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SEDENTARY BEHAVIOUR AND PHYSICAL ACTIVITY IN NEW ZEALAND CHILDREN

INTERVENTION AND MEASUREMENT

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

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ABSTRACT

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/m^2 , 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

0.59; $p=0.07$) 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.

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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 Prapavassis, 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**; Ni Mhurchu, C; Jiang, Y; Jull, A; Prapavessis, H; Hohepa, M; Rodgers, A (2011). Effects of active video games on body composition: A randomized controlled trial. *American Journal of Clinical Nutrition*. doi: 10.3945/ajcn.110.009142.

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.

Foley, L; Maddison, R. (2010). Use of active video games to increase physical activity in children: A (virtual) reality? *Pediatric Exercise Science*, 22(1), pg 7-20.

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.

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Conference presentations

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Foley, L; Maddison, R; Jiang, Y; Ni Mhurchu, C; Jull, A; Rodgers, A; Prapavessis, H; Hohepa, M. Getting active with video games? 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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ABBREVIATIONS

3DPAR	Three Day Physical Activity Recall
ACSM	American College of Sports Medicine
AEE	Activity-related energy expenditure
AEE _{DLW}	Activity-related energy expenditure calculated from doubly labelled water
AEE _{MARCA}	Activity-related energy expenditure calculated from Multimedia Activity Recall for Children and Adolescents
BET	Behavioural Economics Theory
BIA	Bioelectrical impedance analysis
BMI	Body mass index
bpm	Beats per minute
CI	Confidence interval
cm	Centimetre
CO ₂	Carbon dioxide
DALY	Disability-adjusted life year
DLW	Doubly labelled water
eGAME	Electronic Games to Aid Motivation to Exercise Study
GEMS	Girls Health Enrichment Multi-site Study
H	Hydrogen
H ₂ O	Water
HR _{flex}	Flex heart rate
HR _{max}	Maximum heart rate
HRR	Heart rate reserve
ICC	Intra-class correlation coefficient
IDEAA	Intelligent device for energy expenditure and activity

ITT	Intention-to-treat
J	Joule
kcal	Kilocalorie
kg	Kilogram
kJ	Kilojoule
LoA	Limits of Agreement
LOCF	Last observation carried forward
MARCA	Multimedia Activity Recall for Children and Adolescents
MET	Metabolic equivalent
m	Metre
mg	Milligram
MJ	Megajoule
ml	Millilitre
mm	Millimetre
mmHg	Millimetres of mercury
MVPA	Moderate-vigorous physical activity
MVPA _{ACC}	Moderate-vigorous physical activity calculated from accelerometry
MVPA _{MARCA}	Moderate-vigorous physical activity calculated from Multimedia Activity Recall for Children and Adolescents
NHMRC	National Health and Medical Research Council
NZ	New Zealand
O	Oxygen
OR	Odds ratio
p	Significance value
PACMAN	Physical Activity in Children: MARCA Validation Study
PAL	Physical Activity Level
PAQ-C	Physical Activity Questionnaire for Children
PDPAR	Previous Day Physical Activity Recall

RCT	Randomised controlled trial
rpm	Revolutions per minute
SAE	Serious Adverse Event
SAPAC	Self-Administered Physical Activity Checklist
SAS	Statistical Analysis System
SCEE	Sony Computer Entertainment Europe
SCENZ	Sony Computer Entertainment New Zealand
SD	Standard deviation
SE	Standard error
SED _{ACC}	Sedentary behaviour calculated from accelerometry
SED _{MARCA}	Sedentary behaviour calculated from Multimedia Activity Recall for Children and Adolescents
SOFIT	System for Observing Fitness Instruction Time
SOPLAY	System for Observing Play and Leisure Activity in Youth
TEE	Total energy expenditure
TEE _{DLW}	Total energy expenditure calculated from doubly labelled water
TEE _{MARCA}	Total energy expenditure calculated from Multimedia Activity Recall for Children and Adolescents
TV	Television
UK	United Kingdom
US	United States of America
USB	Universal Serial Bus
WHO	World Health Organization
VO ₂	Volume of oxygen consumption
VO _{2max}	Maximum volume of oxygen consumption
YRBS	Youth Risk Behaviour Surveillance Survey
zBMI	Standardised body mass index