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Individual, behavioural and environmental pathways to adolescent obesity.

Research Thesis

submitted for the degree

Doctor of Philosophy

Paola Teresa Chivers

School of Health Sciences

The University of Notre Dame, Australia

June 2010

Dedicated to the memory of my

Zia Grazia

Declaration of Authorship

This thesis is my own work and contains no material which has been accepted for the award of any degree or diploma in any other institution.

To the best of my knowledge, the thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

Paola Teresa Chivers

Abstract

The longitudinal investigations of the contributions of obesogenic variables to developmental pathways of adolescent obesity were examined. Key obesogenic variables were examined from the extensive database of the Western Australian Pregnancy Cohort (Raine) Study. The data set included variables collected in utero (18-20 weeks), at birth, and at ages 1, 2, 3, 6, 8, 10, and 14 years.

The key research question was: How do individual, behavioural and environmental factors in childhood contribute to weight status at early adolescence? Investigation of this key question examined how factors change over time and their respective influence on obesity, identified critical points in the timing of change, and gender differences.

The conceptual model was framed from an individual, behavioural and environmental perspective, based on Bandura's Social Cognitive Theory. Cross-sectional statistics described the sample and variables of interest. A longitudinal model of BMI from birth to 14 years using linear mixed modelling examined the influence of obesogenic variables on BMI over time and differences across weight status groups. Interrelationships between key variables and BMI at each follow-up and over time were investigated using exploratory structural equation modelling.

Some key findings were that adolescents who were overweight or obese at 14 years followed different BMI trajectories from birth, compared to those of normal weight. There was a difference between weight status groups in the timing of adiposity rebound ($p<.001$) and BMI at nadir ($p<.001$), as well as differences in influence of obesogenic factors. The obese group had the fastest increase of BMI over time ($p<.005$), while the rate of change was faster for females compared to males ($p<.001$). Interrelationships between physical activity and sedentary behaviours were shown and changed across models at age 6 years ($\chi 2$ (df=22) = 25.036 p=.295), age 8 years ($\chi 2$ (df=32) = 33.326 p=.403, age 10 years ($\chi 2$ (df=40) = 47.820 p=.185) and age 14 years ($\chi 2$ (df=57) = 59.487 p=.385).

This study showed, within the constraints of available obesogenic variables, the complex interrelationships between individual, behavioural and environmental factors, and their relative importance to obesity from birth through to early adolescence. Weight status is a complex balancing act between positive and negative influences, and an individual's ability (genetic, psychological and environmental) to be resilient to the impact of negative influences. Early childhood was identified as a critical time point for establishing key behaviours that influence later obesity.

Acknowledgements

This amazing journey would never have started without the enthusiasm and encouragement of my supervisors Professor Beth Hands and Professor Helen Parker. En route ... Professor Max Bulsara for everything statistical!

Special thanks to Beth, for being the LION in my corner! You are an inspiring, motivating and exceptional person ... and amazing Supervisor.

Thanks go to Dr. Dawne Larkin and Dr. Garth Kendall for their early critique of my PhD proposal and continued support, encouragement and wealth of expertise. Throughout my research program I have been fortunate to have many people assist and guide me in my endeavours for the love and passion of research. Special mention to: Jan Harmsen, librarian extraordinaire; Brady West – linear mixed models; Professor Paul Swank for his interest and expertise in linear mixed models and structural equation modelling; Dr. Emil Coman - SEM and AMOS; SEMNET; and Dr. Fleur McIntyre who provided support and showed me the way.

This research would not have been possible without the Raine Study. I am extremely grateful to all the families who took part in this study and the whole Raine Study team.

Thanks to my friends, for being interested in what I was doing, the sanity conversations, lunches, dinners and coffee. My brother Anthony and best friend Kayleen – thanks for always being there.

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Figure 1. Normal Q-Q plot of residuals for the final BMI linear mixed model, separated by gender and IOTF weight status groups. 383

Abbreviations

ABS	Australian Bureau of Statistics
AFEA	Australian Fitness Education Award
AFL	Australian Football League
BMI	body mass index
cm	centimetre
KEMH	King Edward Memorial Hospital for Women
kg	kilogram
kg/m^2	kilogram per metre squared
IMQ	Infant Monitoring Questionnaire
IOTF	International Obesity Task Force
LMM	linear mixed model
MAND	McCarron Assessment of Neuromuscular Development
mths	months
NW	normal weight (according to IOTF weight status categories)
OB	obese (according to IOTF weight status categories)
OW	overweight (according to IOTF weight status categories)
PWC170	Physical Work Capacity at heart rate of 170 beats per minute
SEIFA	Socioeconomic Index For Areas
SEM	structural equation model
SES	socioeconomic status
TV	television
VO_2 Max	maximum oxygen consumption
WHR	waist-hip ratio
WHtR	waist-height ratio
yrs	years

Statistical Notations

AIC	Akaike's Information Criterion
CFI	Comparative Fit Index
CI	confidence interval
M	mean
MAR	missing at random
n	number of cases (sub sample)
N	total number of cases (full sample)
p	probability
RMSEA	Root Mean Square Error of Approximation
SD	standard deviation
t	t-test
TLI	Tucker Lewis Index
$\chi 2$	chi-square
%	percentage

Glossary

Absolute aerobic fitness is the raw score for PWC 170 (American College of Sports Medicine, 2009)

Adiposity is a term used to describe the amount of associated fatness and is an excessive accumulation of lipids (*Stedman's Medical Dictionary*, 2006).

Adiposity rebound is the age at which BMI increases continuously from its lowest BMI value (nadir) (Rolland-Cachera, Deheeger, Bellisle, Sempe, Guilloud-Bataille, & Patois, 1984).

Body Mass Index (BMI) is a proxy indicator of fatness. It is a measure calculated by dividing a person's weight in kilograms by their height in metres squared (Cole, Bellizzi, Flegal, & Dietz, 2000).

$$BMI = \frac{X\ kg}{X\ m^2}$$

Epigenetic influence is any heritable influence on genes (Walley, Blakemore, & Froguel, 2006).

Height is a vertical measure of how tall a person is, measured in centimetres or metres (*Stedman's Medical Dictionary*, 2006).

Inactivity describes the non-participation in a given activity or activities (Hands, Parker, Glasson, Brinkman, & Read, 2004).

Intensity (activity) is the ranking of the intensity of activity (light, moderate or vigorous) based on self-report or a compendium of activity type classification (Hands et al., 2004).

Listwise is a method for handling missing data. Listwise deletion involves the removal of an entire case (individual) from the analysis if any single value is missing (SPSS for Windows, Rel.17.0.0. 2008; SPSS Inc., Chicago, IL)

Nadir (in respect to adiposity rebound) is the lowest BMI value (Rolland-Cachera et al., 1984).

Obese is the term ascribed to a person whose BMI is above a certain cut off point using the IOTF standards. These cut-offs are age adjusted for children up to age 18, but for adults obese refers to a BMI ≥30 kg/m^2 (Cole et al., 2000).

Obesogenic is the term used to describe factors that are associated causes with overweight or obese (Quinion, 2002).

Overweight is the term ascribed to a person whose BMI is above a certain cut off point, but below the obese cut off point using the IOTF standards. These cut-offs are age adjusted for children up to age 18, but for adults overweight refers to a BMI between 25-29.9 kg/m^2 (Cole et al., 2000).

Physical activity is any bodily movement produced by skeletal muscles that result in energy expenditure (Caspersen, Powell, & Christenson, 1985).

Physical Education describes school curriculum based physical activity sessions (Hands et al., 2004).

Physical fitness is a set of health or skill related attributes that can be measured by prescribed tests and relates to the ability to perform physical activity (Caspersen et al., 1985)

PWC 170 is a physical fitness test for cardiorespiratory fitness. It predicts the required workload for a heart-rate of 170 beats per minute (Caspersen et al., 1985)

Relative aerobic fitness is the raw score for PWC 170 adjusted for body weight (American College of Sports Medicine, 2009)

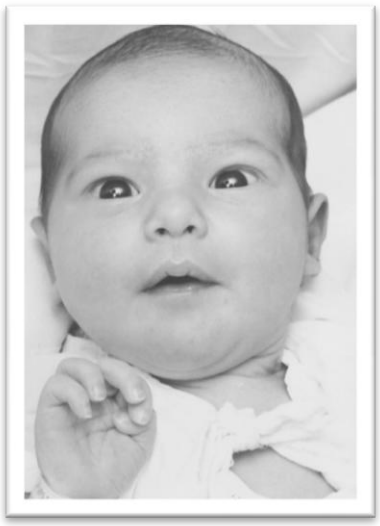
Sedentary activity is used to describe activities that require minimal energy expenditure such as screen based activities (Hands et al., 2004).

School Sport describes school curriculum based sport sessions (Hands et al., 2004).

Waist girth is a measure in centimetres of the circumference of a person's waist (measured in The Raine Study at the level of the umbilicus) and is an indicator of central adiposity (Hands et al., 2004).

Weight is a measure in kilograms of the mass of a person (*Stedman's Medical Dictionary*, 2006).

Weight status refers to the categories normal weight, overweight and obese which are based on the IOTF cut-points, age and gender adjusted equivalent of 18 kg/m^2 and 25 kg/m^2 at 18 years of age (Cole et al., 2000).



Birth

"Birth is the sudden opening of a window, through which you look out upon a stupendous prospect.

For what has happened? A miracle!

You have exchanged nothing for the possibility of everything."

Author unknown