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SEDENTARY BEHAVIOUR AND PHYSICAL ACTIVITY IN NEW ZEALAND CHILDREN

INTERVENTION AND MEASUREMENT

Louise Sherwyn Foley

A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy

University of Auckland, 2011.

.
Background: Increasing physical activity and decreasing sedentary behaviour is important for the prevention and treatment of childhood obesity. Interventions to decrease sedentary behaviour (primarily sedentary screen-time) in children have had success in reducing screen-time, increasing physical activity and improving body composition. Active video games, where players physically interact with on-screen images, are a promising intervention for reducing sedentary behaviour and increasing physical activity. However, there is a dearth of intervention research. Furthermore, research is limited by difficulties in accurately measuring these behaviours.

Aim: To examine new approaches for intervention in, and measurement of, sedentary behaviour and physical activity in New Zealand children.

Method: Two complementary studies were undertaken. The first was a large (n=322) randomised controlled trial that examined the effect of a 24 week active video games intervention on physical activity, sedentary behaviour and body composition in overweight and obese children. The second was a validation (n=32) of a self-report tool used to quantify daily energy expenditure, sedentary behaviour and physical activity in children. Doubly labelled water and accelerometry were used as the validation standards for energy expenditure and behaviour, respectively.

Results: The first study found a significant treatment effect for body mass index over 24 weeks (-0.24kg/m², 95% CI -0.44 to -0.05, p=0.02), favouring the intervention group. Overall levels of physical activity and sedentary behaviour did not change; however intervention participants reported playing more active video games (10.03 minutes, 95% CI 6.26 to 13.81, p<0.0001), and less sedentary video games (-9.39 minutes, 95% CI -19.38 to
than control. In the second study, the self-report tool indicated moderate validity for the assessment of total daily energy expenditure (rho=0.70, p<0.0001) and activity-related energy expenditure (rho=0.54, p=0.001) compared to the criterion standard of doubly labelled water. Compared to accelerometry, the self-report tool indicated moderate validity for the assessment of time spent in physical activity (rho=0.42, p=0.02) and weak validity for the assessment of time spent in sedentary behaviour (0.20, p=0.30).

Conclusion: Active video games may be useful to promote a healthy weight in overweight or obese children. The self-report tool may be used in future sedentary behaviour intervention research.
ACKNOWLEDGEMENTS

I wish to formally acknowledge and thank the following people for their contribution to this thesis.

Most importantly, I wish to extend my sincere thanks to my supervisors Dr Ralph Maddison and Associate Professor Raina Elley, for their support, expert knowledge and guidance. I am particularly indebted to my primary supervisor Dr Maddison for his availability to discuss questions and ideas, and for his detailed critique of my writing. Dr Maddison created an environment in which I was challenged and encouraged to grow as a scientist.

I would like to thank the investigators on the eGAME trial for their guidance in the design and interpretation of the study: Dr Ralph Maddison, Associate Professor Cliona Ni Mhurchu, Associate Professor Andrew Jull, Dr Yannan Jiang, Professor Harry Prapavessis, Professor Anthony Rodgers, Stephen Vander Hoorn, Dr Maea Hohepa and Dr David Schaaf. I would particularly like to acknowledge Dr Jiang for her assistance with statistical issues and her ability to simplify and explain complicated concepts. I also wish to acknowledge the eGAME trial research assistants for their help collecting data, which was an enormous undertaking: Vaughan Roberts, Midi Tsai, Karen Roberts, Lindsay Hill, Bridget Wadham, Alison McKinlay and Ofa Dewes.

I would like to thank the co-investigators on the PACMAN study: Dr Ralph Maddison, Professor Elaine Rush, Dr Timothy Olds, Dr Kate Ridley and Dr Yannan Jiang. All provided advice and guidance on their area of expertise. I would particularly like to acknowledge Professor Rush for her practical assistance in helping me to learn the doubly labelled water
Thanks also to the PACMAN research assistant Michelle Hull who assisted me with data collection.

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“The mind is not a vessel to be filled, but a fire to be ignited” - Plutarch
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CONTRIBUTION OF STUDY INVESTIGATORS

Dr Ralph Maddison and Professor Anthony Rodgers, who was replaced by Associate Professor Raina Elley early on during the candidacy, were the supervisors of this thesis. Under their guidance, the candidate sought funding for this PhD candidacy. Dr Ralph Maddison and Associate Professor Raina Elley read and provided advice on the structure and content of this thesis.

The candidate was primarily responsible for the design, selection of studies, synthesis of results and interpretation of the two systematic reviews and one narrative review contained within this thesis.

Dr Ralph Maddison was the primary investigator of the eGAME trial, recruited all co-investigators, and obtained funding for the study. He was responsible for the study design and oversight throughout, as well as gaining preliminary ethical approval for the study. Under the supervision of Dr Maddison, the candidate contributed to the design and interpretation of the eGAME trial findings. The candidate acted as the study manager and was responsible for finalising ethical approval, the development of the protocol, the development of all study materials and processes, the design and implementation of the recruitment strategy, data collection from participants, and the training and management of research assistants who assisted with data collection. The candidate contributed to manuscripts describing the eGAME trial protocol and results.

The eGAME trial co-investigators were Associate Professor Cliona Ni Mhurchu, Associate Professor Andrew Jull, Dr Yannan Jiang, Professor Harry Prapavessis, Professor Anthony Rodgers, Stephen Vander Hoorn, Dr Maea Hohepa and Dr David Schaaf. All co-investigators contributed to the design and interpretation of the eGAME trial findings,
and contributed to manuscripts describing the eGAME trial protocol and results. The study statisticians Dr Yannan Jiang and Stephen Vander Hoorn were responsible for developing the eGAME trial statistical analysis plan and conducting analyses.

The candidate was the primary investigator of the PACMAN study and obtained funding for the study, with the oversight of her primary supervisor, Dr Ralph Maddison. She was primarily responsible for design of the study and the interpretation of study findings. The candidate acted as the study manager and was responsible for gaining ethical approval, the development of the protocol, the development of all study materials and processes, the design and implementation of the recruitment strategy, data collection from participants and the training and management of a research assistant who assisted with data collection. The candidate was primarily responsible for a manuscript describing the PACMAN study results.

The PACMAN study co-investigators were Dr Ralph Maddison, Professor Elaine Rush, Dr Timothy Olds, Dr Kate Ridley and Dr Yannan Jiang. All co-investigators contributed to the design and interpretation of the PACMAN study findings, and contributed to a manuscript describing the study results. Dr Ralph Maddison provided general day-to-day oversight and advice. Professor Elaine Rush provided practical advice and guidance for use of the doubly labelled water technique. Dr Timothy Olds and Dr Kate Ridley are the authors of the tool that was tested in this validation study and hold the licence for its use. Dr Yannan Jiang assisted with data analysis, interpretation of the results and the generation of figures.
PUBLICATIONS AND CONFERENCE PRESENTATIONS

Publications


Maddison R; Foley L; Jiang Y; Ni Mhurchu C; Jull A; Rodgers A; Prapavessis, H; Vander Hoorn, S; Hohepa, M (2010). Electronic games to aid motivation to exercise: a randomized controlled trial. *Obesity Reviews, 11*(Suppl 1), pg 50.


Maddison, R; Foley, L; Ni Mhurchu, C; Jull, A; Jiang, Y; Prapavessis, H; Rodgers, A; Vander Hoorn, S; Hohepa, M; Schaaf, D. (2009). Feasibility, design and conduct of a pragmatic randomized controlled trial to reduce overweight and obesity in children: The Electronic Games to Aid Motivation to Exercise (eGAME) study. *BMC Public Health, 9*, pg 146.


Foley, L; Maddison, R; Rush, E; Olds, T; Ridley, K; Jiang, Y (submitted). Doubly labeled water validation of a computerized use-of-time recall. *Medicine & Science in Sports and Exercise.*
Conference presentations

Foley, L; Maddison, R; Rush, E; Olds, T; Ridley, K; Jiang, Y. Doubly labelled water validation of a computerised use-of-time recall for the measurement of energy expenditure in youth (accepted). June 2011. Annual Conference of the International Society of Behavioral Nutrition and Physical Activity, Melbourne, Australia. [Oral presentation].

Maddison R; Foley L; Jiang Y; Ni Mhurchu C; Jull A; Rodgers A; Prapavessis, H;

Foley, L; Maddison, R; Jiang, Y; Ni Mhurchu, C; Jull, A; Rodgers, A; Prapavessis, H;

Maddison, R; Foley, L; Jiang, Y; Ni Mhurchu, C; Jull, A; Rodgers, A; Prapavessis, H; Hohepa, M. Electronic games to aid motivation to exercise (eGAME): A randomized controlled trial. June 2010. Annual Conference of the International Society of Behavioral Nutrition and Physical Activity, Minneapolis, USA. [Oral presentation]

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<tbody>
<tr>
<td>3DPAR</td>
<td>Three Day Physical Activity Recall</td>
</tr>
<tr>
<td>ACSM</td>
<td>American College of Sports Medicine</td>
</tr>
<tr>
<td>AEE</td>
<td>Activity-related energy expenditure</td>
</tr>
<tr>
<td>AEE&lt;sub&gt;DLW&lt;/sub&gt;</td>
<td>Activity-related energy expenditure calculated from doubly labelled water</td>
</tr>
<tr>
<td>AEE&lt;sub&gt;MARCA&lt;/sub&gt;</td>
<td>Activity-related energy expenditure calculated from Multimedia Activity Recall for Children and Adolescents</td>
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<tr>
<td>BET</td>
<td>Behavioural Economics Theory</td>
</tr>
<tr>
<td>BIA</td>
<td>Bioelectrical impedance analysis</td>
</tr>
<tr>
<td>BMI</td>
<td>Body mass index</td>
</tr>
<tr>
<td>bpm</td>
<td>Beats per minute</td>
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<tr>
<td>CI</td>
<td>Confidence interval</td>
</tr>
<tr>
<td>cm</td>
<td>Centimetre</td>
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<tr>
<td>CO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>Carbon dioxide</td>
</tr>
<tr>
<td>DALY</td>
<td>Disability-adjusted life year</td>
</tr>
<tr>
<td>DLW</td>
<td>Doubly labelled water</td>
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<tr>
<td>eGAME</td>
<td>Electronic Games to Aid Motivation to Exercise Study</td>
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<tr>
<td>GEMS</td>
<td>Girls Health Enrichment Multi-site Study</td>
</tr>
<tr>
<td>H</td>
<td>Hydrogen</td>
</tr>
<tr>
<td>H&lt;sub&gt;2&lt;/sub&gt;O</td>
<td>Water</td>
</tr>
<tr>
<td>HR&lt;sub&gt;flex&lt;/sub&gt;</td>
<td>Flex heart rate</td>
</tr>
<tr>
<td>HR&lt;sub&gt;max&lt;/sub&gt;</td>
<td>Maximum heart rate</td>
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<tr>
<td>HRR</td>
<td>Heart rate reserve</td>
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<tr>
<td>ICC</td>
<td>Intra-class correlation coefficient</td>
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<td>IDEAA</td>
<td>Intelligent device for energy expenditure and activity</td>
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<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<tr>
<td>ITT</td>
<td>Intention-to-treat</td>
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<tr>
<td>J</td>
<td>Joule</td>
</tr>
<tr>
<td>kcal</td>
<td>Kilocalorie</td>
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<tr>
<td>kg</td>
<td>Kilogram</td>
</tr>
<tr>
<td>kJ</td>
<td>Kilojoule</td>
</tr>
<tr>
<td>LoA</td>
<td>Limits of Agreement</td>
</tr>
<tr>
<td>LOCF</td>
<td>Last observation carried forward</td>
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<tr>
<td>MARCA</td>
<td>Multimedia Activity Recall for Children and Adolescents</td>
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<tr>
<td>MET</td>
<td>Metabolic equivalent</td>
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<tr>
<td>m</td>
<td>Metre</td>
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<tr>
<td>mg</td>
<td>Milligram</td>
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<tr>
<td>MJ</td>
<td>Megajoule</td>
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<tr>
<td>ml</td>
<td>Millilitre</td>
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<tr>
<td>mm</td>
<td>Millimetre</td>
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<tr>
<td>mmHg</td>
<td>Millimetres of mercury</td>
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<tr>
<td>MVPA</td>
<td>Moderate-vigorous physical activity</td>
</tr>
<tr>
<td>MVPA&lt;sub&gt;ACC&lt;/sub&gt;</td>
<td>Moderate-vigorous physical activity calculated from accelerometry</td>
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<tr>
<td>MVPA&lt;sub&gt;MARCA&lt;/sub&gt;</td>
<td>Moderate-vigorous physical activity calculated from Multimedia Activity Recall for Children and Adolescents</td>
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<tr>
<td>NHMRC</td>
<td>National Health and Medical Research Council</td>
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<tr>
<td>NZ</td>
<td>New Zealand</td>
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<tr>
<td>O</td>
<td>Oxygen</td>
</tr>
<tr>
<td>OR</td>
<td>Odds ratio</td>
</tr>
<tr>
<td>p</td>
<td>Significance value</td>
</tr>
<tr>
<td>PACMAN</td>
<td>Physical Activity in Children: MARCA Validation Study</td>
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<tr>
<td>PAL</td>
<td>Physical Activity Level</td>
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<td>PAQ-C</td>
<td>Physical Activity Questionnaire for Children</td>
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<tr>
<td>PDPAR</td>
<td>Previous Day Physical Activity Recall</td>
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<tr>
<td>Abbreviation</td>
<td>Description</td>
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<td>--------------</td>
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<tr>
<td>RCT</td>
<td>Randomised controlled trial</td>
</tr>
<tr>
<td>rpm</td>
<td>Revolutions per minute</td>
</tr>
<tr>
<td>SAE</td>
<td>Serious Adverse Event</td>
</tr>
<tr>
<td>SAPAC</td>
<td>Self-Administered Physical Activity Checklist</td>
</tr>
<tr>
<td>SAS</td>
<td>Statistical Analysis System</td>
</tr>
<tr>
<td>SCCEE</td>
<td>Sony Computer Entertainment Europe</td>
</tr>
<tr>
<td>SCENZ</td>
<td>Sony Computer Entertainment New Zealand</td>
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<tr>
<td>SD</td>
<td>Standard deviation</td>
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<tr>
<td>SE</td>
<td>Standard error</td>
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<tr>
<td>SED_{ACC}</td>
<td>Sedentary behaviour calculated from accelerometry</td>
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<td>SED_{MARCA}</td>
<td>Sedentary behaviour calculated from Multimedia Activity Recall for Children and Adolescents</td>
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<td>SOFIT</td>
<td>System for Observing Fitness Instruction Time</td>
</tr>
<tr>
<td>SOPLAY</td>
<td>System for Observing Play and Leisure Activity in Youth</td>
</tr>
<tr>
<td>TEE</td>
<td>Total energy expenditure</td>
</tr>
<tr>
<td>TEE_{DLW}</td>
<td>Total energy expenditure calculated from doubly labelled water</td>
</tr>
<tr>
<td>TEE_{MARCA}</td>
<td>Total energy expenditure calculated from Multimedia Activity Recall for Children and Adolescents</td>
</tr>
<tr>
<td>TV</td>
<td>Television</td>
</tr>
<tr>
<td>UK</td>
<td>United Kingdom</td>
</tr>
<tr>
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<tr>
<td>USB</td>
<td>Universal Serial Bus</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
</tr>
<tr>
<td>VO\textsubscript{2}</td>
<td>Volume of oxygen consumption</td>
</tr>
<tr>
<td>VO\textsubscript{2,\text{max}}</td>
<td>Maximum volume of oxygen consumption</td>
</tr>
<tr>
<td>YRBS</td>
<td>Youth Risk Behaviour Surveillance Survey</td>
</tr>
<tr>
<td>zBMI</td>
<td>Standardised body mass index</td>
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