Individual, behavioural and environmental pathways to adolescent obesity

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Chapter Six
Summary and Conclusions

This final chapter revisits the major research questions posed in Chapter One and summarises the key findings. Directions for future research are discussed, along with the practical implications of these results.

The over-arching research question for this study was:

**How do individual, behavioural and environmental factors during childhood contribute to weight status at adolescence?**

This study has shown, within the constraints of available variables that complex interrelationships exist between individual, behavioural and environmental factors. Their relative importance to maintaining healthy weight from birth through to early adolescence varies. Healthy weight maintenance is a complex balancing act maximising positive and minimising negative influences, and an individual’s ability (genetic, psychological and behavioural) to be resilient to the impact of negative influences.

Evidence from this study supports the complex, reciprocal interactions occurring over time and among obesogenic factors as per the Bandura (2001) model of Social Cognitive Theory. For example self concept results depict important relationships between motor competence, perceived benefits and barriers to physical activity; and actual physical activity participation. Support is provided for the perspective that human learning occurs through modelling processes and observing others (Lindzey et al., 1978), as shown by the effect of parental and peer influences. Differences in behaviours between individuals, and between weight status groups,
demonstrate the complex interactions of human behaviour involving individual thoughts and actions, beliefs and competencies, in the context of social influences and structures (Davis, 2006). Lastly, the exploratory SEM models concur with Bandura’s (2001) overall social cognitive model. BMI was shown to be affected by both direct and indirect effects, among and between factors, which change and evolve over time and with age.

The two main over-arching findings were:

- Individual, behavioural and environmental factors affect adolescent weight status in positive and negative ways. These effects are cumulative over time and vary with gender, age, and weight status.
- Individual, behavioural and environmental factors operate in both direct and indirect ways to influence BMI. The strength of these associations changes over time and varies with age and gender.

Several sub questions were explored during the course of this study and are now discussed, providing further support to these two key findings.

What is the relative contribution of individual, behavioural and environmental factors to weight status before birth to adolescence?

Over the life course, the influence of individual, behavioural and environmental factors is ever changing. Prenatally, the mother’s eating and smoking behaviour all have a significant impact on the gestational age, weight and health of the child at birth. In the first year after birth, early feeding choices are a significant and dominant predictor of weight and their influence remains until at least 14 years (Chivers et al., 2010). Developmental and coordination progress is critical through early childhood, and contributes to physical activity behaviours and self concepts in later childhood and adolescence. At puberty, the child’s body is changing dramatically both physically and emotionally.
Key determinants of adolescent obesity identified in this study were:

- Prenatal environment;
- Early feeding choices;
- Motor development and abilities;
- Physical activity behaviours;
- Screen time viewing patterns;
- Attitudes towards physical activity participation; and
- Mother’s BMI.

What is the relative contribution of individual, behavioural and environmental factors in a longitudinal model of BMI?

Longitudinal examinations using the LMM demonstrated that individual, behavioural and environmental factors had both positive and negative effects on BMI, sometimes specific to gender and weight status at 14 years (Chivers et al., 2009). This latter finding lends support to the notion of an epigenetic mechanism with obesity (Campión et al., 2009). For example adolescents who were classified obese at age 14 years and as a toddler were reported to be *not like their peers* in locomotor skills had higher BMI. For the overweight group, both motor competence and parenting style were more important. Overall, the more negative the influences the higher the BMI, that is, these negative influences were additive. This cumulative effect on BMI change has been suggested by others (Hesketh, Carlin, Wake, & Crawford, 2009).

The key findings were:

- BMI pathways differ statistically between normal weight, overweight and obese adolescents from three years.
- Individual, behavioural and environmental factors affect BMI in a cumulative manner, dependent upon gender, age and weight status.
The early childhood years were shown to be critical periods for the establishment of healthy weight related behaviours. The relationship between maternal smoking and birth weight highlighted the importance of the intrauterine environment to eventual adolescent weight status. In the toddler years the timing of, and BMI at adiposity rebound, early infant feeding patterns, developmental progress, and activity behaviours were associated with later obesity, as well as precursors for later childhood behaviours. Age 6 years in particular was identified as a critical turning point for behavioural patterns, and the point at which more data were available concerning physical activity behaviours. Life stress variables were also important at age 6 years. Also, screen time was critical in the establishment of early physical activity behaviours at age 6 years. This finding provides support to current Australian policy discussions that reducing screen time in young children is a significant health and well being issue (Centre for Community Child Health, 2009). However, even more concerning, was that the obese group was already on a trajectory to unhealthy weight as early as age 3 years, as shown by the BMI LMM and also by adiposity rebound investigations (Chivers et al., 2009).

Not surprisingly, gender differences were shown repeatedly across variables, and were generally consistent with previous literature. Notably, the effect of obesogenic factors worked in different ways for males and females, as well as changed over time. Generally, females were more influenced by social perspectives (e.g. peer support), while males were influenced more by performance (e.g. athletic competence). Screen time patterns were similar only until age 10 years, then at 14 years males spent significantly more time involved in screen activities than females. Physical activity behaviours and levels were different with males being more active, at higher intensities and having more positive attitudes. The changes with puberty
were also notably different, with females being further advanced in pubertal
development compared to males at age 14 years.

In respect to obesity, some factors were more important for one gender. For
example, the LMM identified interactions with gender for language, organised sport
and physical appearance. Their BMI trajectories also differed, with a crossover
point between 8 and 10 years, after which females’ BMI, on average, was higher
than males (Chivers et al., 2009). Exploratory SEM models also demonstrated
gender differences in pathways to weight status. For example the pathway from
income to screen time was not significant for females but significant for males at 14
years.

Key findings included:

- Scores, ratings or test results were different between males and females,
  with these differences were usually consistent across weight status groups;
- Females were influenced more by social perspectives of obesogenic factors;
- Males were influenced more by performance perspectives of obesogenic
  factors;
- The influence of screen time was more important for males at adolescence;
and
- The influence of puberty on obesogenic factors began earlier for females.

How do the interrelationships between individual, behavioural and environmental
factors affect BMI?

Valuable insights were gained from exploratory SEM modelling of the complex
interrelationships between individual, behavioural and environmental factors, in
the pathways to BMI. In early childhood (age 6 and 8 years), screen time was an
important predictor of BMI, but by 10 years the interrelationships were more
complex. Motor competency, aerobic fitness and physical activity were highly
interrelated and together predictive both directly and indirectly of BMI. Although
in the early years, motor competency was less important in predicting weight status, these early levels were important in the tracking of motor competence at 14 years (Hands et al., 2010b) where they played an important role in the age 14 year model of BMI. Overall, motor competence, as expressed in early childhood development, may be an integral part of facilitating a healthier lifestyle later on. These exploratory processes also identified factors not influential in the overall model. Diet, the school environment, self concept, and valuing of physical activity all had no role in the overall model, although these factors were the result of influence of factors within the model.

The key findings were:

- Interrelationships among individual, behavioural and environmental factors are complex and dynamic.
- Individual, behavioural and environmental factors operate in both direct and indirect ways to influence BMI at each follow-up age.
- Gender differences influence factors and the strength of pathways to BMI.

Limitations

The limitations to this research have been outlined specifically in Chapter One and addressed in the discussion Chapter Five, with a brief summary outlined here. The data for this study was drawn from the Raine Study up to the 14 year collection point and inherits many of the limitations of the data collection process. This cohort may not be truely representative of the metropolitan Western Australian population as it was not drawn randomly. More specific to this research was the restriction of variables to identified obesogenic factors; use of BMI as a proxy measure of adiposity, along with use of IOTF cut-points for weight status; non-standardized observational data; mixture of caregiver and adolescent reporting; changes in how information was collected on variables that tracked over time; limitations in how variable information was originally recorded (e.g. diet); restricted data collection points with sampling frequency low, especially in respect to capturing adiposity rebound; and the exploratory rather than confirmatory
processes used in SEM. Overall however, these limitations are well recognised in studies of obesity and are not considered to adversely affect the generalisability or significance of the results.

**Strengths**

One of the key strengths of this study was the relatively large sample and longitudinal nature of the research design spanning from birth to 14 years. It provided an opportunity to examine early pathways of weight status, and in particular an examination of the timing of the adiposity rebound in an Australian cohort. The large sample, even with attrition, provided for more accurate distinctions to be made among gender and weight categories (Chivers et al., 2009).

The unique mixed modelling statistics used to model trajectories of BMI accounted for correlated errors normally associated with repeated, continuous and correlated observations. The mixed model permitted the evaluation of age as a covariate, rather than predetermined averaged time points (survey waves), which increased the validity of the model (Chivers et al., 2009).

This modelling approach provided an opportunity to test factors that might drive accelerated and early increases in BMI. Early pathways of weight status were examined, in particular the possible influence of obesogenic factors. Specifically clarifying the influence of early infant feeding on adolescent BMI and its relationship with adiposity rebound demonstrated the value of such statistical testing (Chivers et al., 2010).

The use of exploratory SEM highlighted the importance of early childhood in the development of sedentary and physical activity behaviours (6 years), that track into adolescence, and play a concurrent role with adiposity (Hands et al., 2010b). Model development demonstrated complex interrelationships at ages 6, 8, 10 and 14 years and how these pathways and their influence changed. These models provide
hypothetical models that can now be tested with other data using confirmatory SEM techniques.

**Future Research**

The ongoing nature of the Raine Study means that currently another wave of data is available (age 18 years). This presents an ongoing opportunity to explore the current study’s findings and investigate whether these reported influences continue into early adulthood.

More specifically, based on the findings from this research, as well as identified gaps in knowledge (things that couldn’t be tested due to lack of data), three key areas for further research were identified. These include aspects related to the preschool years, parent BMI, and adolescent motivations.

**Preschool years.**

The preschool years require a more in depth analysis to ascertain key behavioural and environmental influences that may impact on concurrent and future obesogenic behaviours, including protective mechanisms. These may include:

- An investigation into differences in pre-school lifestyle behaviours, particularly for those children overweight and obese in early childhood.
- An investigation of behavioural differences between pre-school children in the home environment with their primary caregiver, in the home environment cared by relatives, or in community based day-care.
- An investigation on how parental behavioural mechanisms impact on their child’s physical activity, sedentary activity and lifestyle behaviours in these early years.
**Parent BMI.**  
The behavioural mechanisms in daily living associated with parent BMI, but particularly mother’s BMI warrant further investigation.

- An investigation of the differences between behavioural characteristics (physical activity, diet, BMI, attitudes and values) of mothers who smoked during pregnancy, compared to non-smokers, and their relationship to childhood overweight.
- An investigation of how parental behavioural mechanisms impact on their child’s physical activity, sedentary activity and lifestyle behaviours?
- An investigation on how parenting styles differ between healthy weight versus unhealthy weight parents?

**Self concept.**  
The development of self concept in the early years, the possible lag effects into adolescence and their relationship with future behaviours (e.g. activity participation, screen time patterns) requires further investigation, particularly differences between healthy weight and unhealthy weight.

- An investigation of external motivators for being active, and their role in obesity.
- An investigation into general motivational differences for exhibiting healthy behaviours (e.g. active, healthy diet), between healthy weight and overweight.
- An investigation into how self concept changes from early childhood into adolescence, with a specific focus on concurrent analysis of activity and sedentary behaviours and possible lag effects.
Conclusion

This study shows, within the constraints of available data and the 14 year time frame of the longitudinal investigation, the complex interrelationships between individual, behavioural and environmental factors, and their relative importance to maintaining healthy weight from birth through to early adolescence. Healthy weight maintenance is a complex balancing act between positive and negative influences, and an individual’s ability (genetic, psychological and behavioural) to be resilient to the impact of negative influences. Early childhood is identified as a critical time point for establishing key behaviours that influence weight status in adolescence.

This research demonstrates the complex and dynamic nature of obesity. It highlights that causation is multi-factorial with identifiable patterns for sub groups. As such, prevention and intervention policies and prevention programs need to be multi-faceted, and target gender and weight status groups differently. Clearly, the current concern for obesity rates among Australian children requires a focus on early pre-school behaviours, particularly at home, and in association with maternal behaviours.