refer to the instructions in the Section Three to answer all questions

Please **remember** that

- **THERE ARE NO RIGHT OR WRONG ANSWERS SO TRY TO BE AS ACCURATE AND HONEST AS POSSIBLE**
- **RESULTS ARE STRICTLY CONFIDENTIAL**
- **IT IS IMPORTANT THAT YOU ANSWER ALL QUESTIONS REQUIRED**
- **YOU ARE ABLE TO WITHDRAW FROM THE STUDY AT ANY TIME IF YOU NO LONGER TO PARTICIPATE**

Thank you for your time and effort.
SECTION ONE  DEMOGRAPHIC DATA

The following questions are about your name, gender, age and family background

1.1. Name _______ given name ___________ family name

1.2. Grade (tick one)___6 ___7

1.3. Gender (tick one)___Male ___Female

1.4. Date of Birth:___ / ___ / 19___

1.5. Where were you born in (tick one)?

___Australia ___ outside Australia ___ don't know

1.6. If you were born outside Australia,

A. Please specify which country you were born in?

__________________________

B. How long have you been living in Australia (tick one)

___ 1-2 years of residence

___3-4 years of residence

___5-9 years of residence

___10 years or more of residence

___ don't know

1.7. Do you speak a language other than English at home (tick one)? ___Yes ___No

If yes, what is the language?__________
2.1. How tall are you without shoes (self-estimated)? _____ centimetres or _____ ft/inches

2.2. How much do you weigh without clothes or shoes (self-estimated)? _____ kilograms or _____ lb/stones

2.3. In your opinion, would you describe yourself as: (tick one)

1___ very skinny
2___ skinny
3___ average
4___ overweight
5___ very overweight
6___ I do not understand this question

2.4. Tick one figure below which most accurately represents your body type?

For boy

[Diagram of 9 figures indicating different body types]

For girl

184
2.5. Would you like to LOSE weight (tick one)?

___ Yes  ___ No  ___ Unknown

Why? _______________________________

2.6. Have you ever tried to LOSE weight (tick one)?  ___ Yes  ___ No (if No go to 2.8)

If YES, how old were you when you first tried to LOSE weight? ___

2.7. If you ever tried to LOSE weight please tick the methods you have used (multiple ticks)

___ Eating smaller meals
___ missing meals
___ Eating special diets
___ not eating all day
___ Exercising
___ Counting the calorie of foods
___ Drinking less

Other methods ________________________________________________

2.8. Would you like to GAIN weight (tick one)?  ___ Yes  ___ No  ___ Unknown

Why? _______________________________
2.9. Have you ever tried to GAIN weight (tick one)?   ___YES    ___NO (If NO go to 2.11)

If YES, how old were you when you first tried to gain weight? ___

2.10. If you have ever tried to GAIN weight please tick the methods you have used (multiple ticks)

   ____ Eating larger meals
   ____ Eating extra meals
   _____Eating a lot of junk foods
   ____ Doing weights
   ____ Drinking more
   ____ Special diets
   ____ Counting the calorie of foods
   ____ Exercising less

Other methods _________________________________________________

2.11. Tick one figure below which most accurately show how you would like to look?

For boy

1  2  3  4  5  6  7  8  9

For girl
2.12. Tick one male or female figure below which you find most attractive

For boy

For girl
SECTION THREE     Three-day activity diary

INSTRUCTIONS

This questionnaire asks you to record all activities you performed in 24 hours a day, you need to keep the activity diary writing in three days (two schooldays and one weekend day). Please write down the names of activities and how much time (minutes) you performed such activity. Please review the examples provided before writing your diary.

We recommend you bring the Section Three questionnaire to school everyday as the research team would check the diary and answer the questions you asked. To help the recall of activities accurately, you would better take a few minutes to write the school day activity diary before leave for school, at lunch time, before leave for home from school and before go to bed, and write the weekend day activity diary after breakfast, after lunch, after dinner and before go to bed.

Example one: Joy Smith's activity diary

Date: 20/11/2001       Tuesday

<table>
<thead>
<tr>
<th>Time</th>
<th>0-15 minutes</th>
<th>16-30 minutes</th>
<th>31-45 minutes</th>
<th>46-60 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wake-up School's in</td>
<td>Resting in bed</td>
<td>Making the bed 5' Brush teeth 5' Taking a shower 5'</td>
<td>Take a shower</td>
<td>Getting dressed</td>
</tr>
<tr>
<td>8:00 AM</td>
<td>eating</td>
<td>Quick walking</td>
<td></td>
<td>Listening in class</td>
</tr>
<tr>
<td>9:00 AM</td>
<td>writing</td>
<td></td>
<td></td>
<td>Reading</td>
</tr>
<tr>
<td>10:00 AM</td>
<td></td>
<td></td>
<td>eating</td>
<td>Writing by hand</td>
</tr>
<tr>
<td>11:00 AM</td>
<td>volleyball</td>
<td></td>
<td></td>
<td>resting</td>
</tr>
<tr>
<td>12:00 PM</td>
<td></td>
<td>eating</td>
<td></td>
<td>Slow running</td>
</tr>
<tr>
<td>1:00 PM</td>
<td></td>
<td>resting</td>
<td>Listening in class</td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>Activity 1</td>
<td>Activity 2</td>
<td>Activity 3</td>
<td>Activity 4</td>
</tr>
<tr>
<td>--------</td>
<td>------------</td>
<td>------------</td>
<td>------------</td>
<td>------------</td>
</tr>
<tr>
<td>2:00 PM</td>
<td></td>
<td></td>
<td>Writing by hand</td>
<td></td>
</tr>
<tr>
<td>3:00 PM</td>
<td>Quick walking</td>
<td></td>
<td>watch TV</td>
<td></td>
</tr>
<tr>
<td>4:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5:00 PM</td>
<td>Brisking waking</td>
<td></td>
<td>Riding a bicycle</td>
<td></td>
</tr>
<tr>
<td>6:00 PM</td>
<td>resting</td>
<td></td>
<td>Doing homework</td>
<td></td>
</tr>
<tr>
<td>7:00 PM</td>
<td>eating</td>
<td></td>
<td>Washing dishes</td>
<td>Listening to music</td>
</tr>
<tr>
<td>8:00 PM</td>
<td>Reading</td>
<td></td>
<td>Taking a walk</td>
<td></td>
</tr>
<tr>
<td>Bed time</td>
<td>9:00 PM</td>
<td>Take a bath</td>
<td>Making the bed</td>
<td>Sleeping</td>
</tr>
<tr>
<td></td>
<td>10:00 PM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>11:00 PM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>12:00 PM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1:00 AM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2:00 AM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3:00 AM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4:00 AM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5:00 AM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6:00 AM</td>
<td></td>
<td>Resting in bed</td>
<td>Resting in bed</td>
</tr>
</tbody>
</table>

If an activity is carried out less than 15 minutes just write down the minutes spent behind the name of activity in the box. If an activity is carried out over a long period (eg. sleeping) you can draw a continuous line in the rectangular boxes which follow until such a time when there is a change in activity. Please review the example that follows.

**Weekend day**  Date: 20 / 10/ 2001  □ SAT □ SUN

<table>
<thead>
<tr>
<th>Time (from 7:00 AM to 12:00 PM)</th>
<th>0-15 minutes</th>
<th>16-30 minutes</th>
<th>31-45 minutes</th>
<th>46-60 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:00 AM</td>
<td>Resting in bed</td>
<td>Making the bed 5’</td>
<td>Take a shower</td>
<td>Getting dressed</td>
</tr>
<tr>
<td>8:00 AM</td>
<td>eating</td>
<td>Quick walking</td>
<td></td>
<td>Listening in class</td>
</tr>
<tr>
<td>9:00 AM</td>
<td></td>
<td></td>
<td></td>
<td>Reading</td>
</tr>
<tr>
<td>10:00 AM</td>
<td>writing</td>
<td></td>
<td>eating</td>
<td>Writing by hand</td>
</tr>
</tbody>
</table>
### THREE-DAY ACTIVITY DIARY

You are now ready to start the activity diary by filling the date first. The research team will be available in school for consulting and explanation of questionnaires.

- Please put completed activity diary together with other parts of questionnaire except for Part One into the enclosed envelop and return the sealed envelop to your school teacher.
- Please bring the Part One when you are asked to measure your height and weight by the research team.

**WEEK DAYS**

**Day 1**  
Date: _____ / ______ / ______  _MON_ _TUE_ _WED_ _THU_ _FRI_  

<table>
<thead>
<tr>
<th>Time</th>
<th>0-15 minutes</th>
<th>16-30 minutes</th>
<th>31-45 minutes</th>
<th>46-60 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:00 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8:00 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9:00 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:00 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11:00 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please follow the segments to recall your all activities in the day.

1. wake-up
2. school's in
3. recess
4. school's out
5. bed time

**Continue Day 1**

<table>
<thead>
<tr>
<th>Time</th>
<th>0-15 minutes</th>
<th>16-30 minutes</th>
<th>31-45 minutes</th>
<th>46-60 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12:00 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:00 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2:00 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3:00 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4:00 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5:00 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6:00 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### WEEK DAYS

**Day 2**  
Date: __/__/____  
MON  TUE  WED  THU  FRI

<table>
<thead>
<tr>
<th>Time</th>
<th>0-15 minutes</th>
<th>16-30 minutes</th>
<th>31-45 minutes</th>
<th>46-60 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:00 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8:00 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9:00 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:00 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11:00 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please follow the segments to recall your all activities in the day:

1. wake-up
2. school's in
3. recess
4. school's out
5. bed time

---

**Continue Day 2**

<table>
<thead>
<tr>
<th>Time</th>
<th>0-15 minutes</th>
<th>16-30 minutes</th>
<th>31-45 minutes</th>
<th>46-60 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12:00 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:00 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2:00 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3:00 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4:00 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5:00 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6:00 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Please follow the segments to recall your all activities in the day:

<table>
<thead>
<tr>
<th>Time</th>
<th>0-15 minutes</th>
<th>16-30 minutes</th>
<th>31-45 minutes</th>
<th>46-60 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:00 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8:00 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9:00 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:00 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11:00 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Morning  
2. Afternoon  
3. Evening  
4. Night

- Please put completed activity diary together with other parts of questionnaire except for Part One into the enclosed envelop and return the sealed envelop to your school teacher.

- Please bring the Part One when you are asked to measure your height and weight by the research team.

Please try to return the completed questionnaire within 5 days!

Thank you for your time and effort.
APPENDIX B: QUESTIONNAIRES USED IN PILOT STUDY

Code__________Name_________ (optional)

Day 1 (school days) activity diary

SECTION THREE  Three-day activity diary

INSTRUCTIONS

This questionnaire asks you to record all activities you performed in 24 hours a day, you need to keep the activity diary writing in three days (two schooldays and one weekend day). Please remember: record the details (including name and duration) of every activity you performed as long as you can. Followings are some examples for you.

Example one:

activity diary after getting up at 7:00am in the morning

<table>
<thead>
<tr>
<th>7:00am morning</th>
<th>7:00 to 7:15</th>
<th>7:15 to 7:30</th>
<th>7:30 to 7:45</th>
<th>7:45 to 8:00</th>
</tr>
</thead>
<tbody>
<tr>
<td>activity mins</td>
<td>activity mins</td>
<td>activity mins</td>
<td>activity mins</td>
<td></td>
</tr>
<tr>
<td>In toilet 5</td>
<td>breakfast 5</td>
<td>Brush teeth 5</td>
<td>Walk to school 5</td>
<td></td>
</tr>
<tr>
<td>shower 5</td>
<td>breakfast 5</td>
<td>Listen music 5</td>
<td>Walk to school 5</td>
<td></td>
</tr>
<tr>
<td>Dress up 5</td>
<td>breakfast 5</td>
<td>Listen music 5</td>
<td>Walk to school 5</td>
<td></td>
</tr>
</tbody>
</table>

Please DO NOT just write" go to school". You must mention “go to school" either by car, or bus or walking or running etc.

Example two:

<table>
<thead>
<tr>
<th>11:00am morning</th>
<th>11:00 to 11:15</th>
<th>11:15 to 11:30</th>
<th>11:30 to 11:45</th>
<th>11:45 to 12:00pm</th>
</tr>
</thead>
<tbody>
<tr>
<td>activity mins</td>
<td>activity mins</td>
<td>activity mins</td>
<td>activity mins</td>
<td></td>
</tr>
<tr>
<td>Eating &amp;talking 5</td>
<td>Play soccer 5</td>
<td>Play soccer 5</td>
<td>Sitting quietly 5</td>
<td></td>
</tr>
<tr>
<td>Eating &amp;talking 5</td>
<td>Play soccer 5</td>
<td>Play soccer 5</td>
<td>Sitting quietly 5</td>
<td></td>
</tr>
<tr>
<td>Eating &amp;talking 5</td>
<td>Play soccer 5</td>
<td>Play soccer 5</td>
<td>reading 5</td>
<td></td>
</tr>
</tbody>
</table>

Example three:

<table>
<thead>
<tr>
<th>3:00pm afternoon</th>
<th>3:00 to 3:15</th>
<th>3:15 to 3:30</th>
<th>3:30 to 3:45</th>
<th>3:45 to 4:00pm</th>
</tr>
</thead>
<tbody>
<tr>
<td>activity mins</td>
<td>activity mins</td>
<td>activity mins</td>
<td>activity mins</td>
<td></td>
</tr>
</tbody>
</table>

194
We recommend you take a few minutes to write the school day activity diary *before* leave for school, at lunch time, *before* leave for home from school and *before* go to bed, and write the weekend day activity diary *after* breakfast, *after* lunch, *after* diner and *before* go to bed.

You are now ready to start the activity diary by filling the date first.
<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Mins</th>
<th>Activity</th>
<th>Mins</th>
<th>Activity</th>
<th>Mins</th>
<th>Activity</th>
<th>Mins</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00am morning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:00am morning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11:00am morning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12:00pm afternoon</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:00pm afternoon</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2:00pm afternoon</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3:00pm afternoon</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4:00pm afternoon</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Day 1 activity diary continued

#### Code_____

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Mins</th>
<th>Activity</th>
<th>Mins</th>
<th>Activity</th>
<th>Mins</th>
<th>Activity</th>
<th>Mins</th>
</tr>
</thead>
<tbody>
<tr>
<td>5:00pm afternoon</td>
<td>5:00 to 5:15</td>
<td></td>
<td>5:15 to 5:30</td>
<td></td>
<td>5:30 to 5:45</td>
<td></td>
<td>5:45 to 6:00</td>
<td></td>
</tr>
<tr>
<td>5:00pm evening</td>
<td>6:00 to 6:15</td>
<td></td>
<td>6:15 to 6:30</td>
<td></td>
<td>6:30 to 6:45</td>
<td></td>
<td>6:45 to 7:00</td>
<td></td>
</tr>
<tr>
<td>6:00pm evening</td>
<td>7:00 to 7:15</td>
<td></td>
<td>7:15 to 7:30</td>
<td></td>
<td>7:30 to 7:45</td>
<td></td>
<td>7:45 to 8:00</td>
<td></td>
</tr>
<tr>
<td>7:00pm evening</td>
<td>8:00 to 8:15</td>
<td></td>
<td>8:15 to 8:30</td>
<td></td>
<td>8:30 to 8:45</td>
<td></td>
<td>8:45 to 9:00</td>
<td></td>
</tr>
<tr>
<td>8:00pm evening</td>
<td>9:00 to 9:15</td>
<td></td>
<td>9:15 to 9:30</td>
<td></td>
<td>9:30 to 9:45</td>
<td></td>
<td>9:45 to 10:00</td>
<td></td>
</tr>
<tr>
<td>9:00pm evening</td>
<td>10:00 to 10:15</td>
<td></td>
<td>10:15 to 10:30</td>
<td></td>
<td>10:30 to 10:45</td>
<td></td>
<td>10:45 to 11:00</td>
<td></td>
</tr>
<tr>
<td>10:00pm evening</td>
<td>11:00 to 11:15</td>
<td></td>
<td>11:15 to 11:30</td>
<td></td>
<td>11:30 to 11:45</td>
<td></td>
<td>11:45 to 12:00</td>
<td></td>
</tr>
<tr>
<td>11:00pm evening</td>
<td>12:00 to 12:15</td>
<td></td>
<td>12:15 to 12:30</td>
<td></td>
<td>12:30 to 12:45</td>
<td></td>
<td>12:45 to 1:00am</td>
<td></td>
</tr>
<tr>
<td>12:00am morning</td>
<td>1:00 to 1:15</td>
<td></td>
<td>1:15 to 1:30</td>
<td></td>
<td>1:30 to 1:45</td>
<td></td>
<td>1:45 to 2:00</td>
<td></td>
</tr>
<tr>
<td>1:00am morning</td>
<td>2:00 to 2:15</td>
<td></td>
<td>2:15 to 2:30</td>
<td></td>
<td>2:30 to 2:45</td>
<td></td>
<td>2:45 to 3:00</td>
<td></td>
</tr>
<tr>
<td>2:00am morning</td>
<td>3:00 to 3:15</td>
<td></td>
<td>3:15 to 3:30</td>
<td></td>
<td>3:30 to 3:45</td>
<td></td>
<td>3:45 to 4:00</td>
<td></td>
</tr>
<tr>
<td>3:00am morning</td>
<td>4:00 to 4:15</td>
<td></td>
<td>4:15 to 4:30</td>
<td></td>
<td>4:30 to 4:45</td>
<td></td>
<td>4:45 to 5:00</td>
<td></td>
</tr>
<tr>
<td>4:00am morning</td>
<td>4:00 to 4:15</td>
<td></td>
<td>4:15 to 4:30</td>
<td></td>
<td>4:30 to 4:45</td>
<td></td>
<td>4:45 to 5:00</td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>5:00 to 5:15</td>
<td>5:15 to 5:30</td>
<td>5:30 to 5:45</td>
<td>5:45 to 6:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>--------------</td>
<td>--------------</td>
<td>--------------</td>
<td>--------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>activity</td>
<td>mins</td>
<td>activity</td>
<td>mins</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5:00am</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>morning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6:00am</td>
<td>6:00 to 6:15</td>
<td>6:15 to 6:30</td>
<td>6:30 to 6:45</td>
<td>6:45 to 7:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>morning</td>
<td>activity</td>
<td>mins</td>
<td>activity</td>
<td>mins</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7:00am</td>
<td>7:00 to 7:15</td>
<td>7:15 to 7:30</td>
<td>7:30 to 7:45</td>
<td>7:45 to 8:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>morning</td>
<td>activity</td>
<td>mins</td>
<td>activity</td>
<td>mins</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8:00am</td>
<td>8:00 to 8:15</td>
<td>8:15 to 8:30</td>
<td>8:30 to 8:45</td>
<td>8:45 to 9:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>morning</td>
<td>activity</td>
<td>mins</td>
<td>activity</td>
<td>mins</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Pedometer study instruction

Pedometer study also aims to measure your daily physical activity. You are invited to continue wearing the pedometers for 3-4 days.

1. Please wear the pedometer all day until you go to bed. The next morning you should put the pedometer back on the same position and wear it until you get to school. The research team will reset the pedometer in every morning in the school and ask a couple of questions regarding using the pedometer.

2. If for any reason the pedometer might get wet (for example, whilst swimming or having a bath or shower), please take the pedometer off and put it back on after the activity.

3. The pedometer should be worn on the right side of the waist with pedometer positioned in line with the right knee and attached to the waistband of pants or short.

4. Please do not open the pedometer and participate in your usual activities.
Daily pedometer survey

Code______        Name ______________     Date  _________             Pedometer number_______

1. How did you get to school ( circle one)

☐ Walk       ☐ Car
☐ Ride       ☐ Other ( please name the other way that you got to school)
☐ Bus

2. Did you do any the following activities yesterday? ( check all the activities you did yesterday)

☐ Play an after school sport       ☐ Go swimming
☐ Ride your bike
☐ Other physical activity ( please name the activity
☐ Roller blade

How long was the activity ________________?

3. Did you take the pedometer off before going to bed?

☐ Yes       ☐ No

4. Did you put the pedometer on when you got dressed this morning?

☐ Yes       ☐ No

5. Did you wear the pedometer the whole time you were awake?

☐ Yes       ☐ No

If not, how long were you not wearing it? ________________

Why? ________________
APPENDIX C: INFORMATION SHEET AND CONSENT FORMS
(QUT LETTER HEAD)
The investigation of body image perceptions, weight-control practices and physical activity levels of children and parents in West End State School

INFORMATION FOR PARENT AND CHILD

Studies would indicate that Australian children have been getting fatter in the last decade, however the risk factors contributing to this situation have not been quantified. There are few reports in the literature which explore the relationship between overweight or obesity and physical activity in children from multicultural or ethnic backgrounds. Furthermore, there may be an association between the parental obesity and children's obesity.

In this QUT Ph.D project study, you and your child will be invited to participate in completing questionnaires about family background, how the body is viewed and what weight-control practices are used. You as a parent are also asked some questions about daily physical activity level. Your child will be asked to write a three-day (two weekdays and one weekend day) physical activity diary. Meanwhile, your child will also be invited to have his/her height and weight measured and to record the number of steps taken after 24 hours on three or four consecutive days by wearing a pedometer.

The self-administered questionnaire will take you appropriately 20 minutes. Your child will be supported by the project team at school to help with the completion of questionnaire. Your child’s height and weight will be measured in school by the project team. The pedometer is light and portable and will not hinder or disrupt normal activity. Your child will be given instructions on how to use the pedometer and how it can be removed.

Participation in this project will provide schools with feedback about the status of health and well being of their pupils. Appropriate nutrition advice and physical activity projects and resources will be provided to teachers. If you would like personal feedback information, please feel free to let us know.

Participation in this study is voluntary and subject to your consent. You are free to withdraw from the study without comment or penalty.

To ensure confidentiality of your records, all information will be coded so that they will remain anonymous. Any reports that will be written as a result of this study will also ensure confidentiality of your information.

Each family that agrees to participate in the study will receive a $1 Scratch-It ticket as thankyou with the questionnaires. The children and parents who return completed questionnaires will automatically enter into a draw to win a General Admission ticket to Seaworld (5 prizes for parents and 5 for children). The research code in the questionnaire will be used as the raffle ticket number. Winners will be notified within a month. In addition, each child will be issued a certificate of participation at the end of the project.
If you agree to participate in the study, could you please complete the consent form attached and return it to school before **26th April**.
If you wish to discuss any aspects of this study, please feel free to contact Zaimin Wang on 3864 9756 or my supervisor, A/Prof. Carla Patterson on 3864 5795. You may also contact the Secretary, University of Human Research Ethics Committee on 3864 2902 if you wish to raise any concerns about the ethical conduct of this research.

Sincerely,

Zaimin Wang
Project Officer
Parental consent form for child's participation

Code ______________

1. I have read the information sheet and I understand the nature and the purpose of the QUT Ph.D research project

Please tick the response following

- I agree to participate in the study
  _______ Yes _________ No
- I give permission for my child's participation in the study
  _______ Yes _________ No

2. I understand that my child can withdraw from the study at any time without comment

3. I understand the information collected will not be used for commercial purpose

4. I confirm that I am over 18 years of age

Name of child ______ First name _______ Family name Grade __6__7

Name of parent or guardian _________ First name _______ family name

Relationship to child ____________

Signature of parent or guardian ___________ Date __________

********************************************************************

Project title: investigation of body image perceptions, weight-control practices and physical activity levels of children and parents at West End State School

Investigator: Zaimin Wang, BMed, MMed and MPS FoodNutri
  Ph.D student, School of Public Health
  Queensland University of Technology

Supervisors: Carla Patterson, Ph.D  Andrew Hills, Ph.D
  Associate Professor  Associate Professor
  School of Public Health  School of Human Movement

Studies
  QUT  QUT
APPENDIX E. PARENTAL QUESTIONNAIRE

Code __________

The investigation of parental body image perceptions weight-control practices and physical activity

April 2002
Questionnaires on the investigation of parental body image perceptions, weight-control practices and physical activity level

The questionnaires aim to investigate a variety of attitudes and behaviour about your body image and weight-control practices as well as physical activity levels. It includes three sections.

- **SECTION ONE** "DEMOGRAPHIC DATA"
  It is about your age, gender, occupation and family background.

- **SECTION TWO** "BODY IMAGE PERCEPTIONS, WEIGHT-CONTROL PRACTICES"

- **SECTION THREE** "SELF-REPORTED PHYSICAL ACTIVITY LEVEL",
  Please answer **ALL** questions.

Please remember that

- **THERE ARE NO RIGHT OR WRONG ANSWERS SO TRY TO BE AS ACCURATE AND HONEST AS POSSIBLE**

- **RESULTS ARE STRICTLY CONFIDENTIAL**

- **IT IS IMPORTANT THAT YOU ANSWER ALL QUESTIONS**

- **YOU ARE ABLE TO WITHDRAW FROM THE STUDY AT ANY TIME IF YOU NO LONGER TO PARTICIPATE**

Please try to answer all questions required within **10 days**. When you have finished, please place it into the stamped reply envelop supplied and mail it to us.

Thank you for your time and effort.

School of Public Health, School of Human Movement Studies
Queensland University of Technology
SECTION ONE    DEMOGRAPHIC DATA

The following questions are about your gender, age, occupation and family background

1.1. Gender: ___Male ___Female

1.2. The relationship with the participating children in the survey
   _____ Father/stepfather _______ mother/stepmother _________ others(specify)

1.3. Date of Birth: ___ / ___ / 19___

1.4. Where were you born in?
   _______Australia _________ outside Australia _________ don't know

1.5. If you were born outside Australia,
   A. Please specifies which country you were born in?
      ____________________________________________
   B. How long have you been living in Australia
      _________ 1-2 years of residence
      _________ 3-4 years of residence
      _________ 5-9 years of residence
      _________ 10- 14 years
      _________ 15- 19 years
      _________ 20 years or more of residence

1.6. Do you speak a language other than English at home? _____ Yes _____ No
   If yes, what is the language?__________

1.7. How do you identify your ethnic or cultural background?
   _______ English speaking background _______ Non-English speaking background
   ____ don't know
SECTION TWO  BODY IMAGE, WEIGHT-CONTROL ATTITUDE AND BEHAVIOUR

2.1. What is your HEIGHT (without shoes)?
_____ centimetres    or    _____ ft/inches

2.2. What is your WEIGHT (without clothes or shoes)?
_____ kilograms   or   _____ lb/stones

2.3. In your opinion, would you describe yourself as: (tick one)

1___ very underweight
2___ underweight
3___ average
4___ overweight
5___ very overweight

2.4. Do you want to LOSE weight?               ___Yes___No  ___ Unknown

Why? _______________________________

2.5. Have you ever tried to LOSE weight?  ___Yes___No (if NO please go to 2.7)

If YES, how old were you when you first tried to LOSE weight?  ___

2.6. If you have ever tied to LOSE weight please tick the methods you have used to (multiple tick)

_____ Eating smaller meals
_____ Skipping (missing) meals
_____ Eating special diets
_____ Fasting (not eating all day)
_____ Exercising
Code_________

___ Counting the energy content of foods
___ Drinking less
___ Vomiting
___ Diet pills
___ Laxatives
___ Diuretics (water pills)

Other methods_____________________________________________________

2.7. Do you want to GAIN weight? ___Yes___No ___Unknown

Why? _________________________________

2.8. Have you ever tried to GAIN weight? ___Yes___No ( if NO please go to Section 3)

If YES, how old were you when you first tried to GAIN weight? ___

2.9. If you have ever tried to GAIN weight please tick the method(s) you have used (multiple tick)

___ Eating larger meals
___ Eating extra meals
___ Weight training
___ Liquid supplements
___ Food supplements
___ Special diets
___ Counting the energy content of foods
___ Exercising less
___ Anabolic steroids

Other methods_____________________________________________________

209
SECTION THREE  SELF-REPORTED PHYSICAL ACTIVITY LEVEL

The questions 3.1 to 3.8 are about the physical activity you did in last week

3.1. In the LAST WEEK how many times have you walked continuously, for at least 10 minutes, for recreation/exercise or to get from places? ______________

3.2. What do you estimate the total time (minutes or hours) that you spent walking in this way in the LAST WEEK? ______________

3.3. In the LAST WEEK how many times did you do any vigorous gardening or heavy work around the yard, which made you breathe harder or puff and pant? ______

3.4. What do you estimate the total time (minutes or hours) that you spent doing vigorous gardening or heavy work around the yard in the LAST WEEK? ______

The questions 3.5 and 3.6 EXCLUDE household or gardening or yardwork

3.5. In the LAST WEEK, how many times did you do any vigorous physical activity, which made you breathe harder or puff and pant? (eg. jogging, cycling, aerobics, competitive tennis, etc) __________

3.6. What do you estimate was the total time that you spent doing this vigorous physical activity in the LAST WEEK? ______________

The questions 3.7 and 3.8 EXCLUDE household or gardening or yardwork

3.7 In the LAST WEEK how many times did you do any other more moderate physical activity that you haven't already mentioned? (eg. gentle swimming, social tennis, golf, etc) __________

3.8 What do you estimate the total time (minutes or hours) that you spent doing these activities in the LAST WEEK? __________
The questions 3.9 to 3.11 are about your **WEEKLY** level of activity in the **LAST SIX MONTHS**

**Code**

3.9. On average, in the LAST SIX MONTHS how much time ( minutes or hours) did you spend each week walking for recreation /exercise or to get to or from places? (THIS IS WALKING CONTINUOUSLY FOR AT LEAST 10 MINUTES)_______

Question **3.10 EXCLUDES** household or gardening or yardwork

3.10. On average, in the LAST SIX MONTHS how much time ( minutes or hours) did you spend each week doing vigorous physical activity which made you breathe harder or puff and pant? (Eg. jogging, cycling, aerobics, competitive tennis, etc)_______

Question **3.11 EXCLUDES** household or gardening or yardwork

3.11. On average, in the LAST SIX MONTHS how much time ( minutes or hours) did you spend each week doing any other more moderate physical activity that you haven't already mentioned? (Eg. gentle swimming, social tennis, golf, etc)_______

**************************************************************************

Please try to return the completed questionnaire within **10 days**!

*Thank you for your time and effort*
REFERENCES


224


