Parenting Practice and Physical Activity: 
Exploring the Gendered Influences of Modeling, Support, and Control on 
Young Children’s Objectively Measured Physical Activity

by

Mwalu Jan Peeters

A Thesis 
presented to 
The University of Guelph

In partial fulfillment of requirements 
for the degree of 
Master of Science 
in 
Family Relations and Applied Nutrition

Guelph, Ontario, Canada

©Mwalu Jan Peeters, May, 2018
ABSTRACT

PARENTING PRACTICE AND PHYSICAL ACTIVITY: EXPLORING THE GENDERED INFLUENCES OF MODELING, SUPPORT, AND CONTROL ON YOUNG CHILDREN’S OBJECTIVELY MEASURED PHYSICAL ACTIVITY

Mwalu Jan Peeters
University of Guelph, 2018

This study examined associations between parents’ physical activity-related parenting practices and objectively measured activity levels in their preschool-aged children. Survey data from 16 mother-father dyads participating in the Guelph Family Health Study was used to generate estimates of maternal and paternal physical activity, modeling, supportive, and controlling behaviours. Physical activity (PA) in the 24 participating children (15 males, 9 females) was measured using accelerometers. Linear regression modeling using the generalized estimating equation (GEE) approach was applied to identify associations between parenting practices and children’s moderate-to-vigorous and total physical activity (MVPA and TPA). Analyses stratified by child sex found positive associations between modeling by either parent and female children’s MVPA and TPA, while paternal enrolment of children in structured activities and maternal control were positively associated with MVPA and TPA among males. While maternal control facilitated activity among males, it displayed a significant negative association with female children’s activity levels. Our results revealed differing responses by male and female children to mothers’ and fathers’ PA parenting practices, and suggest the need for further research into the ways that maternal and paternal modeling, support, and control influence young children’s PA behaviours across sexes.
ACKNOWLEDGEMENTS

I would like to extend my sincere and heartfelt thanks to everyone who lent their support, knowledge, expertise, and encouragement to this project; any of my success is due in large part to your contributions.

To my principal advisor, Dr. Jess Haines, thank you for welcoming me into the university community, supporting my research interests, and providing guidance and feedback every step of the way.

To the members of my advisory committee, Drs. Lori Ann Vallis and Gerarda Darlington, thank you for your expertise and critical insights; they were essential to the scholastic rigour of this thesis.

To Dr. Gwen Chapman, dean of the College of Social and Applied Human Sciences, thank you for providing early direction and encouraging my decision to pursue a graduate education, and for your backing throughout my course of study.

To the members of the GFHS team, thanks for being teammates and co-investigators, and providing real-time examples of what this process was supposed to look like. To the GFHS families, thank you for letting us be a part of your lives; none of our work would be possible without you.

To my brothers, sister, mom, and dad, thank you for being there to remind me of the big world around us, and for always providing encouragement with no expectation.

And to my wife and partner, Nadia, and our two beautiful boys, Zakaria and Jad, the best parts of me; thank you for being the loves of my life; for motivating and inspiring me to be a better scholar, husband and father; for helping me keep sight of the ‘what does it all mean?’ questions; and for helping me to maintain faith and perspective throughout this journey.
# TABLE OF CONTENTS

Acknowledgements.................................................................................................................. iii
List of Abbreviations.................................................................................................................. vi
List of Tables.............................................................................................................................. vii

1.0 Introduction .............................................................................................................................. 1

2.0 Review of the Literature ......................................................................................................... 2
   2.1 Overview .............................................................................................................................. 2
   2.2 Health Consequence of Childhood Overweight and Obesity.............................................. 2
   2.3 Measurement and Classification ....................................................................................... 5
   2.4 Childhood Overweight and Obesity – Global and National Prevalence............................ 7
   2.5 Physical Activity and Obesity Prevention ......................................................................... 10
   2.6 Health Benefits of Physical Activity .................................................................................. 11
   2.7 Guidelines .......................................................................................................................... 12
   2.8 Children’s Physical Activity in Global and Canadian Contexts ......................................... 14
   2.9 Correlates of Early Childhood Physical Activity............................................................... 15
   2.10 Physical Activity and Parenting Practice ......................................................................... 21
      2.10.1 Modeling .................................................................................................................... 21
      2.10.2 Support .................................................................................................................... 25
      2.10.3 Control ..................................................................................................................... 28
      2.10.4 Methodological Concerns ....................................................................................... 29

3.0 Rationale, Research Objectives, and Hypotheses ................................................................. 30
   3.1 Rationale ............................................................................................................................ 30
   3.2 Research Objectives .......................................................................................................... 32
   3.3 Hypotheses ....................................................................................................................... 32

4.0 Methods ................................................................................................................................ 34
   4.1 Recruitment and Eligibility ............................................................................................... 34
   4.2 Data Collection ................................................................................................................... 34
      4.2.1 Predictor Variables ..................................................................................................... 35
         4.2.1.1 Modeling ........................................................................................................... 35
         4.2.1.2 Support ............................................................................................................. 35
         4.2.1.3 Control .............................................................................................................. 36
      4.2.2 Outcome Variable ...................................................................................................... 36
         4.2.2.1 Children’s Physical Activity ............................................................................. 36
      4.2.3 Covariates .................................................................................................................. 38

5.0 Data Analysis .......................................................................................................................... 39
   5.1 Internal Consistency ........................................................................................................... 39
   5.2 Distribution Analysis & Tests of Normality ....................................................................... 41
   5.3 Generalized Estimating Equations ..................................................................................... 41
6.0 Results.......................................................................................................................... 42
  6.1 Study Population........................................................................................................... 42
  6.2 Participant Demographics............................................................................................. 42
  6.3 Summary Statistics........................................................................................................ 44
  6.4 GEE Analyses.............................................................................................................. 45
    6.4.1 PA Parenting and Children’s Activity................................................................. 45
    6.4.2 Sex-Stratified Analyses......................................................................................... 47

7.0 Discussion...................................................................................................................... 49
  7.1 Strengths....................................................................................................................... 59
  7.2 Limitations.................................................................................................................... 59
  7.3 Future Directions.......................................................................................................... 61

8.0 Conclusions.................................................................................................................... 63

9.0 References..................................................................................................................... 64

10.0 Appendices..................................................................................................................... 77

  Appendix A: University of Guelph Research Ethics Board Certification of Ethical Acceptability of Research Involving Human Participants (#14AP009)................................................................. 77

  Appendix B: Guelph Family Health Study – Intervention and Longitudinal Study Consent to Participate forms .................................................................................................................. 80

  Appendix C: GFHS Pilot Phase 2 Parent 1 – Child Survey (select items)........................... 90

  Appendix D: GFHS Pilot Phase 2 Parent 1 – Self Survey (select items).............................. 96
LIST OF ABBREVIATIONS

ACTS-MG – Activity Support Scale for Multiple Groups
BMI – Body Mass Index
CCHS – Canadian Community Health Survey
CDC – Centre for Disease Control
CHMS – Canadian Health Measures Survey
CI – Confidence Interval
co-PA – Co-Physical Activity
co-VPA – Co-Vigorous Physical Activity
CSEP – Canadian Society for Exercise Physiology
GEE – Generalized Estimating Equation
GFHS – Guelph Family Health Study
IOTF – International Obesity Task Force
IPAQ – International Physical Activity Questionnaire
IPAQ-SF – International Physical Activity Questionnaire - Short Form
LPA – Light-intensity Physical Activity
MET – Metabolic Equivalent
MGRS – Multicentre Growth Reference Study
MVPA – Moderate to Vigorous Physical Activity
OECD – Organization of Economic Cooperation and Development
PA – Physical Activity
pre-PAQ – Preschool Age Children’s Physical Activity Questionnaire
ROC – Receiver Operating Characteristic
SA – Structured Activities
SD – Standard Deviation
TPA – Total Physical Activity
VPA – Vigorous Physical Activity
WHO – World Health Organization
LIST OF TABLES

Table 1. Cronbach’s coefficient α of full and adapted parental support scale………………………………………44

Table 2. Participant characteristics, individual level……………………………………………………………………46

Table 3. Participant characteristics, family level………………………………………………………………………47

Table 4. Mean scores of parenting practice indicators and children’s PA outcomes………………………………………48

Table 5. Results of GEE analyses, influence of PA parenting practices on children’s MVPA…………………………49

Table 6. Results of GEE analyses, influence of PA parenting practices on children’s TPA……………………………50

Table 7. Results of sex-stratified GEE analyses, influence of PA parenting practices on female and male children’s MVPA…………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………
1.0 INTRODUCTION

Globally, population rates of overweight and obesity have shown a dramatic increase over the past thirty years (Ng et al., 2014). In Canada, the increased prevalence of overweight and obesity has been particularly pronounced among children and youth (Shields, 2006), with a lack of physical activity posited as one of the root causes (Rao, Kropac, Do, Roberts, & Jayaraman, 2017; Tremblay & Willms, 2003). Physical activity (PA) habits developed in childhood have been shown to track throughout the lifespan (Craigie, Lake, Kelly, Adamson, & Mathers, 2011; Jones, Hinkley, Okely, & Salmon, 2013; Telama, 2009), with the early years (from infancy to age 5) identified as a potentially critical intervention period (Reilly, 2008; Small, Anderson, & Melnyk, 2007). Reviews of the correlates of physical activity among young children have identified parental behaviours as significant in predicting children’s levels of activity (Bingham et al., 2016; Hesketh et al., 2017; Hinkley, Crawford, Salmon, Okely, & Hesketh, 2008; Li, Kwan, King-dowling, & Cairney, 2015), but while a substantial amount of research has explored the relationship between parental influence and children’s PA (Gustafson & Rhodes, 2006; Mitchell et al., 2012; Pugliese & Tinsley, 2007; Trost & Loprinzi, 2011), key gaps in our understanding still exist, particularly around the role that sex and gender may play in moderating the impact of parenting practice on behavioural outcomes (Mitchell et al., 2012; Yao & Rhodes, 2015). The proposed project aims to clarify our understanding of the relationship between parenting practices, parent gender and child sex, and children’s participation in physical activity by examining and quantifying the associations between maternal and paternal modeling, supportive, and controlling behaviours with children’s objectively measured levels of physical activity.

2.0 REVIEW OF THE LITERATURE

2.1 OVERVIEW

The worldwide increase in rates of overweight and obesity over the past several decades has been described as a pandemic, with pronounced impacts on mortality, morbidity, and quality of life of those affected (Ng et al., 2014). Rates of childhood overweight and obesity are an area of particular concern,
both because of the disproportionate increase in prevalence experienced by this age group (Ng et al., 2014), and because of the critical role that this life stage play in the development, prevention, maintenance, or avoidance of obesity and it’s related behaviours (Wang & Lobstein, 2006). While some incidence of obesity can be attributed to endogenous factors such as genetics and certain neurological and endocrinological syndromes, researchers have posited a confluence of social, economic, cultural, environmental, and behavioural factors underlying the upward trend (Anderson & Butcher, 2006; Wang & Lobstein, 2006). Changes to the economy, built environment, and patterns of leisure activity that have resulted in reduced opportunities for physical activity and increased sedentary time in transit and at home, work, and school; changing parental roles that have contributed to less functional involvement in children’s day-to-day activities; and changes to the value and risk that parents associate with unsupervised, active, and outdoor play, travel, sports, and recreational activities have all contributed to the imbalance between children’s energy intake and expenditure that is driving the global increase in body size (Anderson & Butcher, 2006; ParticipACTION, 2015; Reilly, 2007; Wang & Lobstein, 2006).

2.2 HEALTH CONSEQUENCES OF CHILDHOOD OVERWEIGHT & OBESITY

Systematic reviews have shown that early life overweight and obesity persists throughout the lifespan, with severe consequences in both the short- and long-term. A growing body of evidence shows that pediatric obesity may contribute to earlier onset and increased childhood prevalence of many health conditions that were once thought to occur predominantly in adults (Daniels, 2015; Reilly, 2007; Reilly et al., 2010).

A primary concern when discussing the health consequences of childhood overweight and obesity is the tendency for excess weight to persist over time, a phenomenon known as ‘tracking’. Systematic reviews have found consistent, high quality evidence that overweight and obesity track from the early years through later childhood, adolescence, and adulthood, with the probability of excess weight later in life increasing with body mass index (BMI) and age at baseline (Daniels, 2015; Reilly, 2007; Singh, Mulder,
Twisk, Van Mechelen, & Chinapaw, 2008). Recently, the Physical Activity Longitudinal Study looked at the stability of BMI over a period of 22 years in a population-based sample of Canadians. Herman, Craig, Gauvin, and Katzmarzyk (2009) found that 83% of overweight youth in the study remained overweight as adults, and that, compared to their healthier weight peers, overweight youth were 6.2 times more likely to become overweight adults.

Diagnoses of childhood overweight and obesity have been associated with a number of physical and psychological comorbidities. General reviews of the immediate health consequences of pediatric overweight and obesity have found an increased prevalence and severity of asthma among children and youth bearing excess weight (Daniels, 2015; Pulgarón, 2013; Reilly et al., 2010). These findings are supported by a recent systematic review specifically examining the association between childhood BMI and risk of asthma in adolescence, which found that obesity precedes and is associated with the persistence and intensity of asthma symptoms (Noal, Menezes, Macedo, & Dumith, 2011). Similarly, general reviews (Daniels, 2015; Reilly, 2007; Reilly et al., 2010) and those focusing specifically on musculoskeletal conditions (Chan & Chen, 2009) have reported a well-documented association between childhood obesity and skeletal abnormalities in the hips and tibia, with a growing body of evidence suggesting possible connections with pain and other symptoms in the feet and back, impairments in gait, and increased fracture risk.

Obesity carries a pronounced social stigma. One consequence of this is a higher prevalence of psychological sequelae, such as anxiety, depression, poor self-esteem, body dissatisfaction, behavioural problems, and impaired social development, found in overweight and obese children and youth compared to their healthier weight peers (Daniels, 2015; Pulgarón, 2013; Reilly, 2007), to the extent that this has been identified as the most widespread health impact of pediatric obesity (Reilly et al., 2003). Psychosocial morbidity may be compounded by the detrimental effect that childhood overweight and obesity has been shown to have on sleep duration and quality, as excess early weight is strongly related to
disrupted sleep patterns and obstructive sleep apnea (Daniels, 2015; Pulgarón, 2013). Sleep disordered breathing may also impact cardiovascular function, an area where evidence increasingly suggests that excess weight in childhood may not only contribute to increased risk of cardiovascular disease and events later in life, but may also precipitate cardiovascular damage and dysfunction in the short-term.

Systematic reviewers have drawn the association between childhood obesity and clustering of cardiometabolic risk factors such as large waist circumference, hypertension, dyslipidemia, and insulin resistance (Daniels, 2015; Pulgarón, 2013; Reilly et al., 2010). Recent evidence supports this assertion, and has shown that the chronic inflammation and oxidative stress associated with obesity and these markers of cardiometabolic disease risk produce changes in cardiovascular structure and function – increased left ventricular mass, decreased systolic and diastolic ventricular deformation characteristics, vascular epithelial dysfunction – that initiate and exponentially accelerate the development of atherosclerosis during childhood (Cote, Harris, Panagiotopoulos, Sandor, & Devlin, 2013; McCrindle, 2015). Obesity-related damage to the body’s cardiovascular and metabolic systems in the formative years not only predisposes children to an increased risk of cardiometabolic disease later in life, it likely initiates and hastens their immediate development. In addition to atherosclerosis, metabolic disorders such as type 2 diabetes and non-alcoholic fatty liver disease – conditions that were previously linked with adult onset – are seen with increasing regularity among children and adolescents in association with excess body weight (Daniels, 2015; McCrindle, 2015; Pulgarón, 2013; Reilly et al., 2010).

Evidence has shown that adults who were overweight or obese as children face a significantly greater likelihood of all cause and cause-specific premature mortality, with mortality attributable to a cardiovascular event presenting the greatest risk (McCrindle, 2015; Reilly & Kelly, 2011; Reilly et al., 2010). This strong association with premature mortality, coupled with continued high rates of childhood obesity, has led some researchers to predict that, for the first time, overall life expectancy among today’s youth may decrease relative to the previous generation (Daniels, 2015). The documented burden of
disease and early death that can be attributed to childhood overweight and obesity underscores the need for continued inquiry into the causes, treatment, and prevention of excess weight gain in pediatric populations.

2.3 MEASUREMENT AND CLASSIFICATION

Ideally, classification of overweight and obesity would be based on direct measures of body composition through methods such as underwater weighing, magnetic resonance imaging, computerized axial tomography scans, or dual energy X-ray absorptiometry (Lobstein, 2010). Use of these methods, however, is impractical for epidemiological and clinical use (He & Sutton, 2004). In the absence of direct measurements of body composition, a consistent definition of childhood obesity based on anthropometric measures that can be applied to population-based data over time is needed (Shields & Tremblay, 2010). In adults, body mass index (BMI), a measure of weight in relation to height, has long served as a proxy measure of adiposity. BMI values between 25 and 30 kg/m² are classified as overweight, and values greater than 30 kg/m² are classified as obese, with all of the concordant health risks (Lobstein, 2010; Shields & Tremblay, 2010). However, wide fluctuations in the relationship between weight and height occur throughout infancy and childhood, and associations between high BMI, morbidity, and mortality in children are less clear than in adults (Lobstein, 2010; Olstad & McCargar, 2009; Shields & Tremblay, 2010). As such, establishing a single healthy BMI standard for the early years is a more complex undertaking. A wide range of growth charts based on data from different surveys and populations are available, and a range of different cut-off thresholds – one or two standard deviations above a reference mean, a BMI-for-age at the 85th, 90th, or 95th percentile of a given reference population, etc. – have been employed in different settings (Lobstein, 2010). In recent years, two primary international standards have emerged.

In 2000, the International Obesity Task Force (IOTF) attempted to bring clarity to the situation by convening an expert panel to develop a set of childhood BMI cut-points that could be linked to health
outcomes and would be suitable for international comparisons (Lobstein, 2010; Shields & Tremblay, 2010). Working with nationally representative cross-sectional data from children and youth in Brazil, Britain, Hong Kong, Singapore, the Netherlands, and the United States between 1963 and 1993, the panel began with the established adult BMI cut-points and extrapolated backward to the age of two, resulting in smooth, sex-specific centile curves that intersect with BMI levels of 25 and 30 kg/m$^2$ at age 18 (Cole, Bellizzi, Flegal, & Dietz, 2000; Lobstein, 2010; Shields & Tremblay, 2010). These ‘Cole classification’ cut-points have been shown to produce more conservative estimates of prevalence than other standards, such as those established by the US Centre for Disease Control (CDC) and the World Health Organization (WHO), and are used primarily for population-level obesity surveillance and international comparisons (Lobstein, 2010; Olstad & McCargar, 2009; Shields & Tremblay, 2010).

In 2006, the WHO released a new set of growth standards for children up to 5 years of age. These new guidelines were based on data from the Multicentre Growth Reference Study (MGRS), a survey of healthy infants and children from Brazil, Ghana, India, Norway, Oman, and the United States selected on the basis of having exposure to a socio-economic environment that favoured optimal growth and development, including breastfeeding, healthy diet, non-smoking mother, and access to basic immunization and health care (Lobstein, 2010; Shields & Tremblay, 2010). For children less than 5 years old, the WHO protocol suggests that those whose BMI falls more than three standard deviations (SDs) above the mean for their age and sex should be labelled as ‘obese’, those whose BMI falls between two and three SDs above the mean should be labelled ‘overweight’, and those whose BMI falls between one and two SDs above the mean should be labelled ‘at risk of overweight’ (Lobstein, 2010; Shields & Tremblay, 2010). Unlike previous approaches that describe reference populations that may or may not embody good health, the WHO growth curves represent an ideal or prescriptive standard for healthy growth under desirable conditions, and have been posited as an international gold standard for growth achievement (Lobstein, 2010; Shields & Tremblay, 2010). In 2010, a joint statement by Dietitians of Canada, the Canadian Paediatric Society, The College of Family Physicians of Canada, and Community
Health Nurses of Canada endorsed their use for the assessment and monitoring of growth in Canadian children (Dietitians of Canada & Canadian Pediatric Society, 2010).

These WHO cut-points for excess weight in children are uniformly lower than those specified by the IOTF. On average, WHO cut-points for overweight among boys are approximately one BMI unit lower than those of the IOTF, while for girls they fall within one BMI unit. Differences are more pronounced in the guidelines for obesity. In particular, WHO standards for classifying 8 to 13 year old boys as obese are almost 3 BMI units lower than those suggested by the IOTF. Differences in classification standards for obesity in children less than 5 years old, while smaller, are still substantial, and, similar to the difference in standards for overweight, range from slightly less than one BMI unit for girls to slightly more than one BMI unit for boys (Shields & Tremblay, 2010). In practice, these differences can lead to substantial variability in estimates of prevalence. Using data from the 2004 Canadian Community Health Survey (CCHS), Shields and Tremblay (2010) found that rates of overweight and obesity among 2 to 5 year old boys were estimated to be 18 percentage points higher when using the WHO cut-points compared to the IOTF guidelines (37% vs 19%). Considerations such as these must be taken into account when comparing data across studies.

2.4 CHILDHOOD OVERWEIGHT & OBESITY – GLOBAL & NATIONAL PREVALENCE

The obesity epidemic has had a pronounced impact on children. Between 1980 and 2013, global rates of overweight and obesity in adults increased by 27.5%. In comparison, in their systematic analysis for the Global Burden of Disease study, Ng et al. (2014) found that the prevalence of overweight and obesity, as defined by the IOTF cut-points, among children and adolescents (2-19 years of age) in developed countries increased from 16.9% of boys and 16.2% of girls in 1980 to 23.8% of boys and 22.6% of girls in 2013, a total relative increase of 47.1%. Ng et al. also found that, in developed countries, peak prevalence of obesity is moving to younger ages. This observation is borne out by the de Onis, Blössner and Borghi’s (2010) study aimed at quantifying global prevalence and trends in overweight and obesity.
among preschool aged children (aged 0-5 years old). Using WHO growth charts as a measurement standard, this review of 450 nationally representative cross-sectional surveys from 144 countries found that, between 1990 and 2010, prevalence rates of overweight and obesity among preschoolers in developed countries increased from 7.9% to 11.7%, a relative increase of 48%.

Recent research has noted the possibility of a stabilization in overweight and obesity rates in developed countries, starting around the late 1990s (Olds et al., 2011; Rokholm, Baker, & Sørensen, 2010; Wabitsch et al., 2014). Rokholm et al. (2010) reviewed 52 studies from 25 countries that measured obesity rates between 1999 and 2010, and found that most described a levelling of prevalence. Among adolescents and children, studies from Australia, Europe, Japan, and the United States described stabilizing rates of overweight and obesity. In their review of high quality evidence from nine countries (Australia, China, England, France, the Netherlands, New Zealand, Sweden, Switzerland, and the United States), Olds et al. (2011) examined data from 467,294 children aged 2-19, and found that, between 1995 and 2008, prevalence rates for obesity and overweight in all of the above countries had effectively stabilized.

Wabitsch et al. (2014) found that, while plateauing and, in some cases, declining childhood obesity rates among developed countries have been observed, levels of extreme obesity, defined as those with BMIs >99th percentile, continue to increase. All of the above reviewers found that, while the observed plateau in obesity rates may constitute more than a temporary lull in the tendency towards increase, overall rates remain significantly higher than in decades past, with all of the concordant risks of morbidity and early mortality. Research into the causes, treatment, and prevention of childhood obesity remains a major global health concern.

In Canada, rates of childhood overweight and obesity have shown substantial increases over the past several decades, with a trajectory that far exceeds the global trend. Nationally representative and directly measured data from the 1978-79 Canada Health Survey and 2004 Canadian Community Health Survey shows that, estimated using the IOTF guidelines, rates of overweight and obesity among 2 to 17 year olds
rose from 15 to 26%, a relative increase of 70%. In the same time frame, prevalence of obesity alone among Canadian children increased by more than two-fold, from 3 to 8% (Shields, 2006). More recent data echoes the more recent global pattern. The 2011, 2013, and 2015 cycles of the CCHS show a plateauing of prevalence rates in the low- to mid-twenties, with rates of overweight and obesity among 3-17 year olds estimated at 24.3, 24.3, and 23.2%, respectively (Statistics Canada, n.d.). Rodd and Sharma (2016) analyzed national survey data from 2004 to 2013 (CCHS data from 2004-2005 and Canadian Health Measures Survey (CHMS) data from 2009-2013) and, using the WHO growth standard, found a slight but significant decrease in prevalence of overweight and obesity among 3-19 year olds, while rates of obesity stabilized. Despite this welcome change in tendency, the authors conclude that continued high prevalence warrants ongoing weight surveillance and control measures for all children.

According to 2004 CCHS data, the rate of overweight among Canadian 2-5 year olds was 15.2%, while 6.3% of Canadian children in this age range were obese (Shields, 2006). While this combined rate of 21.5% has remained steady since 1979, it still places Canada among those Organization of Economic Cooperation and Development (OECD) nations with the highest prevalence of childhood overweight and obesity (Olstad & McCargar, 2009). Though recent analysis has found that Canadian toddlers are significantly less likely than older children to carry excess weight (Rodd & Sharma, 2016), the continued high prevalence rates of overweight and obesity in this age category, coupled with the tendency for weight status to track from the early years through later childhood, adolescence, and into adulthood (Singh et al., 2008), and the critical role that healthy behaviours acquired during the early years may play in preventing disease throughout the lifespan (Reilly, 2008; Small, Anderson, & Melnyk, 2007) makes the further elucidation of those factors that protect from or increase the risk of overweight and obesity during this period a top priority.
2.5 PHYSICAL ACTIVITY & OBESITY PREVENTION

The etiology of childhood obesity is complex, and is undergirded by a confluence of social, economic, cultural, environmental, and behavioural factors (Anderson & Butcher, 2006; Wang & Lobstein, 2006). Reporting on childhood overweight and obesity for the Public Health Agency of Canada, Rao et al. (2017) advocate for an integrative, socioecological approach to prevention that encompasses early-life (maternal weight gain and lifestyle behaviours such as smoking, breastfeeding during the first six months), sociodemographic, behavioural, psychosocial, life stage, and environmental factors. Visscher and Kremers (2015) stress the importance of viewing these interrelated factors as a dynamic system, with interactions at different levels exerting various moderating influences throughout the causal chain. ‘Upstream variables’ such as gender, ethnicity, place of residence, neighbourhood conditions, income adequacy, and socio-economic status have significant associations with the prevalence of overweight and obesity (Rao et al., 2016; Rodd & Sharma, 2016), and the moderating effect that they can have on the impact of more micro-level determinants of weight status should be included in any analysis (Visscher & Kremers, 2015). Nevertheless, efforts to isolate key individual determinants of obesity risk make important contributions, both toward developing our ecological understanding of the obesogenic environment, and towards identifying the essential components of successful preventive interventions.

Systematic reviews of obesity prevention initiatives in pediatric populations have found that those that focus on building healthy eating and activity habits have more stable long-term results and avoid the risk of inculcating weight prejudice, inadequate nutrient intake, or unhealthy slimming practices when compared to those that rely on restrictive or coercive strategies (Dehghan, Akhtar-Danesh, & Merchant, 2005; Flynn et al., 2006; Wofford, 2008). In examining these lifestyle habits, epidemiological studies have found that regular participation in physical activity, along with limited engagement in sedentary behaviours, has a primary protective effect against early life overweight and obesity (Dehghan et al., 2005; Hills, King, & Armstrong, 2007; Reilly, 2008; Rush & Simmons, 2014) with some research suggesting that physical activity and sedentary behaviour are more predictive of children’s BMI than diet
(Jago, Baranowski, Baranowski, Thompson, & Greaves, 2005), and that, for many children, a simple increase in physical activity, independent of other factors, would be sufficient to prevent the early onset of obesity (Sothen, 2004). In interventions targeting obese, overweight, and at-risk children, physical activity has shown to be a critical intervention component that is prominently associated with multiple positive outcomes, including weight stabilization, improved body composition, and decreased chronic disease risk factors (Flynn et al., 2006; Summerbell et al., 2005). In their study of the relationships between physical activity participation, sedentary behaviour, and BMI in a nationally representative sample of Canadian children, Tremblay and Willms (2003) found that children’s participation in both organized sport and unorganized physical activities were negatively associated with being overweight or obese, while TV watching and video game use significantly increased risk. As such, recommendations for best practice in the prevention and treatment of childhood obesity include an emphasis on encouraging and facilitating appropriate levels of physical activity from an early age (Baranowski et al., 2000; Dehghan et al., 2005; Flynn et al., 2006; Fox, 2004; Hills et al., 2007; Reilly, 2008; Saunders, 2007; Sothen, 2004).

2.6 HEALTH BENEFITS OF PHYSICAL ACTIVITY

Physical activity can be defined as any body movement produced by skeletal muscles that results in energy expenditure (Caspersen et al., 1985). Appropriate levels of physical activity during the early years are associated with healthy body weight and a broad range of other physical, mental, emotional, and social health benefits (Longmuir, Colley, Wherley, & Tremblay, 2014; Timmons et al., 2007). A recent systematic review (Timmons et al., 2012) found moderate quality evidence supporting the relationship between increased physical activity levels and bone and skeletal health in toddlers (1-3 years of age), and low to high quality evidence supporting the relationship between increased physical activity and improved measures of adiposity, motor skill development, psychosocial health, and cardiometabolic health indicators in preschoolers (3-5 years of age). Preliminary evidence has also linked higher duration
and frequency of physical activity with improved cognitive development during early childhood (Valerie Carson, Hunter, et al., 2016).

An important secondary benefit of early life physical activity derives from the notion of ‘tracking’, or the idea that health related behaviours adopted during one life stage will ‘carry over’ into the next (Edwards et al., 2013; Jones et al., 2013). Systematic reviews of studies tracking physical activity levels from childhood to adulthood have found moderate evidence of consistency through the lifespan (Craigie et al., 2011; Telama, 2009), while a review looking specifically at tracking within childhood found moderate evidence of consistency through the early years (0-5 years old) and from early to middle childhood (6-12 years old) (Jones et al., 2013).

Studies that look more closely at objectively-measured physical activity patterns in younger children have had varied results, but the weight of evidence seems to suggest that children’s physical activity levels increase from infancy up until around age 3 or 4 (Edwards et al., 2013; Jackson et al., 2003), with a decrease in the subsequent years often associated with entry into kindergarten or elementary school (Jáuregui et al., 2011; Sigmund, Sigmundová, & Ansari, 2009; Taylor, Williams, Farmer, & Taylor, 2013). Gendered differences in both levels and tracking of physical activity are evident from an early age (Edwards et al., 2013; Jackson et al., 2003; Janz, Burns, & Levy, 2005; Kelly et al., 2007; Taylor et al., 2013), and a further elucidation of those mechanisms that may account for and/or mitigate the changes in early life activity levels in boys and girls has the potential to significantly impact this critical health behaviour later in childhood and throughout the lifespan.

2.7 GUIDELINES

Until recently, a limited evidence base describing the relationship between young children’s activity levels and healthy physical, cognitive, emotional, and social development had hindered the establishment of clear guidelines for healthy movement in this age group (Timmons et al., 2007). In 2012, in response to
demand from public health, health care, child care, and fitness practitioners working with young children in the area of exercise and physical activity, and as a nationally-specific counterpoint to the previously established Australian, British, and American standards, the Canadian Society for Exercise Physiology (CSEP), in collaboration with multiple partners and stakeholders, developed the first Canadian Physical Activity Guidelines for the Early Years (aged 0-4 years) (Tremblay et al., 2012).

The Canadian guidelines build on the existing specifications and previous research that aimed to establish links between physical activity and a range of health indicators – including healthy body weight, bone and skeletal health, motor skill development, psychosocial well-being, cognitive development, and cardiometabolic disease risk factors (Timmons et al., 2007), with the goal of identifying “…the frequency, intensity, time and type of physical activity…associated with improved health indicators in the early years” (Tremblay et al., 2012, p 347). With this research objective in mind, systematic review of the scientific evidence and consultation with various stakeholders resulted in an expert consensus that all healthy toddlers (aged 1-2 years) and preschoolers (aged 3-4 years) should accumulate at least 180 minutes of physical activity of any intensity spread throughout the day and progress toward a minimum of 60 minutes of daily moderate to vigorous physical activity (MVPA) by the age of 5, with greater health benefits accruing to those who participate in greater amounts of activity (Longmuir et al., 2014; Tremblay et al., 2012). The guidelines also recommend that young children should take part in a variety of age-appropriate, enjoyable, and safe structured and unstructured activities as part of play, games, sports, transportation, recreation, and physical education; in different indoor and outdoor environments; and in the context of family life, child care, school, and community (Tremblay et al., 2012).

Other recent research on healthy activity patterns throughout the lifespan has incorporated an integrated approach; assessing physical activity, sedentary behaviour, and sleep in combination, and emphasizing the importance of maintaining a healthy balance of these day-to-day movement related behaviours, with adequate levels of activity the key component in an optimal compositional mix (Carson, Tremblay,
Chapat, & Chastin, 2016; Chastin, Palarea-Albaladejo, & Dontje, 2015; Saunders et al., 2016). The CSEP published their 24-Hour Movement Guidelines for the early years (aged 0-4) in 2017 (Tremblay et al., 2017), reiterating the baseline recommendation of 180 minutes of daily total physical activity among young children, and placing greater emphasis on the benefits of higher levels of total physical activity and 60 minutes of daily energetic play as children approach school age.

2.8 CHILDREN’S PHYSICAL ACTIVITY IN GLOBAL & CANADIAN CONTEXTS

Though the absence of benchmark data makes historical comparisons difficult, study results from a range of global contexts suggest that physical activity levels in today’s children are low relative to previous generations, and progressively declining (Hills et al., 2007; Tucker, 2008). Researchers have identified a number of social, cultural, and environmental factors influencing this trend, including a changing technological environment that favours labour saving devices, electronic communications, and screen-based leisure activities; a more safety conscious culture that makes parents less likely to allow unsupervised outdoor travel and active play; limited or declining opportunities for school-based physical activity; limited access to high quality organized sport and structured physical activities outside of school; insufficient early development of fundamental movement skills and physical literacy; and a built environment that is not conducive to active living or opportunities for energetic free play (Hills et al., 2007; ParticipACTION, 2015, 2016; Tremblay et al., 2015; Wechsler, Devereaux, Davis, & Collins, 2000). The development of the Canadian Physical Activity Guidelines was motivated at least in part by research findings that show, along with unprecedentedly high levels of obesity and declining levels of physical fitness, extremely low levels of physical activity among Canadian children (Rao et al., 2017; Tremblay et al., 2012).

Objective, accelerometry-based measures of children’s physical activity levels are collected periodically by Statistics Canada through the Canadian Health Measures Survey. According to data from the 2007-2009 and 2014-2015 iterations of the CHMS, less than 10% of Canadian children and youth (aged 5 – 17

14
years old) are accumulating the 60 minutes of daily moderate to vigorous physical activity recommended for their age group (Colley et al., 2011; Statistics Canada, 2017). In comparison, combined data from the 2009-2011 and 2012-2013 cycles of the CHMS show that approximately 73% of Canadian 3-4 year olds were meeting the recommended guideline of 180 minutes of daily physical activity specified for preschoolers (Garriguet et al., 2016). While this contrast seems encouraging at first glance, much of this difference can be attributed to the shift in emphasis from a higher volume of total physical activity (TPA) in the early years, to a lower volume of higher intensity physical activity as children age (Colley et al., 2013). Closer inspection of the data reveals that only an estimated 24% of 3-4 year olds were attaining the 60 minutes of moderate to vigorous physical activity recommended for preschoolers as they approach the age of 5 (Garriguet et al., 2016). Similarly, only about 30% of 5 year olds were accumulating the 60 minutes of daily MVPA recommended for their age (Garriguet et al., 2016). This consideration, coupled with the demonstrated tendency of physical activity habits acquired during the early years to track into later childhood, adolescence, and adulthood (Craigie et al., 2011; Jones et al., 2013; Telama, 2009), and some research indicating an absolute drop in children’s physical activity levels upon entry into kindergarten or elementary school (Edwards et al., 2013; Jáuregui et al., 2011; Sigmund et al., 2009; Taylor et al., 2013) suggests that increases in preschool children’s physical activity levels could have a beneficial impact on activity levels later in life – when the prevalence of low PA levels is much greater – and have a corresponding impact on health outcomes throughout the lifespan, as well as improving health outcomes and quality of life during childhood.

2.9 CORRELATES OF EARLY CHILDHOOD PHYSICAL ACTIVITY

Identifying correlates of physical activity is a key component in the design and implementation of effective interventions to increase PA and support the maintenance of energy balance in pediatric populations (Bingham et al., 2016; De Craemer et al., 2012; Li, Kwan, King-Dowling, & Cairney, 2015). While systematic reviews of the correlates of physical activity in older children and adolescents are fairly
commonplace (Sallis, Prochaska, & Taylor, 2000; Sterdt, Liersch, & Walter, 2014), studies of the same in younger children are a more recent addition to the field.

Hinkley et al.’s 2008 review (Hinkley, Crawford, Salmon, Okely, & Hesketh, 2008), widely acknowledged as the first to focus specifically on the correlates of physical activity in preschool aged children, found that male sex; parental physical activity levels – particularly the amount of physical activity parents engage in along with their children, often referred to as co-physical activity (co-PA); preschool attendance; and time spent outdoors or in play spaces were associated with higher levels of total physical activity in 2-5 year olds across multiple studies.

Subsequent reviews have provided mixed support for these findings. De Craemer et al. (2012) found evidence associating male sex with increased levels of MVPA, while rural preschool location and some indicators of access to outdoor recreational opportunities -- such as frequent proximity to outdoor play spaces, equipment, and recreational facilities -- were associated with increased MVPA and TPA in 4-6 year olds, though this evidence was less pronounced than that found by Hinkley and colleagues. In contrast to Hinkley et al., De Craemer and colleagues found some evidence that child-initiated activities in groups composed solely of peers – as opposed to those that included parents or other adults – were more conducive to increased children’s PA.

Li et al. (2015) limited their review to prospective or longitudinal studies based on objective measures of physical activity in 2-6 year olds, and found positive associations between children’s PA, parental PA, and the time that parents – particularly fathers – spent playing with their children. These reviewers also found an association between warmer seasons and/or better weather and young children’s PA, though they caution that only a small number of longitudinal studies have investigated this effect. While some research has indicated the particular salience of seasonality for young children’s levels of physical activity in northern climates (Carson, Spence, Cutumisu, Boule, & Edwards, 2010), a review of the literature on
seasonal variation in PA among children and adolescents by Carson and Spence (2010), found that the impact of seasonality on the activity levels of younger children (aged 2-6) was indeterminate, with further research needed to assess the practical significance of this relationship. In contrast to Hinkley et al. and much of the prevailing literature, Li and colleagues found no association between sex and physical activity, an inconsistency that they attribute to the possibility that preschool aged children are less subject to the socially constructed gender roles that place more pressure on boys to participate in sports and other structured and unstructured physical activities as they age.

Bingham et al. (2016) systematically reviewed studies of the correlates and determinants of 0-6 year old children’s physical activity, with correlates defined as independent variables associated with PA in cross-sectional studies, while determinants were defined as variables that had demonstrated a temporal association with PA over the course of a longitudinal study. Their findings largely concurred with the above, identifying male sex as a correlate of MVPA and both a frequently replicated correlate and a determinant of total physical activity. Preschool/child-care attendance was also correlated with both MVPA and TPA. Parental physical activity and time spent outdoors were identified as correlates of children’s total PA, while co-PA was identified as a determinant. In addition, Bingham et al. identified parental support as a significant correlate of total activity during the early years.

Focussing solely on determinants of change in physical activity, Hesketh et al. (2017) reviewed the results of 44 longitudinal studies of 0-6 year old children (38 interventional, 6 prospective cohort). Of the forty-four determinants assessed, only two – parental monitoring and caregiver/provider training – showed consistent positive effects across at least four studies. Parental monitoring – that is, whether the intervention incorporated some means of heightening parental awareness of their children’s levels of PA, such as the use of questionnaires, log-books, or pedometers – was associated with increases in total PA, while provider training – the degree to which care providers had received some form of instruction in leading age-appropriate physical activities – was associated with increases in MVPA. A smaller but
consistent body of research (3 studies, all of which produced significant results) demonstrated a positive association between maternal role-modelling and increased total activity. While no such association was found for father’s modelling behaviour, the authors note that studies assessing paternal determinants were rare, and that these were often based on maternal reports.

A recent review by Lindsay, Greaney, Wallington, Mesa and Salas (2017) corroborates many of the above findings, while identifying several additional factors that may influence preschoolers’ activity levels inside and outside of the home. This review adopted the social ecological model as a theoretical framework for classifying variables based on their level of influence, categorizing them as intrapersonal, interpersonal, environmental (community/neighbourhood), organizational, and policy level factors. While less systematic in their assessment of evidence than the works cited above, the reviewers give further support to sex, parental physical activity, time spent outdoors, and access to appropriate outdoor play spaces as primary correlates of physical activity in children younger than five years old.

All of the above reviews identified variables across the full range of the social ecological model where limited evidence suggests the need for further research to establish firm correlations with children’s activity levels. At the individual/demographic level, Lindsay et al. (2017) found that higher socio-economic status (SES) was associated with higher levels of physical activity in children. This notion is borne out in the Canadian context by results from the 2009-2011 and 2012-2013 CHMS, where data analysis by Garriguet et al. (2016) found that 3-4 year olds in the lowest income households (separated by tertile) were significantly less likely than those in the highest income households to meet physical activity guidelines. In addition, Lindsay et al. found that ethnicity, acculturation, and place of birth all influenced children’s activity levels, though the bulk of this research was specific to the American context. Further research in other national contexts is warranted.
At the interpersonal level, different aspects of family structure – single or dual parent households, parental employment, the presence or absence of siblings – and support for, attitudes toward, and rules and interactions around PA in the family setting were flagged as potentially significant by all reviewers. Hinkley et al. place particular emphasis on the need for further work around the impact of parental logistic support, while Hesketh et al. place a high priority on researching the influence of sibling co-participation and increased opportunities for home-based active play. A recent systematic review on the influence of siblings on children’s health behaviour (Park & Cormier, 2018) found that having fewer siblings was associated with lower levels of physical activity.

Similarly, environmental/contextual factors such as climate, neighbourhood greenness, and actual and perceived neighbourhood safety and social connectedness, in addition to access to outdoor play spaces and recreational opportunities, were seen as having a potentially profound impact on children’s activity levels and related parenting practices (Bingham et al., 2016; De Craemer et al., 2012; Hesketh et al., 2017; Hinkley et al., 2008; Li et al., 2015; Lindsay et al., 2017). Future research should strive to incorporate analysis of these community level variables, including objective and subjective assessments of the physical and social environments.

As described above, preschool or daycare attendance, the location of care facilities, and quality of care are associated with young children’s PA. Reviewers have posited a number or organizational factors -- the number of care providers and structured physical activities in child care settings, adequacy of play spaces, training/education level of caregivers, site-specific policies related to PA and outdoor time -- that may impact children’s PA in this setting (Bingham et al., 2016; Hesketh et al., 2017; Hinkley et al., 2008; Li et al., 2015; Lindsay et al., 2017; Tucker, 2008).

Organizational variables can often be determined at the policy level, and Lindsay et al. discuss the impact that physical activity policies in American early childhood education settings have had on children’s
activity levels. While some research on the effect of PA policies on Canadian preschoolers’ levels of activity has been conducted (Vanderloo, Tucker, Johnson, Burke, & Irwin, 2015), further work in the Canadian context is needed. Several reviewers emphasize the need for more research that includes macroeconomic and other policy-level factors – availability of subsidized child-care; promotion, facilitation and accessibility of active recreation and transport opportunities at regional and national levels – and that identifies and analyzes interactions across the various social ecological domains (Bingham et al., 2016; Hesketh et al., 2017; Hinkley et al., 2008; Lindsay et al., 2017).

While the relative lack of study focussed on upstream and public policy level variables represents a significant gap in knowledge, all of the above reviewers also mention the need for more research based on representative samples and objective measures of physical activity (Bingham et al., 2016; De Craemer et al., 2012; Hesketh et al., 2017; Hinkley et al., 2008; Li et al., 2015). Much of our current knowledge derives from small studies using subjective measures of physical activity, which vary in specificity and are subject to inaccurate recall, social desirability bias, and other instrumental biases (Livingstone, Robson, Wallace, & McKinley, 2003; Oliver, Schofield, & Kolt, 2007; Trost, 2007). Analyses of those persistent intra- and inter-personal and community level factors identified in the research that are based on representative samples and objectively-measured data stand to make an important contribution to our understanding of what predicts adequate, health-promoting levels of physical activity in pediatric populations.

Among the biological, demographic, and sociocultural factors that impact young children’s physical activity mentioned above, the primacy of the family milieu is apparent. In this context, parenting practice emerges as a critical construct. Hinkley et al. (2008) found that while male sex and access to opportunities for outdoor recreation show a consistent positive effect on PA levels throughout the early years and into later childhood and adolescence, parental PA and levels of co-PA were only associated with younger children’s activity levels, suggesting the particular salience of familial physical interaction for this age
group. All but one of the reviews cited above list parental activity levels as predictive of children’s activity, and all of them point to some aspect of the parental role as significant in encouraging and facilitating their children’s activity and providing opportunities for active play. Bingham et al. (2016) identified parental support as a significant correlate of children’s PA, a finding that is corroborated by a number of reviews focussing specifically on the relationship between parental behaviours and their children’s activity levels (Gustafson & Rhodes, 2006; Mitchell et al., 2012; Pugliese & Tinsley, 2007; Trost & Loprinzi, 2011).

2.10 PHYSICAL ACTIVITY & PARENTING PRACTICE

Darling and Steinberg (1993) define parenting practice as context-specific behaviours enacted by parents and aimed at influencing children’s behaviour and development in order to achieve specific socialization goals. In the context of familial physical activity, Davison et al. (2013) further refine this definition to include only those behaviours and strategies used by parents to socialize their children’s PA. Reviewers have noted that effective parenting practices take into account children’s developmental level, and are age appropriate (Lindsay, Sussner, Kim, & Gortmaker, 2006).

In general, health promotion researchers have tended to dichotomize physical activity parenting practices into two areas; modeling and support (Gustafson & Rhodes, 2006; Mitchell et al., 2012; Trost & Loprinzi, 2011; Xu, Wen, & Rissel, 2015). Overall, results of the reviews of physical activity parenting practices suggest a consistent body of evidence affirming the role of parental support in promoting early childhood physical activity, while the evidence for parental modeling is less clear.

2.10.1 MODELING

Parental modeling refers to idea that parents’ own physical activity behaviours may directly influence their children’s physical activity (Pugliese & Tinsley, 2007; Trost & Loprinzi, 2011). Trost and Loprinzi (2011) posit social cognitive theory as a basis for parental modeling’s effect on children’s behaviour. A
key tenet of social cognitive theory is observational learning – the idea that individuals can learn
behaviours and increase their motivation and self-efficacy to perform them by observing them in others
(Bandura, 1998; Hausenblas & Rhodes, 2017). Social cognitive theorists assert that observational learning
is most effective when the person being observed is powerful, respected, or considered to be similar to the
observer (Bandura, 1998; Trost & Loprinzi, 2011). As such, parents – often the primary caregivers,
behavioural models, environmental gate-keepers, and social forces in young children’s lives – are
regarded as potentially potent sources of influence (Davison & Birch, 2001; Gustafson & Rhodes, 2006;

In practice, research on the relationship between parental modeling and children’s levels of physical
activity has produced mixed results. A 2006 survey of the literature by Gustafson and Rhodes found that,
of 14 studies examining the relationship between parental modeling and children’s PA, six found a
positive correlation, seven found no relationship, and one found an inverse relationship between
children’s and parents’ physical activity levels (Gustafson & Rhodes, 2006). In contrast, 18 of 19 studies
looking at the relationship between parental support and children’s PA found a strong positive correlation.
Trost and Loprinzi (2011) evaluated 103 studies examining parental influence on children’s PA, and
found little evidence of association between parent and child activity levels. Yao and Rhodes (2015)
identified 12 review papers summarizing research on the relationship between parent and child PA. Of
these, three did not support a link between the two variables, while eight were inconclusive. In addition,
Yao and Rhodes conducted a comprehensive meta-analysis of 115 studies in order to produce a
quantitative estimate of the effect sizes of parental modeling and support. Their results found a weak
association between parental modeling and children’s physical activity (summary $r = 0.16$, 95%
confidence interval (CI) = 0.09-0.24), while analysis of parental support produced a moderate effect size
(summary $r = 0.38$, 95% CI = 0.30-0.46).
Other reviews have shown a more substantial modeling effect. In a systematic review of parental influences on physical activity in young children (aged 2-7), Mitchell et al. (2012) found that nine out of 10 studies evaluating the impact of parental PA on children’s activity found a significant positive association. Xu et al.’s 2015 review of the effect of parental influences on physical activity and screen time among young children (aged less than 6) found moderate to strong evidence of association between parental PA and children’s activity levels, with eight out of 10 analyzed studies showing a significant positive relationship.

A number of possible explanations exist for this relative inconsistency. One important factor to consider is the moderating effect of age. The reviews by Mitchell et al. and Xu et al. that found a more consistent relationship between modeling and children’s activity were specific to younger children (aged 2-7 and <6, respectively), while those that produced more mixed results spanned a wider age range, often from early childhood to adolescence. While still including data from older, school-aged children, Pugliese and Tinsley (2007) found that the relationship between parental modeling and younger children’s activity (aged < 9.75) was significantly stronger than that with older children (aged 9.75-12), a pattern that may well persist at earlier ages.

The context of parental activity is another important variable. Trost and Loprinzi (2011) note that studies of parental modeling often do not differentiate between parental PA performed independently and activity performed with children, where activities performed independently would offer limited opportunities for observational learning and emulation. Children’s level of awareness of their parents’ physical activity, whether or not they are present when it is performed, may also play a role.

Finally, several reviewers suggest a possible moderating relationship between parental activity, parental support, and children’s activity levels (Gustafson & Rhodes, 2006; Trost & Loprinzi, 2011). It can be argued that parental modeling alone is insufficient to remove barriers or otherwise enable children’s
activity, and that when adequate support is also provided, the influence of modeling can be felt. Studies that have sought to demonstrate this relationship statistically have found that, when a significant correlation between children’s and parents’ physical activity levels is observed, this relationship is rendered trivial once support is added to the model (Welk et al., 2003).

In describing the impact of parental modeling on children’s PA, many reviewers make reference to Moore et al.’s 1991 study of objectively measured physical activity in a cohort of 4-7 year olds. This well-regarded study aptly illustrates the gendered and cumulative dimensions of the modeling construct. Using data from the Framingham Children’s study, the researchers found that children with active mothers were twice as likely to be active than those with inactive mothers, children with active fathers were 3.5 times more likely to be active than those with inactive fathers, and children with two active parents were almost six times more likely to be active than children from families with less active parents.

While Trost and Loprinzi (2011) found that the influence of maternal and paternal activity levels on children’s PA did not appear to be sex specific, other recent reviews have observed a gendered effect. Gustafson and Rhodes (2006) found that mothers’ level of activity was more consistently correlated with daughters than with sons, with six of 11 studies analyzing the maternal PA modeling relationship showing a significant mother-daughter correlation, while only three were observed for mothers and sons. The same reviewers found a smaller body of evidence suggesting that fathers’ activity may exert a stronger overall influence on children of both sexes, with a more pronounced effect on sons than on daughters (Gustafson & Rhodes, 2006).

Yao and Rhodes' 2015 meta-analysis attempted to quantify the moderating effects of gender on parental PA modeling, and largely supported the relationships described above. In 49 studies, the effect of father-son PA modeling ($r = 0.29, 95\% \text{ CI} = 0.21-0.36$) was significantly stronger than mother-son PA modeling ($r = 0.19, 95\% \text{ CI} = 0.14-0.23$). Parent gender did not moderate the relationship between parental
modeling and daughters’ PA, that is, in the 62 studies analyzed, the correlation between father-daughter and mother-daughter activity levels did not differ significantly. Further inquiry into those factors that moderate the impact of physical activity in parents of all genders on their children’s behaviours may provide valuable insights into the integral role that mothers and fathers play in establishing and maintaining healthy PA norms throughout the early years and beyond. Yao and Rhodes stress that this relationship may be particularly salient early in life, when parents play a more critical role than peer or other environmental influences, and when parent-child co-PA is likely to be more prevalent than at later developmental stages.

2.10.2 SUPPORT

Social cognitive theory may also serve as a basis for explaining the effects of parent’s supportive behaviours on their children’s physical activity. Adherents of this theory assert the importance of a supportive environment – where actions are encouraged and facilitated, and barriers are minimized – to the establishment and maintenance of desired behaviours (Bandura, 1998; Hausenblas & Rhodes, 2017; Trost & Loprinzi, 2011). As described above, reviews of the impact of parental support on children’s PA have produced consistent positive results (Gustafson & Rhodes, 2006; Trost & Loprinzi, 2011; Yao & Rhodes, 2015). Xu et al. (2015) found moderate to strong evidence linking parental support with children’s PA, while Pugliese and Tinsley's 2007 meta-analysis found that children and adolescents were almost twice as likely to be active when their parents were supportive. Mitchell et al. (2012) found that parent’s supportive behaviours were positively associated with physical activity in 2-7 year olds, and cited one study, by Zecevic, Tremblay, Lovsin, and Michel (2010), which found that preschoolers who received greater parental support were 6.3 times more likely to be highly active (>1hr daily PA, subjective report) than those children whose parents were less supportive. Gustafson and Rhodes (2006) posit that the correlation between parental support and children’s activity may be direct, as is more likely in the case of parental involvement or facilitation, or indirectly mediated by psychosocial constructs such as self-efficacy.
Parental support is often dichotomized into two dimensions; encouragement and facilitation (Beets, Cardinal, & Alderman, 2010; Gustafson & Rhodes, 2006; Pugliese & Tinsley, 2007; Trost & Loprinzi, 2011; Yao & Rhodes, 2015). Encouragement refers to the persuasion, promoting, or prompting of a child to be active (Pugliese & Tinsley, 2007), and praising them when they do so (Yao & Rhodes, 2015), while facilitation refers to the instrumental component of support, that is, parental behaviours that eliminate barriers or concretely facilitate access to opportunities for children to be physically active (Gustafson & Rhodes, 2006; Pugliese & Tinsley, 2007; Trost & Loprinzi, 2011). This might include enrolling children in physical activity programs; providing transport to exercise, sport, or activity events or venues; provision of sporting or play equipment; organizing children’s physical environment in a way that is conducive to activity; or other forms of material or financial support (Gustafson & Rhodes, 2006; Pugliese & Tinsley, 2007; Trost & Loprinzi, 2011). In their study of the mechanisms of parental influence on children’s physical activity, Welk, Wood, and Morss (2003) found that facilitation exerted a greater unique influence on activity outcomes than other parental support constructs such as encouragement and involvement. Focus group research on the topic has found that facilitative behaviours such as providing transport to sporting or PA-friendly locations increases children’s subjectively reported PA; while barriers to facilitation such as lack of transport or funds for organized activities have been identified as a significant parental concern (De Lepeleere, DeSmet, Verloigne, Cardon, & De Bourdeaudhuij, 2013; Smith et al., 2010).

Researchers have posited a number of factors that potentially moderate the impact of parental support on children’s PA behaviours. In their 2006 review, Gustafson and Rhodes found that younger children were more likely to receive parental support, and were more receptive to verbal prompts encouraging physical activity. The same review found that boys tended to receive more parental support than girls – specifically, support for exercise and encouragement to participate in competitive sports – and that parental support explained more of the variance in PA behaviour in boys than in girls. These reviewers
argue that differences in parental support due to sex could be an important factor in explaining the differences in boys’ and girls’ activity levels that are observed from a young age and persist throughout the lifespan.

Inquiry into the differing impacts of parental support attributable to parent gender has produced less conclusive results. Pugliese and Tinsley’s (2007) meta-analysis found no statistical differences between mothers and fathers in relation to child and adolescent PA. Trost and Loprinzi’s (2011) review found that only 11 of the 71 evaluated studies assessed support by mothers and fathers separately; most gave a single measure that combined the supportive behaviours of both parents. Those studies that did assess parental support on an individual basis had less conclusive results than those that assessed combined support, with 38% reporting positive, significant results for maternal support and 57% reporting positive, significant results for paternal support, compared with 69% of those that measured support behaviours of both parents. The reviewers attribute this inconsistency to methodological differences between the studies, and the tendency of those studies using individual measures of parental support to be smaller in sample size and lower in statistical power. Yao and Rhodes (2015) found no statistical difference with regard to parental gender when looking at mothers’ and fathers’ support for their daughters’ physical activity, but discovered a limited amount of research with fathers suggesting that the father-son dyad could be particularly salient with regard to boys’ PA.

Similarly, other potential moderators of the impact of parental support have been subject to limited amounts of scholastic inquiry. Pugliese and Tinsley’s (2007) review, for example, did not take ethnic or socioeconomic influences into account, while acknowledging that variability would exist as a function of both. Gustafson and Rhodes (2006) found a limited amount of data suggesting that socioeconomic status (SES) may be positively correlated with support’s effect on children’s activity, although this finding’s validity suffers due to the use of inconsistent and sometimes unvalidated measures of SES across the associated studies. The bulk of the research on physical activity parenting and ethnicity has occurred in
the United States; further research is needed to flesh out the interactions between socioeconomic and environmental differences and the observed discrepancies in parental support between American ethnic groups (Gustafson & Rhodes, 2006; Trost & Loprinzi, 2011), as well as further research on the effect of ethnicity in the Canadian and other national contexts. Some work has been done around the impact of family structure, but more research is needed on the ways that only-child, multiple sibling, single parent, dual parent, same-sex, blended, and bi-nuclear households negotiate and enact their familial roles with regard to physical activity support in a variety of cultural and national contexts and physical, social, and policy environments (Davison et al., 2013; Gustafson & Rhodes, 2006; Trost & Loprinzi, 2011).

2.10.3 CONTROL

A third aspect of parenting practice identified by research as significant to children’s activity are the ways in which parents control physical activity and related behaviours. The use of physical activity as a reward, and the threat of diminished opportunities for active play as a disciplinary tool, are areas of particular interest. Davison et al. (2013) define control as where parents exert influence over children through directive, restrictive, and punitive parenting practices with the goal of forcing children to meet parent demands. Trost and Loprinzi (2011) found that forms of control over physical activity -- establishing barriers and restricting access to opportunities for active play or outdoor time -- were important elements of parental influence. Vaughn, Hales, and Ward (2013), while acknowledging the relative lack of available survey instruments for assessing the full range of rules and limits parents may impose around their children’s active play, found that the use of physical activity to control other aspects of children’s behaviour was associated with increased levels of outdoor time and MVPA. Further research into controlling physical activity parenting practices – wilfully restricting physical activity or limiting access to opportunities to be active, and the use of physical activity as a disciplinary tool, reward, or punishment – is necessary.
2.10.4 METHODOLOGICAL CONCERNS

Across the breadth of literature on physical activity parenting, a number of methodological concerns are consistently raised. One major point of interest is the lack of longitudinal studies in the area. In each of the systematic reviews of parenting practice and physical activity cited above, cross-sectional studies made up at least 80% of the body of research being analyzed (Gustafson & Rhodes, 2006; Mitchell et al., 2012; Pugliese & Tinsley, 2007; Trost & Loprinzi, 2011; Yao & Rhodes, 2015). More longitudinal studies are needed in order to more effectively infer causality, and to analyze the ways in which relationships evolve and shift in relation to time and social context (Yao & Rhodes, 2015).

Pugliese and Tinsley (2007) found a significantly greater relationship between parental behaviours and children’s activity in studies that used some form of convenience sampling as opposed to a principled sampling method. They suggest that over-reliance on volunteers likely leads to oversampling of more active families, a self-selection bias that is inherent in much of the research on familial physical activity. Mitchell et al. (2012) provide a further critique of sampling practices in questioning the generalizability of data that is largely based on white, urban, well-educated, middle-to-upper class populations, as suggested by the lack of research on a more varied range of ethnic and socio-economic groups.

Lack of gender parity is also an issue, as the over-representation of mothers and the relative lack of studies analysing the unique influences of mothers and fathers within the full spectrum of family structures has resulted in significant gaps in our understanding of the maternal and paternal roles as they relate to children of both sexes (Mitchell et al., 2012; Vollmer, Adamsons, Gorin, Foster, & Mobley, 2015; Yao & Rhodes, 2015). Future research that targets and incentivizes fathers’ participation is necessary to leverage the demonstrated influence that fathers have on their children’s health behaviours (Davison et al., 2016; Morgan et al., 2017).
Subjective reports – by participants or a proxy -- of physical activity are associated with social desirability, recall, and other reporting biases, and substantial measurement error (Cliff, Reilly, & Okely, 2009; Livingstone, Robson, Wallace, & McKinley, 2003; Oliver et al., 2007; Reilly et al., 2008; Trost, 2007). While reviews demonstrate that the majority of studies still rely on subjective reports of physical activity (Pugliese & Tinsley, 2007; Trost & Loprinzi, 2011; Xu et al., 2015; Yao & Rhodes, 2015), Yao and Rhodes (2015) found that method of PA measurement was a significant moderator of effect size. Their analysis found that studies based on objective measures demonstrated a small effect size ($r = 0.20$, 95% CI = 0.13–0.26), compared with a moderate effect for those based on self-reports ($r = 0.46$, 95% CI = 0.37–0.55). The use of objective measures of PA in order to accurately quantify and classify physical activity of different intensity levels in young children, as per national guidelines, is recommended (Oliver et al., 2007; Pate et al., 2010; Reilly et al., 2008; Trost, 2007; Trost & Loprinzi, 2011).

Finally, more research that is specific to the lived experiences and practical realities of preschool aged children and their parents is necessary (O’Connor et al., 2013; Yao & Rhodes, 2015). Researchers note that effective supportive practices vary across developmental stages (Lindsay et al., 2006; Trost & Loprinzi, 2011), and should be categorized and explored accordingly (Yao & Rhodes, 2015). Identifying those parental behaviours that are significantly predictive of healthy levels of physical activity during children’s early years – the ways that parents can most effectively support young children in being active – contributes to a growing, ecologically valid evidence-base supporting healthy families and populations.

3.0 RATIONALE, RESEARCH OBJECTIVES & HYPOTHESES

3.1 RATIONALE

Low levels of physical activity among toddlers and preschoolers are a significant factor in the continued high prevalence of overweight and obesity among Canadians of all walks of life (Garriguet et al., 2016; Rao et al., 2017). Effective parenting practices have been associated with increases in young children’s levels of activity, but, as discussed above, significant gaps exist in the corpus of research on the subject.
(Davison et al., 2013; Gustafson & Rhodes, 2006; Mitchell et al., 2012; Pugliese & Tinsley, 2007; Trost & Loprinzi, 2011; Xu et al., 2015; Yao & Rhodes, 2015). The aim of this project is to contribute to our understanding of effective physical activity parenting during the early years by addressing the following three key limitations.

First, the project helps to address the lack of data on fathers’ unique role in modeling and supporting their children’s exercise and activity behaviours. While evidence has shown that fathers’ PA habits and parenting practices may have a particularly salient impact on their children’s activity levels (Gustafson & Rhodes, 2006; Li et al., 2015; Moore et al., 1991; Trost & Loprinzi, 2011; Yao & Rhodes, 2015), fathers are dramatically underrepresented in the research on parenting and pediatric health, both in terms of their participation, and in the publication of results that pertain specifically to paternal practice (Davison et al., 2016; Mitchell et al., 2012; Morgan et al., 2017; Vollmer et al., 2015; Walsh, Crawford, Cameron, Campbell, & Hesketh, 2017). The relative lack of scholarly inquiry in this area presents a significant opportunity for health researchers to generate impactful knowledge targeting an understudied and influential population, and to potentially facilitate increases in paternal involvement and engagement in critical early life health behaviours via targeted interventions that take into account fathers’ specific roles and contributions to the family dynamic. Our study includes data from fathers, whose physical activity parenting behaviours and their effects are disaggregated and compared to participant mothers in order to identify differences in the relationships between maternal and paternal PA parenting practices and their influence on their sons’ and daughters’ observed levels of physical activity.

Second, our study makes use of objective measures of children’s physical activity. As discussed above, while the bulk of current research is based on subjective reports of PA, objective measures avoid the biases associated with these (Cliff et al., 2009; Pate et al., 2010; Reilly et al., 2008; Trost, 2007; Trost & Loprinzi, 2011). Accelerometers in particular provide a more accurate assessment of the frequency, duration, and intensity of instances of physical activity than proxy- or self-reports of PA (Bornstein,
Beets, Byun, & McIver, 2011; Oliver et al., 2007; Pate et al., 2010; Reilly et al., 2008). Accelerometers are small, lightweight, and durable, making them an effective tool for use with pediatric populations where obtrusive or overly delicate instruments would be impractical (Cliff et al., 2009; Pate et al., 2010; Trost, 2007). In addition, accelerometers are a good fit to the nature, patterns, and tempo of physical activity in young children, which is often unpredictable, intermittent, sporadic, and omnidirectional.

Children’s MVPA tends to occur in periodic bursts of motion interspersed with periods of sedentary behaviour and lower intensity physical activity, and is infrequently maintained for continuous amounts of time (i.e. walking fast or running for minutes at a time) (Bailey et al., 1995; Cliff et al., 2009; Oliver et al., 2007). In their ability to capture short bursts of activity of varying intensity and in different planes, accelerometers are well-suited to quantifying and classifying movement among toddlers and preschool-aged children (Bornstein et al., 2011; Cliff et al., 2009; Oliver et al., 2007; Trost, 2007). Use of objectively-measured physical activity data allows for more accurate estimates of activity prevalence and a clearer description of the dose-response relationships between parenting practices and children’s PA behaviours in our study population.

Finally, our research aims to shed light on those parenting practices that are most effective with regard to physical activity during the early years. Clear guidelines for physical activity requirements among Canadian toddlers and preschoolers are a relatively recent development (Tremblay et al., 2012). As such, research into the practices that are conducive to adequate levels of activity in this population is a relatively new field of inquiry. Reviewers have identified the need for assessments of the PA parenting – child PA relationship that take into account children’s age, as practices that are conducive to higher levels of physical activity are likely to be developmentally-specific (Davison et al., 2013; Lindsay et al., 2006; Mitchell et al., 2012; Pugliese & Tinsley, 2007; Yao & Rhodes, 2015). Our research aims to elucidate those aspects of parenting practice that significantly impact the behaviour of children under the age of five – a critical developmental stage during which physical activity habits are formed that are likely to be maintained throughout the lifespan (Craigie et al., 2011; Jones et al., 2013; Telama, 2009), and during
which parents potentially wield substantially greater influence than at later life stages (Welk et al., 2003; Yao & Rhodes, 2015).

3.2 RESEARCH OBJECTIVES

The overall objective of our research is to examine the relationship between PA-related parenting practices and young children’s objectively measured levels of physical activity. More specifically, this project aims to identify and assess gendered differences in parental influence – the varying impact that mothers’ and fathers’ modeling, supportive, and controlling practices may have on their sons’ and daughters’ PA behaviours.

3.3 HYPOTHESES

We hypothesize that children whose parents model appropriate physical activity behaviours and regularly enact supportive PA parenting practices will engage in more total PA and MVPA, and that children whose parents exercise more control over their physical activity behaviours (limiting access to opportunities for active recreation or outdoor time, or using sports, physical activities, or outdoor time as a reward or punishment) will engage in less. We hypothesize that the main effect of support will be greater than that of modeling, and that parental modeling and support will interact such that modeling’s impact on children’s activity will be significantly greater in the presence of higher levels of support. As suggested by previous research, we hypothesize that gender will exert significant effects on the relationship between parenting practices and children’s activity, with mothers’ modeling and support behaviours more strongly associated with daughters’ physical activity than with sons’, fathers’ modeling and support behaviours more strongly associated with sons’ PA than with daughters’, and with fathers’ PA parenting practices displaying a stronger association with physical activity levels in children of either sex than mothers’.
4.0 METHODS

4.1 RECRUITMENT AND ELIGIBILITY

Baseline data was obtained from the Guelph Family Health Study (GFHS) phase 2 pilot. The GFHS is a home-based, longitudinal study aimed at identifying early life risk factors for obesity and chronic disease, and testing family-based intervention strategies for instilling and maintaining healthy behaviours from the early years on. Participant families were drawn from the Guelph/Wellington County region of Southern Ontario (Guelph, Rockwood, Fergus, Elora, Mount Forest, and Puslinch), and were recruited through a combination of flyers and posters, word-of-mouth, social media outreach, and partnerships with local community health organizations including the Guelph Family Health Team, Guelph Community Health Centre, YMCA-YWCA of Guelph, and local Ontario Early Years Centres. Inclusion criteria comprised having at least one child between the ages of 18 months and 5 years old at the time of recruitment, residence in the Guelph area with no plans to relocate in the coming year, English literacy in at least one parent in order to complete study questionnaires, and the absence of any severe health conditions that would prohibit children from participating in study activities. The study was approved by the University of Guelph Research Ethics Board (REB14AP009, see Appendix A), and all procedures were administered after receiving parents’ written informed consent (see Appendix B). In total, 39 families (64 parents and 60 children) participated in the phase 2 pilot, with 47 participant children completing the accelerometry component of the study.

4.2 DATA COLLECTION

Following eligibility screening and informed consent, participating parents completed an online questionnaire capturing basic demographic information (gender, ethnicity, number of children, marital status, relation to children, education, income, time in Canada) as well as information related to parents’ habitual physical activity and PA parenting practices. Home-visits were then arranged through the study co-ordinator, during which interested families were provided with instructions and accelerometers for each participating child.
4.2.1 PREDICTOR VARIABLES

4.2.1.1 MODELING

Two dimensions of parental modeling – habitual physical activity and intentional modeling practices -- were analyzed. Habitual physical activity in participating parents was assessed using the International Physical Activity Questionnaire – Short Form (IPAQ-SF), which was included as one module of the GFHS questionnaire. The IPAQ-SF is a self-administered surveillance instrument designed to measure adult physical activity across multiple domains (Bauman et al., 2009; IPAQ, 2005). It has shown acceptable reliability and validity in a representative sample of healthy Canadian adults (Craig et al., 2003) and is useful for categorizing individuals into low, moderate, and high levels of PA participation and/or estimating their median weekly energy expenditure expressed in metabolic equivalent (MET) - minutes (IPAQ, 2005).

In conjunction with the IPAQ-SF, the online questionnaire contains four items pertaining to parents’ approach to modeling PA behaviours: “I encourage my child to be physically active by being active myself and leading by example (role modeling)”, “I make sure my child is aware that I am physically active”, “I exercise or am physically active on a regular basis”, and “I enjoy exercise and physical activity”. These items were drawn from the Activity Support Scale for Multiple Groups (ACTS-MG) , a measure of parental support for children’s activity that has been validated in an ethnically diverse sample of American parents (Davison, Li, Baskin, Cox, & Affuso, 2011; Sleddens et al., 2012). Each item was answered using a four-point response scale with the response categories 1 - ‘strongly disagree’, 2 – ‘disagree’, 4 – ‘agree’, and 5 – ‘strongly agree’. The sum of the four item scores was averaged and used as a composite measure of intentional parental PA modeling.

4.2.1.2 SUPPORT

The GFHS questionnaire includes four items related to parents’ logistic support of their children’s PA: “I enroll my child in sport teams or activities such as soccer, basketball, and dance”, “I take my child to
places where s/he can be active”, “I take my child outside to play when the weather is nice”, and “I would rather my child play indoors because I don't want to sit outside and watch him/her play”, the last of which was reverse coded to provide a positive measure of support for outdoor activity. Items were drawn from the ACTS-MG (Davison et al., 2011) and a physical activity parenting practice survey developed by Vaughn, Hales, and Ward (2013) for use among parents of 2-5 year old children. As above, items were answered using a four-point response scale and averaged to generate a composite measure of instrumental/logistic support.

4.2.1.3 CONTROL
Parental control or limiting of children’s physical activity and outdoor time and/or use of PA and outdoor time as a disciplinary tool were assessed using four questionnaire items: “I offer sports or physical activities to my child as a reward for good behaviour”, “I use sports and physical activities to get my child to do something (e.g. ‘You can’t go outside to play until you eat all your peas.’)”, “I offer extra outdoor time as a reward for good behaviour”, and “I take away outside time for bad behaviour”; all drawn from Vaughn et al.’s (2013) PA parenting practice survey. Again, items were answered using a four-point response scale, and averaged to generate a composite score for parental control of children’s physical activity and outdoor time and use of PA and outdoor time as a means to control other aspects of behaviour.

4.2.2 OUTCOME VARIABLE
4.2.2.1 CHILDREN’S PHYSICAL ACTIVITY
Children’s physical activity was measured via accelerometry. Accelerometers have been described as the method of choice for objective measurement of physical activity in free-living individuals (Bornstein et al., 2011; Reilly et al., 2008; Trost, 2007), and have been shown to produce reliable and valid estimates of time spent engaged in physical activity of varying intensity levels in preschool aged children (Oliver et al., 2007; Pate, Almeida, McIver, Pfeiffer, & Dowda, 2006; Trost, 2007). The Actigraph GT3-X

36
(Actigraph, 2017a), a triaxial accelerometer whose uniaxial antecedents have well-established utility and validity for research among preschoolers (Cain, Sallis, Conway, Van Dyck, & Calhoon, 2012; Cliff et al., 2009; Oliver et al., 2007; Pate et al., 2010) was used. Parents were given an accelerometer for each participating child, and instructed to place accelerometers on their child’s right hip, next to the umbilicus, in keeping with current literature suggesting that hip placement is likely to produce the most accurate estimates of pediatric PA (Cliff et al., 2009; Reilly et al., 2008; Toschke et al., 2007; Yang & Hsu, 2010). Children were asked to wear the accelerometer for seven days, 24 hours a day, removing it only for water based activities such as swimming and bathing. Research by Penpraze et al. (2006) has demonstrated that a monitoring time of seven days maximizes reliability of PA estimates in young children. In keeping with the body of research suggesting that shorter epoch lengths are better at capturing the short bursts of MVPA common to the target age group (Colley, Harvey, Grattan, Adamo, & Colley, 2014; Hislop, Bulley, Mercer, & Reilly, 2012; Vale, Santos, Silva, Soares-Miranda, & Mota, 2009), a 1-second epoch length was used. Accelerometers were set to a sampling frequency of 30 hertz. The ActiLife software (Actigraph, 2017b) was used as a data analysis platform, with the algorithm developed by Choi, Liu, Matthews, and Buchowski (2011) used to classify wear and non-wear times. Only subjects with a minimum of 6 hours of valid wear time per day for a minimum of 3 days, commonly used thresholds for ‘valid days’ and minimum wear days in studies of pre-school aged children (Cain et al., 2012), were included in the analysis.

Activity count cut-points validated for use among free-living pediatric populations were applied to the accelerometry-derived activity counts to classify activity as sedentary, light-intensity, or moderate-to-vigorous intensity. Cut-points, derived from calibration with measures of energy expenditure or direct observation, that denote population specific activity count thresholds are typically used to classify periods of accelerometer-recorded activity into various levels of intensity (sedentary behaviour or SB, light-intensity physical activity or LPA, and moderate-to-vigorous physical activity or MVPA) (Cliff et al., 2009; Reilly et al., 2008). The problem of ‘cut-point non-equivalence’ and the wide and biologically
meaningful variation in classification of activity intensities that results from the use of any of the different cut-points validated for use in pediatric populations has been the subject of much discussion (Bornstein et al., 2011; Cliff et al., 2009; Colley et al., 2013; Hnatiuk et al., 2014; Oliver et al., 2007; Reilly et al., 2008; Trost, 2007). While consensus on the most appropriate set of cut-points for use among pre-school aged children has yet to be reached, some research (Janssen et al., 2013) has indicated higher classification accuracy for 4-6 year old children’s MVPA using the Pate et al. (2006) formulation of ≥ 420 counts/15s relative to other cut-points validated in pediatric populations. The Pate et al. thresholds were calibrated using activity counts and VO2 in a study population of healthy, North American 3-5 year olds (M = 4.4, SD = 0.8) engaged in structured activities. Cut-points for MVPA and vigorous physical activity (VPA) were determined using linear equations, and cross-validated with the same population’s activity counts and VO2 during free-living, unstructured play. More recent research by Trost, Fees, Haar, Murray, and Crowe (2012) derived a similar threshold for MVPA (> 418 counts/15s) from calibration with toddlers’ (M = 2.1 years, SD = 0.4 directly observed physical activity during free play, with cut-points determined using receiver operating characteristic (ROC) curve analyses. While supporting the use of the Pate cut-points for MVPA, the Trost et al. guidelines also include similarly derived thresholds for light-intensity physical activity, and so were used throughout our analysis to classify children’s daily activity as SB, LPA, or MVPA. Once classified, bouts of activity at the different levels of intensity were summed and divided by the number of eligible calendar days on which the accelerometer was worn to produce estimates of mean daily total physical activity (LPA plus MVPA) and MVPA.

4.2.3 COVARIATES

Information on household income, preschool or daycare attendance, presence of siblings, and the proximity of the family dwelling to children’s play areas was collected through the initial online questionnaire. Total pre-tax annual household income was determined through self-report by the primary parent, with respondents choosing from a list of $10 000 increments ranging from less than $10 000 to $150 000 or more. Preschool or daycare attendance was determined through one questionnaire item
asking if the participating child or children is/are currently attending childcare, day care, preschool, or school. Presence of siblings was determined through one questionnaire item asking the number of children in the household. Proximity to children’s play areas was assessed by one questionnaire item asking if there is a children’s playground within ten minutes walking distance of the respondent family’s residence. All three of the preceding items were coded dichotomously. The accelerometer wear-period’s start and end dates were recorded by parents in a log book and retrieved upon return of the devices. Start and end dates were used to categorize accelerometer wear-periods according to season, with winter defined as December through February, spring as March through May, summer as June through August, and fall as September through November, in keeping with other research conducted in the northern hemisphere (Carson et al., 2010).

5.0 DATA ANALYSIS

Statistical analyses, including generation of descriptive statistics illustrating the general demographic characteristics of the study population, tests of internal consistency, data distribution analyses and tests of normality, and generalized estimating equations, were conducted using SAS University Edition (SAS Institute Inc., 2016).

5.1 INTERNAL CONSISTENCY

Cronbach’s α is a commonly used method of assessing the internal reliability of a psychometric test. More specifically, it describes the internal consistency of a multi-item measure, indicating how closely related the responses to a set of items that ostensibly measure a similar construct are (Field, 2013; Gliner, Morgan, & Leech, 2017). In order to verify the internal consistency of the GFHS survey measures of parenting practice, the Cronbach’s coefficient α’s of all three parenting practice indicators for both mothers and fathers – that is, maternal and paternal modeling, support, and control – were generated using SAS’ CORR procedure.
In general, the survey measures scored well, with coefficient α’s above the accepted benchmark of 0.70 (Field, 2013; Ho Yu, 2001). The lone exception was the maternal support construct, which produced an initial coefficient α of 0.13. Data produced by SAS illustrated that this low coefficient was due in large part to one survey item assessing parental enrolment of children in structured activities -- “I enroll my child in sport teams or activities such as soccer, basketball, and dance” -- which displayed a negative correlation with the total test score ($r = -0.12$). The impact of an individual item on the overall test of internal reliability can be illustrated by calculating the Cronbach’s α for the remaining items when the item in question is removed (Ho Yu, 2001). In this case, when the item assessing maternal enrolment of children in structured activities was removed from the overall scale measuring maternal support, Cronbach’s α for the remaining four items increased to an acceptable level ($α = 0.71$, see Table 1).

A similar pattern was observed in the scale measuring paternal support. While this measure’s omnibus coefficient α was already adequate ($α = 0.77$), the item assessing paternal enrolment of children in structured activities, as with its maternal counterpart, exhibited the lowest correlation with the total test score ($r = 0.39$, compared with correlation coefficients ranging from 0.55 to 0.76 for the other four items). As in the case of the maternal construct, removing this item alone from the paternal support scale resulted in an improved Cronbach’s α ($α = 0.86$, see Table 1). Based on this analysis, and on the item’s questionable face validity in that there might not be sufficient amounts of sports programming and structured activities available in the community to children in the target age range, the item assessing parental enrolment of children in structured activities was removed from the overall measure of parental support, and instead analyzed as a stand-alone construct heretofore referred to as ‘parental enrolment in structured activities (SA)’.
Table 1. Cronbach’s coefficient α of full and adapted* parental support scale.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Cronbach’s α of full scale</th>
<th>Cronbach’s α of adapted scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal modeling</td>
<td>0.81</td>
<td>0.81</td>
</tr>
<tr>
<td>Maternal support</td>
<td>0.13</td>
<td>0.71</td>
</tr>
<tr>
<td>Maternal control</td>
<td>0.88</td>
<td>0.88</td>
</tr>
<tr>
<td>Paternal modeling</td>
<td>0.88</td>
<td>0.88</td>
</tr>
<tr>
<td>Paternal support</td>
<td>0.77</td>
<td>0.86</td>
</tr>
<tr>
<td>Paternal control</td>
<td>0.84</td>
<td>0.84</td>
</tr>
</tbody>
</table>

*Coefficient α’s calculated after removing item “I enroll my child in sport teams or activities such as soccer, basketball, and dance” from scale.

5.2 DISTRIBUTION ANALYSIS & TESTS OF NORMALITY

Prior to applying the generalized estimating equation (GEE), distribution of the outcome variables was assessed. While both moderate-to-vigorous physical activity and total physical activity displayed adequate normality according to histograms and Q-Q plots, TPA did produce a significant Kolmogorov-Smirnov test score ($p = 0.03$); it was assumed that this would not disproportionately impact the GEE’s efficiency.

5.3 GENERALIZED ESTIMATING EQUATIONS

Generalized estimating equations can be used to analyze data that arises from correlated observations (Homish, Edwards, Eiden, & Leonard, 2011; Liang & Zeger, 1993). In our case, GEEs were applied to account for clustering of responses among family members while assessing the relationships between each of our predictive factors (maternal and paternal habitual PA, intentional modeling, support, and control) and children’s physical activity outcomes. Coefficient estimates were produced for an unadjusted model, and a model adjusted for child sex and family income. While a number of other factors (preschool or daycare attendance, presence of siblings, proximity of family dwelling to children’s play areas or parks, season) have been posited as potential confounders (Bingham et al., 2016; Garriguet et al., 2016; Hesketh et al., 2017; Hinkley et al., 2008; Lindsay et al., 2017; Pfeiffer, Dowda, McIver, & Pate, 2009) and response data on these variables was collected, the relatively small size of the final study population precluded their inclusion in the statistical analysis. Despite the small sample size, the gendered effects of
parental influence were explored via analyses stratified by child sex. While the initial hypotheses had included a posited interaction between parental modeling and support, the relatively small size of the data set also precluded this analysis. In all analyses, significance was determined as $p \leq 0.05$.

6.0 RESULTS

6.1 STUDY POPULATION

As described above, 47 of the 60 child participants in the GFHS Pilot Phase 2 completed the accelerometry component of the study. Of these, 35 met the wear-time criteria of 6 hours/day for a minimum of three days. In order to maximize comparability between maternal and paternal factors, only those participants who had survey response data from two parents were included in the final analysis. The final study population included 24 child participants from 16 households. Among the included subjects, the mean number of days on which the accelerometers were worn was 8 ($SD = 1.26$), while the mean daily wear-time was 19 hours ($SD = 2.28$).

6.2 PARTICIPANT DEMOGRAPHICS

Individual and family level demographic characteristics of study participants are presented in Tables 2 and 3, respectively. Of the 24 participating children, 15 were male (62.5%) and 9 were female (37.5%). The study population was relatively homogenous in terms of ethnicity, with 21 of the children (87.5%) identified by their parents as white. Twenty-one participants (87.5%) spent time outside of parental care (i.e. were enrolled in school, preschool, or daycare, or were receiving in-home care from a babysitter, nanny, or relative). Sixteen participants wore their accelerometers during the spring (67%), 4 during winter (17%), and 2 each in summer and fall (8% each). The mean age of participant children at the time of accelerometer assessment was 3.9 ($SD = 1.48$), with participants ranging in age from 2 to 6 years old.

Sixteen households were represented in the study. Of these, 12 were home to multiple siblings (75%). Structurally, participant families were quite homogenous, with 15 of 16 reporting a two-parent family
structure (94%). Similarly, household income was clustered in the higher range, with no families reporting an annual income of < $50,000, 10 families reporting an annual income between $50,000 and $100,000 (62.5%), and 6 families reporting an annual income over $100,000 (37.5%). Mean reported household income was $116,250 (SD = $31,389.90). All participating families reported living within 10 minutes walking distance of a children’s outdoor play area or park.

Table 2. Participant characteristics, individual level.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Count (%) / Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>24 (100)</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>9 (37.5)</td>
</tr>
<tr>
<td>Male</td>
<td>15 (62.5)</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>21 (87.5)</td>
</tr>
<tr>
<td>Other</td>
<td>3 (12.5)</td>
</tr>
<tr>
<td>In care*</td>
<td>21 (87.5)</td>
</tr>
<tr>
<td>Season</td>
<td></td>
</tr>
<tr>
<td>Winter</td>
<td>4 (17)</td>
</tr>
<tr>
<td>Spring</td>
<td>16 (67)</td>
</tr>
<tr>
<td>Summer</td>
<td>2 (8)</td>
</tr>
<tr>
<td>Fall</td>
<td>2 (8)</td>
</tr>
<tr>
<td>Age</td>
<td>3.90 (1.48)</td>
</tr>
</tbody>
</table>

*whether subject spends time outside of parental care (i.e. enrolled in school, preschool, or daycare, or receiving in-home care from a babysitter, nanny, or relative)

Table 3. Participant characteristics, family level.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Count (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>16 (100)</td>
</tr>
<tr>
<td>Siblings present</td>
<td>12 (75)</td>
</tr>
<tr>
<td>Two parent household</td>
<td>15 (94)</td>
</tr>
<tr>
<td>Household income</td>
<td></td>
</tr>
<tr>
<td>$50,000 - $100,000</td>
<td>10 (62.5)</td>
</tr>
<tr>
<td>&gt; $100,000</td>
<td>6 (37.5)</td>
</tr>
</tbody>
</table>
6.3 SUMMARY STATISTICS

Mean scores of PA parenting indicators and children’s PA outcomes are presented in Table 4. Fathers (3522 MET-mins/week, $SD = 2935$) reported substantially higher median levels of habitual physical activity than mothers (1478 MET-mins/week, $SD = 1451$). Scores on the remaining PA parenting indicators were similar across parent genders, with mothers ($M = 4.00, SD = 0.85$) scoring slightly higher than fathers ($M = 3.77, SD = 0.96$) on intentional modeling, mothers ($M = 4.65, SD = 0.37$) scoring slightly higher than fathers ($M = 4.35, SD = 0.67$) on support, fathers ($M = 2.38, SD = 0.97$) scoring slightly higher than mothers ($M = 2.01, SD = 0.96$) on control, and fathers ($M = 4.21, SD = 1.14$) scoring slightly higher than mothers ($M = 4.08, SD = 1.28$) on the stand-alone ‘enrolling in structured activities’ measure. Participant children averaged 96 minutes of daily MVPA ($SD = 24$) and 204 minutes daily TPA ($SD = 38$).

Table 4. Mean scores of parenting practice indicators* and children’s PA outcomes.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean score (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paternal IPAQ**</td>
<td>3522 (2935)</td>
</tr>
<tr>
<td>Paternal modeling</td>
<td>3.77 (0.96)</td>
</tr>
<tr>
<td>Paternal support</td>
<td>4.35 (0.67)</td>
</tr>
<tr>
<td>Enrolling in SA</td>
<td>4.21 (1.14)</td>
</tr>
<tr>
<td>Paternal control</td>
<td>2.38 (0.97)</td>
</tr>
<tr>
<td>Maternal IPAQ**</td>
<td>1478 (1451)</td>
</tr>
<tr>
<td>Maternal modeling</td>
<td>4.00 (0.85)</td>
</tr>
<tr>
<td>Maternal support</td>
<td>4.65 (0.37)</td>
</tr>
<tr>
<td>Enrolling in SA</td>
<td>4.08 (1.28)</td>
</tr>
<tr>
<td>Maternal control</td>
<td>2.01 (0.96)</td>
</tr>
<tr>
<td>MVPA***</td>
<td>96 (24)</td>
</tr>
<tr>
<td>TPA***</td>
<td>204 (38)</td>
</tr>
</tbody>
</table>

*minimum score = 1, maximum score = 5  
**parent’s median MET-mins/week, as calculated by IPAQ-SF  
***average daily minutes
6.4 GEE ANALYSES

6.4.1 PA PARENTING AND CHILDREN’S ACTIVITY

β coefficients derived from the generalized estimating equation analyses of the influence of individual PA parenting practices on children’s MVPA and TPA are presented in Tables 5 and 6, respectively. Results are presented for both an unadjusted model, and a model adjusted for child sex and household income. In the unadjusted model, maternal control was the only factor that displayed a significant positive association with children’s PA outcomes, and was associated with 11.35 additional minutes of daily MVPA (95% CI [2.09, 20.60], \( p = 0.02 \)) and 19.52 additional minutes daily TPA (95% CI [4.35, 34.16], \( p = 0.01 \)). Conversely, paternal support displayed a significant negative association with children’s PA outcomes in the unadjusted model, with β coefficients of -15.56 (95% CI [-26.13, -4.99], \( p < 0.01 \)) and -31.89 (95% CI [-46.30, -17.48], \( p < 0.01 \)) for children’s MVPA and TPA, respectively.

Results from the adjusted model follow a similar pattern, with the exception of maternal control, which was no longer significantly associated with children’s MVPA. Maternal control retained its significant positive association with children’s total activity; it was associated with roughly 20 extra minutes daily TPA (\( \beta = 19.21, 95\% \text{ CI} [2.16, 36.26], p = 0.03 \)) after controlling for income and child sex. Paternal support maintained its significant negative associations, and was associated with approximately 17 minutes less daily MVPA (\( \beta = -16.57, 95\% \text{ CI} [-28.54, -4.59], p < 0.01 \)) and over 30 minutes less daily TPA (\( \beta = -35.86, 95\% \text{ CI} [-50.49, -21.24], p < 0.01 \)). In addition, paternal enrolment of children in structured activities was associated with significantly more MVPA (\( \beta = 9.05, 95\% \text{ CI} [2.24, 15.87], p < 0.01 \)) and TPA (\( \beta = 13.56, 95\% \text{ CI} [1.53, 25.60], p = 0.03 \)) in the adjusted model.
Table 5. Results of GEE analyses, influence of PA parenting practices on children’s MVPA.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Unadjusted model</th>
<th>Adjusted model*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β</td>
<td>(95% CI)</td>
</tr>
<tr>
<td>Paternal IPAQ</td>
<td>0.00</td>
<td>(-0.004, 0.002)</td>
</tr>
<tr>
<td>Paternal modeling</td>
<td>-4.99</td>
<td>(-16.55, 6.58)</td>
</tr>
<tr>
<td>Paternal support</td>
<td>-15.56</td>
<td>(-26.13, -4.99)</td>
</tr>
<tr>
<td>Enrolling in SA</td>
<td>6.52</td>
<td>(-0.54, 13.57)</td>
</tr>
<tr>
<td>Paternal control</td>
<td>0.63</td>
<td>(-9.22, 10.48)</td>
</tr>
<tr>
<td>Maternal IPAQ</td>
<td>0.00</td>
<td>(-0.01, 0.00)</td>
</tr>
<tr>
<td>Maternal modeling</td>
<td>4.23</td>
<td>(-4.75, 13.21)</td>
</tr>
<tr>
<td>Maternal support</td>
<td>0.44</td>
<td>(-25.07, 25.94)</td>
</tr>
<tr>
<td>Enrolling in SA</td>
<td>5.67</td>
<td>(-0.63, 11.97)</td>
</tr>
<tr>
<td>Maternal control</td>
<td>11.35</td>
<td>(2.09, 20.60)</td>
</tr>
</tbody>
</table>

Note: CI, confidence interval; bold text, statistically significant results.
*model adjusted for child sex and household income

Table 6. Results of GEE analyses, influence of PA parenting practices on children’s TPA.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Unadjusted model</th>
<th>Adjusted model*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β</td>
<td>(95% CI)</td>
</tr>
<tr>
<td>Paternal IPAQ</td>
<td>0.00</td>
<td>(-0.01, 0.00)</td>
</tr>
<tr>
<td>Paternal modeling</td>
<td>-11.80</td>
<td>(-30.46, 6.86)</td>
</tr>
<tr>
<td>Paternal support</td>
<td>-31.89</td>
<td>(-46.30, -17.48)</td>
</tr>
<tr>
<td>Enrolling in SA</td>
<td>9.64</td>
<td>(-2.10, 21.37)</td>
</tr>
<tr>
<td>Paternal control</td>
<td>6.24</td>
<td>(-11.11, 23.60)</td>
</tr>
<tr>
<td>Maternal IPAQ</td>
<td>0.00</td>
<td>(-0.01, 0.01)</td>
</tr>
<tr>
<td>Maternal modeling</td>
<td>6.12</td>
<td>(-9.18, 21.43)</td>
</tr>
<tr>
<td>Maternal support</td>
<td>-20.35</td>
<td>(-60.89, 20.18)</td>
</tr>
<tr>
<td>Enrolling in SA</td>
<td>7.66</td>
<td>(-3.93, 19.26)</td>
</tr>
<tr>
<td>Maternal control</td>
<td>19.52</td>
<td>(4.35, 34.16)</td>
</tr>
</tbody>
</table>

Note: CI, confidence interval; bold text, statistically significant results.
*model adjusted for child sex and household income
6.4.2 SEX-STRATIFIED ANALYSES

GEE analyses stratified by child sex were conducted to elucidate the differences in the relationships between parenting practices and children’s behaviours in parents and children of the same and opposite sexes. Results of these sex-stratified GEE analyses are presented in Tables 7 and 8, respectively. β coefficients were derived from an unadjusted model, in order to limit the number of factors present in the model relative to sample size.

Table 7. Results of sex-stratified GEE analyses, influence of PA parenting practices on female and male children’s MVPA.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Female children (N = 9)</th>
<th>Male children (N = 15)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β (95% CI)</td>
<td>β (95% CI)</td>
</tr>
<tr>
<td>Paternal IPAQ</td>
<td>0.00 (0.00, 0.00)</td>
<td>0.00 (-0.01, 0.00)</td>
</tr>
<tr>
<td>Paternal modeling</td>
<td>13.25 (4.21, 22.30)</td>
<td>-9.10 (-18.79, 0.60)</td>
</tr>
<tr>
<td>Paternal support</td>
<td>4.53 (-21.11, 30.17)</td>
<td>-15.77 (-25.24, -6.31)</td>
</tr>
<tr>
<td>Enrolling in SA</td>
<td>5.12 (-0.34, 10.58)</td>
<td>10.84 (1.04, 20.65)</td>
</tr>
<tr>
<td>Paternal control</td>
<td>-7.80 (-16.65, 1.04)</td>
<td>5.57 (-5.76, 16.90)</td>
</tr>
<tr>
<td>Maternal IPAQ</td>
<td>0.00 (-0.01, 0.00)</td>
<td>0.01 (0.00, 0.02)</td>
</tr>
<tr>
<td>Maternal modeling</td>
<td>10.81 (3.61, 18.01)</td>
<td>-3.66 (-16.82, 9.49)</td>
</tr>
<tr>
<td>Maternal support</td>
<td>17.52 (-24.32, 59.37)</td>
<td>-15.21 (-47.16, 16.73)</td>
</tr>
<tr>
<td>Enrolling in SA</td>
<td>-0.04 (-6.58, 6.50)</td>
<td>9.39 (-1.11, 19.88)</td>
</tr>
<tr>
<td>Maternal control</td>
<td>-17.96 (-32.14, -3.79)</td>
<td>16.24 (8.78, 23.70)</td>
</tr>
</tbody>
</table>

Note: CI, confidence interval; bold text, statistically significant results.

In the sex-stratified analyses, maternal control retained a significant positive association with male children’s MVPA (β = 16.24, 95% CI [8.78, 23.70], p < 0.01). However, this relationship was reversed among female children (β = -17.96, 95% CI [-32.14, -3.79], p = 0.01). Paternal IPAQ bore no significance with regard to female children’s MVPA, but displayed a statistically significant but biologically negligible association with MVPA among male children (β = 0.00, 95% CI [-0.01, 0.00], p < 0.05), while maternal IPAQ was not significantly associated with male children’s MVPA and displayed a statistically significant but biologically negligible association with MVPA among female children (β = 0.00, 95% CI [-0.01, 0.00], p < 0.01). In contrast to the GEE analyses of the unstratified study population, where
parental modeling bore no significant effects, both paternal (β = 13.25, 95% CI [4.21, 22.30], p < 0.01) and maternal (β = 10.81, 95% CI [3.61, 18.01], p < 0.01) intentional modeling displayed a significant positive association with female children’s MVPA. Neither parents’ intentional modeling practices showed any significant association with male children’s MVPA. As in the unstratified analysis, paternal support was negatively associated with male children’s MVPA (β = -15.77, 95% CI [-25.24, -6.31], p < 0.01), while paternal enrolment in structured activities demonstrated a positive association (β = 10.84, 95% CI [1.04, 20.65], p = 0.03). Neither of these two factors displayed any significant associations with female children’s MVPA.

Table 8. Results of sex-stratified GEE analyses, influence of PA parenting practices on female and male children’s TPA.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Female children (N = 9)</th>
<th>Male children (N = 15)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β (95% CI)</td>
<td>β (95% CI)</td>
</tr>
<tr>
<td>Paternal IPAQ</td>
<td>0.00 (-0.001, 0.003)</td>
<td>-0.01 (-0.02, 0.00)</td>
</tr>
<tr>
<td>Paternal modeling</td>
<td>13.91 (1.63, 26.19)</td>
<td>-18.16 (-35.77, -0.56)</td>
</tr>
<tr>
<td>Paternal support</td>
<td>-20.14 (-57.79, 17.51)</td>
<td>-33.11 (-46.72, -19.50)</td>
</tr>
<tr>
<td>Enrolling in SA</td>
<td>1.72 (-5.00, 8.44)</td>
<td>18.15 (1.68, 34.62)</td>
</tr>
<tr>
<td>Paternal control</td>
<td>-10.39 (-19.29, -1.49)</td>
<td>16.51 (-2.85, 35.88)</td>
</tr>
<tr>
<td>Maternal IPAQ</td>
<td>0.00 (-0.01, 0.00)</td>
<td>0.01 (-0.01, 0.03)</td>
</tr>
<tr>
<td>Maternal support</td>
<td>6.63 (-45.04, 58.30)</td>
<td>-44.88 (-96.44, 6.67)</td>
</tr>
<tr>
<td>Enrolling in SA</td>
<td>-0.43 (-7.06, 6.20)</td>
<td>13.15 (-5.08, 31.38)</td>
</tr>
<tr>
<td>Maternal control</td>
<td>-25.00 (-34.74, -15.27)</td>
<td>28.15 (13.86, 42.44)</td>
</tr>
</tbody>
</table>

Note: CI, confidence interval; bold text, statistically significant results.

This general pattern persisted in the GEE analyses of parenting practice and TPA, with some slight differences. As above, maternal control showed a significant positive association with TPA among male children (β = 28.15, 95% CI [13.86, 42.44], p < 0.01), while this association was negative among females (β = -25.00, 95% CI [-34.74, -15.27], p < 0.01). In addition, paternal control displayed its own significant negative association with female children’s TPA (β = -10.39, 95% CI [-19.29, -1.49], p = 0.02). As with MVPA, parental IPAQ scores both showed statistically significant but biologically negligible associations.
with TPA in children of the same gender (paternal IPAQ and TPA in male children, $\beta = -0.01$, 95% CI [-0.02, 0.00], $p = 0.03$; maternal IPAQ and TPA in female children, $\beta = 0.00$, 95% CI [-0.01, 0.00], $p = 0.04$). Intentional modeling by both parents remained significant in predicting increased levels of TPA among female children (paternal modeling, $\beta = 13.91$, 95% CI [1.63, 26.19], $p = 0.03$; maternal modeling, $\beta = 14.24$, 95% CI [6.79, 21.69], $p < 0.01$), while paternal modeling was associated with decreased TPA among male children ($\beta = -18.16$, 95% CI [-35.77, -0.56], $p = 0.04$). Relationships between parental support constructs and children’s TPA followed the same pattern as above, with the overall measure of paternal support displaying a significant negative association with male children’s TPA ($\beta = -33.11$, 95% CI [-46.72, -19.50], $p < 0.01$), while the association between paternal enrolment of male children in structured activities and TPA was positive ($\beta = 18.15$, 95% CI [1.68, 34.62], $p = 0.03$). As with MVPA, neither of these constructs displayed a significant association with female children’s TPA.

7.0 DISCUSSION

In our sample of Guelph-area families with preschool-aged children, we found that the associations between maternal and paternal parenting practices and children’s MVPA and TPA appeared to differ by child sex. Results of the sex-stratified GEE analyses demonstrate different, and, in some cases, opposing responses of male and female children to parental modeling, paternal support, paternal enrolment in structured activities, and parental control.

Our initial main hypotheses were that children whose parents modeled healthy physical activity behaviours, as illustrated by their IPAQ scores and survey responses to our intentional modeling scale, and regularly enacted supportive PA parenting practices, as illustrated by their responses to the survey measure of support, would engage in more total PA and MVPA, while children whose parents exercised more control over their physical activity behaviours (limiting access to opportunities for active recreation or outdoor time, or using sports, physical activities, or outdoor time as a reward or punishment) would engage in less. If the data is examined in aggregate (i.e., with males and female children together), these
hypotheses prove false, as the parental IPAQ, intentional modeling, and support constructs are not positively associated with children’s MVPA or TPA. In the cases of paternal support and maternal control, our hypotheses are reversed, as these constructs displayed negative and positive associations, respectively, with children’s activity levels. Stratifying by child sex, however, significantly alters this picture, as discussed below.

Our secondary hypothesis, that parental support would have a greater positive effect than parental modeling, and that the two constructs would interact such that modeling’s impact on children’s activity would be greater in the presence of higher levels of support, was mooted as neither construct showed consistent positive associations with children’s activity outcomes.

Evaluation of our tertiary hypotheses, that parent and child genders would influence the relationships between parenting practice and children’s activity such that mothers’ modeling and support behaviours would be more strongly associated with daughters’ physical activity while fathers’ modeling and support behaviours would be more strongly associated with sons’, and that fathers would exert a greater overall influence on children of both sexes, was complicated by the relatively small size of our final study population. While the small number of participants make it difficult to draw any firm conclusions, exploratory analyses of our data suggest that, while there is little support in our study for a biologically significant parental influence aligning strictly along gender lines as hypothesized, the notion that maternal and paternal parenting practices influence male and female children’s PA behaviours differently is supported by our data. Our findings suggest that intentional modeling by both mothers and fathers is more salient to female children, while enrolment in structured activities only seems to have a positive impact on male children’s activity levels. Maternal control, meanwhile, appears to have divergent effects on children of opposite sexes; facilitating activity among male children while impeding it among females. The negative associations between our overall measure of paternal support and male children’s levels of
MVPA and TPA suggests the need for further research to refine our measure of support and clarify this association.

The inverse association of paternal support with male children’s levels of activity is an unexpected finding. While a substantial body of literature has identified parental support as a positive correlate of children’s activity (Bingham et al., 2016; Gustafson & Rhodes, 2006; Mitchell et al., 2012; Pugliese & Tinsley, 2007; Trost & Loprinzi, 2011; Xu et al., 2015; Yao & Rhodes, 2015), researchers have also identified a number of challenges associated with accurately operationalizing and measuring this construct, some of which are specific to measurement in families with younger children.

While research into parenting practice relies heavily on self-reports of parenting behaviour, these subjective methods of data collection are known to be susceptible to systematic distortion, including measurement error, recall and estimation error, and conscious biases (Mâsse & Watts, 2013; Mitchell et al., 2012; Morsbach & Prinz, 2006; Pugliese & Tinsley, 2007). Of particular interest to us is the possible impact of social desirability bias – the desire to present oneself in a favourable light – on our assessment of parental support. Morsbach and Prinz (2004) found high levels of consistency in the perceived social desirability of different parenting behaviours in a sample of American parents. Research has suggested a number of strategies that can be used to reduce socially desirable responding in parents, including the use of self-administered questionnaires, impersonal/computer administration of survey items, respondent anonymity, and the use of implicit measures, as in item 4 of our parental support scale, “I would rather my child play indoors because I don’t want to sit outside and watch her/him play” (Mâsse & Watts, 2013; Morsbach & Prinz, 2006). Although our study mitigates some of the concerns around socially desirable responding in that it uses all of the above strategies, it is still likely that shared perceptions of what constitutes good parenting act to bias participant responses, resulting in an overestimate of actual supportive practices. Overestimates of parental support may be a factor in the respective findings of non-
significance and negative influence in our analysis of the associations between maternal and paternal support and children’s levels of physical activity.

Reviews of the methods used by researchers to assess parental support for PA have found that studies often make use of instruments with questionable psychometric validity (Davison et al., 2013; Sleddens et al., 2012; Trost, McDonald, & Cohen, 2013). This problem is compounded in research focussed on toddlers and pre-schoolers, as researchers have identified a distinct lack of PA parenting practice instruments that have been validated for these age groups (O’Connor et al., 2014; Vaughn et al., 2013). In our study, the composite measure of parental support consisted of four items, two of which were taken from Davison et al.’s ACTS-MG (2011), one from Vaughn et al.’s PA parenting practice instrument (2013), and one of which was created for the study. While the Vaughn instrument has been validated in a population of 2-5 year old children, the ACTS-MG was designed with an ethnically diverse, elementary school age population in mind, and validated as such. One of the items taken from the ACTS-MG – assessing parental enrolment of children in structured activities – was removed from our measure after testing for internal consistency. While the remaining item – “I take my child to places where s/he can be active,” – displays surface validity, it remains unclear whether those practices used by parents of older children and found to be valid in predicting their activity remain so when applied to younger children (O’Connor et al., 2014). It is feasible that an assessment of parental support based on an instrument derived from more extensive formative research focussed specifically on those supportive practices used and found to be efficacious by parents of preschool-aged children would reveal a different association with children’s activity levels than the one we observed.

Another potential factor contributing to the findings of negative influence and non-significance in the association between paternal and maternal support and children’s activity may have been the unidimensionality of our measure. As described above, parental support is often dichotomized into two dimensions; encouragement – that is, intangible aspects of support such as persuading, promoting, or
prompting a child to be active, and praising them when they do so; and facilitation – the more tangible, instrumental, or logistic aspects of support, such as providing transport to venues for physical activity or removing barriers to activity in and around the home (Beets et al., 2010; Gustafson & Rhodes, 2006; Pugliese & Tinsley, 2007; Trost & Loprinzi, 2011; Yao & Rhodes, 2015). While our measure focussed on the logistic aspects of support, systematic reviews of physical activity parenting survey instruments have suggested that inclusion of a separate scale for parental encouragement within the overall measure of parental support could provide valuable information (Sleddens et al., 2012). In fact, some research has suggested that the intangible aspects of support may be more salient for younger children, in that they receive more encouragement (Garcia et al., 1995; Taylor, Baranowski, & Sallis, 1994) and are more responsive to it (Gustafson & Rhodes, 2006) than their older peers. Inclusion of an assessment of parents’ intangible support for children’s activity could feasibly impact the direction and significance of our findings. Further research focussed specifically on toddlers and pre-schoolers is necessary to strengthen our understanding of the relative influences of encouragement and facilitation on these age groups.

As with parental support, the finding that direct parental modeling – as indicated by self-reported estimates of habitual parental activity based on the IPAQ-SF – shows a non-significant or negligible association with physical activity levels in children of either sex may be in part attributable to biases and systemic errors in measurement. Self-reports of physical activity have historically been subject to questions about their validity, reliability, and particular susceptibility to social desirability and recall biases (Sallis & Saelens, 2000; Shephard, 2003). Critiques of the IPAQ-SF have pointed out the likelihood of misreporting due to recall error and measurement issues such as order effects, high variance, and a tendency for this instrument to overestimate PA prevalence (Bauman, Ainsworth, et al., 2009). Bauman et al. recommend using IPAQ-SF output as a categorical rather than a continuous measure in order to decrease the amount of variance associated with outcomes. A systematic review of IPAQ-SF validation studies by Lee, Macfarlane, Lam, and Stewart (2011) found that, of 18 studies correlating IPAQ scores with an objective measure of TPA, none reached the minimal acceptable standard ($r = 0.5$)
in the literature for objective activity measuring devices. The same review found that the IPAQ-SF typically overestimated TPA by 84% in comparison with an objective criterion. Taken together, the tendency of the IPAQ-SF towards overestimates and high variance may have contributed to the lack of significance and/or negligible effect sizes seen in the associations between parents’ reports of their own activity and their children’s objectively measured levels of MVPA and TPA. Future research should incorporate objective measures of parental PA in order to produce a more accurate portrayal of the parent-child PA modeling relationship.

A recent study by Walsh et al. (2017) used the IPAQ-SF to assess the relationship between self-reported paternal activity and objective, accelerometry-based estimates of young children’s PA. Similar to our findings, these researchers found no clear associations between father’s activity levels and that of their children, and recommend the use of more robust, objective indicators of parental physical activity in order to improve measurement accuracy and reliability. In addition to the observed tendency of self-report measures such as IPAQ to produce over-estimates of PA, the authors suggest several other explanations for the lack of significance in their findings. One proposed possibility is that paternal PA could be occurring at the expense of children’s activity, that is, fathers may be engaging in activity while their children are being carried in a stroller or bike seat, or are otherwise occupied with sedentary pursuits. Another possibility is that parental activity may be occurring at times and in venues where children are not present, thus eliminating any potential modeling effects and/or opportunities for co-PA. Walsh et al. recommend that future inquiry should include some measure of parent-child proximity during activity in order to better ascertain the effects of parent-child modeling and co-PA.

Another recent study of preschool-aged children and their fathers (Vollmer et al., 2015) found significant positive associations between fathers’ and children’s vigorous physical activity. While further work is needed to clarify the association between VPA and health outcomes in younger children, research by Carson et al. (2014) has linked time spent in VPA with improved cardiometabolic health indicators and
reduced risk of chronic disease in youth, and systematic reviews on the topic have ascribed a potentially
greater health benefit to higher levels of VPA (compared to MVPA) in children aged 5-17 (Janssen et al.,
2010). Although Vollmer et al.’s results were based on the pre-school age children’s physical activity
questionnaire (pre-PAQ), a subjective assessment of parents’ and pre-school children’s regular PA
behaviours in the home environment (Dwyer, Hardy, Peat, & Baur, 2011), the significance of their
findings, the potential health benefits of increased VPA, and the body of research alluding to both the
relatively high levels of paternal engagement in and the high relational value that fathers place on rough-
and-tumble play and other forms of co-VPA (Fletcher, Morgan, May, Lubans, & George, 2011) suggest
the need for further exploration of this topic. As age-appropriate cut-points for VPA in toddlers and
preschoolers are identified and validated, these should be applied to data sets like our own in order to
elucidate the associations between VPA participation in mothers, fathers, and their children.

As with parental self-reports of habitual physical activity and PA-supportive practices, subjective
assessments of parents’ intentional modeling practices may be influenced by social desirability and recall
biases (Loprinzi & Trost, 2010; Mâsse & Watts, 2013; Mitchell et al., 2012; Morsbach & Prinz, 2006). In
addition, our study as presently constituted is unable to account for shared parent and child physical
activity or co-PA, that is, physical activity that parents engage in alongside or in concert with their
children. Co-PA has been identified by several reviewers as predictive of children’s overall levels of
physical activity (Bingham et al., 2016; Hinkley et al., 2008), and may be particularly salient at younger
ages when children are more likely to have a parent engaged in active play with them (Beets et al., 2010;
Yao & Rhodes, 2015). As such, the lack of an indicator of co-PA in our intentional modeling construct
may have weakened its observed effects across sexes.

Research into the differential effects of maternal and paternal modeling on children of different sexes has
produced mixed findings. Some results have suggested a ‘gender-specific effect’, where correlations
between parent and child activity levels are stronger between father-son and mother-daughter pairings
than between parent-child pairings across sexes (Fuemmeler, Anderson, & Mâsse, 2011; Seabra, Mendonça, Göring, Thomis, & Maia, 2008). Others, in contrast to the above and the results of the reviews by Gustafson and Rhodes and Yao and Rhodes cited earlier, have suggested a ‘mother effect’, where maternal participation in physical activity exhibits a greater influence on activity levels in children of both sexes than that by fathers (Jacobi et al., 2011; Schoeppe et al., 2016). In these cases, the authors have attributed the greater maternal influence to mothers’ traditional role as primary caregiver, especially with younger children, and even in dual-income households, where mothers tend to work fewer hours outside of the home and engage in dyadic activity with children during domestic and leisure time more frequently than fathers. Jacobi et al. found that, within the greater overall influence exerted by mothers on children of both sexes, the mother-daughter PA association was stronger than that for mothers and sons; while Schoeppe et al. identified differences in the mother-daughter and mother-son modeling relationships related to the type of physical activity being modeled (i.e. maternal participation in sport and walking active transport positively influenced boys’ levels of activity, while maternal participation in outdoor activities as well as the aforementioned two had a positive impact on PA in girls).

Our results add a new thread to this conversation in that they suggest a greater modeling influence by parents of either gender on female children; maternal and paternal intentional modeling were both associated with increased MVPA and TPA in our female study population. Schoeppe et al., in keeping with their own findings and the body of research suggesting that male gender is predictive of higher levels of PA in young children (Bingham et al., 2016; Hinkley et al., 2008), have suggested that the increased salience of parental modeling for girls may be because boys, already prone to higher levels of activity, require ‘less inspiration’ for PA participation and so display a more muted response to external stimuli; an explanation that could also be applied to our findings.

On the other hand, our results suggest that enrolment in structured activities, particularly by fathers, was more salient among the male children in our study, as this isolated aspect of support was associated with
increased levels of both MVPA and TPA among boys. Research into mothers’ and fathers’ different roles in supporting children’s activity have found higher levels of logistic support among mothers (Beets et al., 2010; Davison, Cutting, & Birch, 2003), and this was reflected in our overall measure of parental support. However, fathers in our study population scored higher than mothers on the lone item assessing parental enrolment of children in SA. One possible explanation of the significance of this particular component of support among fathers could be that its effect derives in part from the relatively high levels of father engagement in this parenting practice; a sort of ‘novelty bump’ where the relatively rare fact of higher paternal involvement results in a disproportionate behavioural response. It may also be that higher paternal scores on this aspect of logistic support are reflective of a higher degree of father involvement in other areas. If higher scores on the individual measure of enrolment in SA are indicative of exceptional levels of paternal support elsewhere, then it follows that this would have a substantive effect on children’s activity levels as illustrated by the significant positive association. A similar argument could be made with regard to family attitudes toward and values around structured PA, with higher paternal scores on the measure of enrolment in SA possibly being reflective of a high value placed on participation in sport or other structured activities within the family. As above, adherence to such values would likely have a substantive effect on children’s and all family members’ levels of activity. That only male children’s mean activity levels showed a positive association with enrolment in structured activity could be reflective of a gendered disparity in available activity programming. Another possibility is that it reflects a familial emphasis on traditionally gendered modes of activity, with male children receiving more support for participation in sport and other structured, competitive, or strenuous activities from an early age, as has been reported in reviews of the literature on early childhood PA and related parenting practice (Gustafson & Rhodes, 2006; Pocock, Trivedi, Wills, Bunn, & Magnusson, 2010).

The association between higher levels of maternal control and increases in male children’s levels of physical activity is not unprecedented in the literature. Vaughn et al. (2013), for example, also found that the use of PA to reward or control child behaviour was positively associated with accelerometer-measured
MVPA in a sample of preschool-aged children. While this association – more rules and potential constraints leading to more activity – might seem counter-intuitive on its surface, these researchers drew an analogy between children’s response to parental control of PA to similar restrictive and rewarding practices around junk food, where research on food parenting has linked greater restrictions and the use of food rewards with increased consumption of the prohibited and/or incentivized foods. Vaughn et al. also note that this relationship may be reflective of parents’ reactions to their children’s behaviours, as parents of very active children may recognize the utility of regulating their children’s PA more closely than their less active siblings or peers. In the context of physical activity behaviours, this association may have dual benefits – active children’s proclivity for healthier levels of PA can be channeled by parents into a means of influencing other, peripherally-related behaviours, in a positive feedback loop that ideally helps regulate other behaviours while stimulating increased PA.

The divergent responses of male and female children to parental control may be attributable in part to some of the factors discussed above. The greater salience of maternal compared to paternal controlling behaviours may be attributable to the high prevalence of traditionally constructed parent-gender roles within participant families, with mothers more often accepting the responsibility of being primary caregiver and disciplinarian. The tendency for male children to be more active than their female counterparts may make the feedback loop described above -- higher activity leading to increased parental regulation of PA and use of PA-opportunities as behavioural incentives leading to further increases in activity – more likely among male children. In addition, the possible surplus of opportunities for structured PA available to boys and reported higher levels of support for their engagement in them may contribute to greater resilience by boys towards attempts to limit their physical activity. When faced with a situation where parents choose to deny or constrain access to PA opportunities, boys may find it easier to ‘try again’ or continue to press for opportunities to be active, in that their social environment offers more of these, and offers more encouragement in attaining them. Girls, not offered the same supports,
may as result be more likely to turn to sedentary forms of activity instead, contributing to the observed negative association of their activity levels with levels of parental control.

7.1 STRENGTHS

The strengths of this research relate mainly to the gaps in our knowledge about the relationship between PA parenting practices and preschool-aged children’s activity behaviours that it aims to help fill. The use of objective measures to assess activity levels in pediatric health research has been recommended by reviewers (Bingham et al., 2016; De Craemer et al., 2012; Hesketh et al., 2017; Hinkley et al., 2008; Li et al., 2015), and this study’s application of accelerometry to measure and categorize the duration and intensity of participant children’s physical activity allows for more accurate estimates of activity prevalence in our study population (Bornstein et al., 2011; Oliver et al., 2007; Pate et al., 2010). The study’s focus on toddlers and preschoolers – relatively understudied age groups where the relationships between parenting practices and activity levels are less well-understood than among older children and adolescents – contributes to its novelty, as does the use of a multidimensional assessment of parenting practice that incorporates habitual activity, intentional modeling, logistic support, and parental control. The inclusion of a measure of parental control, in particular, contributes to our understanding of an aspect of PA parenting that has been identified as salient but remains understudied (Davison et al., 2013; Trost & Loprinzi, 2011; Vaughn et al., 2013). Finally, the inclusion, disaggregation, and independent analysis of paternal data is one of the study’s key strengths, contributing to our understanding of the historically understudied role of fathers in the context of family health, and allowing us to identify and analyze the disparate influences that mothers and fathers have on the PA behaviours of children of either sex.

7.2 LIMITATIONS

After applying data processing criteria, the final study population consisted of 24 participant children, 15 boys and 9 girls; a less than ideal gender distribution within a relatively small sample size. As described above, the study population was relatively homogenous in terms of the range of ethnicities, family
structures, and income levels present. While some of this homogeneity may be reflective of the study’s sampling frame, the lack of diversity, coupled with the small number of participants, makes it unlikely that results are generalizable to the broader regional or national level at this time; they are best viewed as exploratory findings, particularly the results of the sex-stratified analyses.

Self-selection bias may be another hindrance to the generalizability of our results, as researchers have found a significantly greater relationship between parenting practices and children’s activity in studies that relied on volunteers as opposed to a principled sampling method (Pugliese & Tinsley, 2007). This concern may be exacerbated by our focus on only those child participants who had survey response data for both parents. The idea that volunteers for the study may actually represent a more active subset of the population is borne out by our results. Participant children’s mean levels of daily MVPA ($M = 94$) and TPA ($M = 201$) were considerably higher than current national recommendations, 18 of 24 participants (75%) engaged in an average of over 180 minutes daily total physical activity, and 22 of 24 participants engaged in over 60 minutes of average daily MVPA (92%). As encouraging as these results are, the substantially higher rate of adherence to the MVPA guideline when compared to current estimates of prevalence among Canadian 3-5 year olds (Garriguet et al., 2016) suggest that study participants’ attributes may not be representative of the national population. One mitigating factor in this regard could relate to the seasonality of our data. A preponderance of the study’s accelerometer data was collected during the spring and summer months. Research by Carson et al. (2010) suggests that levels of total PA among North American preschool children may be higher during these times of year, which may provide some explanation for the relatively high rates of activity observed in our sample. Similarly, some level of reactivity on the part of both the parents and children being monitored ought to be assumed; this would also contribute to higher observed activity levels.

Another demographic concern relates to the age of participating children. Participants’ mean age was 3.9 years old. However, two participants were over 6 years old at the time of measurement, while the cut-
points applied to participants’ accelerometer data to classify MVPA (Pate et al., 2006; Trost et al., 2012) have only been validated in preschool-aged (< 5 years old) populations. Although some research comparing accelerometer cut-points (Janssen et al., 2013) has found that the Pate et al. equation displayed the best classification accuracy for PA in a population of 4-6 year olds, caution is warranted in interpreting our results.

As discussed above, research based on subjective reports of behaviour are inevitably susceptible to social desirability, recall, and other response biases. In addition, the validity of our survey instrument for parental support may have been impeded by its focus on facilitation with no scale to assess encouragement, the lack of a measure of co-PA, and by the possible lack of developmental specificity in the selection and phrasing of survey items.

7.3 FUTURE DIRECTIONS
The development of a comprehensive, multi-dimensional parenting practice scale specific to the lived experiences and actual practices of the parents of toddlers and pre-school aged children – or the psychometric validation of existing scales for parents of older children in this population of interest – should be a research priority. As discussed by O’Connor et al., (2014), it is unclear whether those parenting practices that are effective in influencing PA behaviours among older children are also used effectively in younger families. Formative research in this area should also explore the influence of the non-tangible aspects of parental support, and aim to clarify whether parental encouragement holds a particular salience for younger children. As suggested by Walsh et al. (2017) and the prevailing criticisms with regard to the use of the IPAQ-SF and other forms of PA self-report, future studies of parental modeling should incorporate objective measures of activity for both parents and children in order to increase the accuracy and validity of their estimates of prevalence and the associations derived from them. Incorporating measures of parent-child proximity during PA and/or subjective assessments of the amount of shared familial activity would also be useful in more accurately ascertaining the influence of direct
modeling and co-PA. Finally, as evidence for the health benefits of VPA in younger children emerges, the development and application of validated vigorous activity cut-points to data sets such as our own may be useful in expanding our understanding of the VPA modeling relationship identified by Vollmer et al. (2015).

As the size of the GFHS study population increases, sex-stratified analyses may be repeated with greater confidence in the validity and generalizability of the results. A larger, more diverse study population will also allow for the inclusion of additional, potentially confounding variables such as family structure, ethnicity, whether children are in care, season, etc. in the statistical model. Future inquiry might also seek to include objective or subjective assessments of neighbourhood physical and social environments, such as the survey item on proximity to children’s parks and outdoor play areas, in their analysis.

Much of the discussion of the differing influences of maternal and paternal PA parenting has hinged on mothers’ traditional role as children’s primary caregiver. Future analyses might seek to include a more nuanced examination of household gender roles and the domestic division of labour in order to ascertain whether participant families do indeed adhere to stereotyped maternal and paternal roles, and to what extent the distribution of household responsibilities affects parents’ relative influences on their children. Similarly, a closer examination of the differences in the available opportunities and levels of encouragement for various forms of PA for male and female children could elucidate some of our findings with regard to boys’ and girls’ varied responses to different forms of parental support. Existing research on the gendered dimensions of PA parenting influence has identified type of activity as a salient factor (Schoeppe et al., 2016). Future research that incorporates an analysis of the effects that type, location, domain, and intensity of both parents’ and children’s activity may have on the relationships between parenting practice and familial activity outcomes could produce interesting results. Finally, maternal control emerged as a significant predictor of both increased and decreased activity in our study population, with its influence bifurcating according to child sex. Further research into both the gendered
dimensions of parental control and the ways in which it acts to facilitate or inhibit male and female children’s levels of activity is warranted.

8.0 CONCLUSIONS

This study examined the associations between maternal and paternal PA parenting practices – including habitual activity, intentional modeling, logistic support, and controlling behaviours – and levels of objectively measured MVPA and TPA in a sample of toddlers and preschoolers participating in the Guelph Family Health Study. Exploratory analyses stratified by sex revealed differences in the ways that male and female children respond to mothers’ and fathers’ PA parenting practices, with female children more responsive to intentional modeling, male children more responsive to paternal enrolment in structured PA, and males and females diverging in their responses to maternal control, which facilitated activity in boys, but inhibited activity in girls. Our measure of paternal support was negatively associated with activity among male children. These findings suggest the need for further research into the salient aspects of parental support for preschool-aged children, and more nuanced examinations of the influence of gendered parenting roles and the possible differences in opportunities and support for different forms of PA offered to male and female children. Finally, our results point to the need for further examination of the role that parental control may play in both facilitating and inhibiting physical activity in preschool-aged children of either sex.
REFERENCES


https://doi.org/http://dx.doi.org/10.4236/ape.2015.52015


Shields, M., & Tremblay, M. S. (2010). Canadian childhood obesity estimates based on WHO, IOTF and


Walsh, A. D., Crawford, D., Cameron, A. J., Campbell, K. J., & Hesketh, K. D. (2017). Associations between the physical activity levels of fathers and their children at 20 months, 3.5 and five years of age. BMC Public Health, 17(1), 1–8. https://doi.org/10.1186/s12889-017-4545-8


APPENDIX A: University of Guelph Research Ethics Board Certification of Ethical Acceptability of Research Involving Human Participants (#14AP009)

**RESEARCH ETHICS BOARDS**

Certification of Ethical Acceptability of Research Involving Human Participants

**APPROVAL PERIOD:** May 14, 2014

**EXPIRY DATE:** May 14, 2016

**REB:** NPES

**REB NUMBER:** 14AP009

**TYPE OF REVIEW:** Full Board

**PRINCIPAL INVESTIGATOR:** Ma, David (davidma@uoguelph.ca)

**DEPARTMENT:** Human Health & Nutritional Sciences

**SPONSOR(S):** University of Guelph - Better Planet Project

**TITLE OF PROJECT:** Guelph Family Health Study

**CHANGES:**

<table>
<thead>
<tr>
<th>Date</th>
<th>Document Name</th>
<th>Version</th>
<th>Change Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>24-Jun-14</td>
<td>Parent #1 Consent</td>
<td>2</td>
<td>The consent form was modified to remove the duplication of information, to simplify the language used and to remove detailed information from the consent to separate pages (links) of the study website. Two new check boxes were added to the consent for the acknowledgment of the Pilot and Biobank studies.</td>
</tr>
<tr>
<td></td>
<td>Parent #2 Consent</td>
<td>2</td>
<td>The consent form was modified to remove the duplication of information, to simplify the language used and to remove detailed information from the consent to separate pages (links) of the study website. Two new check boxes were added to the consent for the acknowledgment of the Pilot and Biobank studies.</td>
</tr>
<tr>
<td>8-Oct-14</td>
<td>Parent #1 Q#1 Paper Copy FINAL Sept 24</td>
<td>1</td>
<td>New document</td>
</tr>
<tr>
<td></td>
<td>Parent #1 Q#2 Paper Copy FINAL Sept 24</td>
<td>1</td>
<td>New document</td>
</tr>
<tr>
<td></td>
<td>Parent #1 Q#3 Paper Copy FINAL Sept 24</td>
<td>1</td>
<td>New document</td>
</tr>
<tr>
<td></td>
<td>Parent #2 Q#1 Paper Copy FINAL Sept 24</td>
<td>1</td>
<td>New document</td>
</tr>
<tr>
<td></td>
<td>Parent #2 Q#2 Paper Copy FINAL Sept 24</td>
<td>1</td>
<td>New document</td>
</tr>
</tbody>
</table>
The members of the University of Guelph Research Ethics Board have examined the protocol which describes the participation of the human participants in the above-named research project and considers the procedures, as described by the applicant, to conform to the University's ethical standards and the Tri-Council Policy Statement, 2nd Edition.

The REB requires that researchers:

- Adhere to the protocol as last reviewed and approved by the REB.
- Receive approval from the REB for any modifications before they can be implemented.
- Report any change in the source of funding.
- Report unexpected events or incidental findings to the REB as soon as possible with an indication of how these events affect, in the view of the Principal Investigator, the safety of the participants, and the continuation of the protocol.
- Are responsible for ascertaining and complying with all applicable legal and regulatory requirements with respect to consent and the protection of privacy of participants in the jurisdiction of the research project.

The Principal Investigator must:

- Ensure that the ethical guidelines and approvals of facilities or institutions involved in the research are obtained and filed with the REB prior to the initiation of any research protocols.
• Submit a Status Report to the REB upon completion of the project. If the research is a multi-year project, a status report must be submitted annually prior to the expiry date. Failure to submit an annual status report will lead to your study being suspended and potentially terminated.

The approval for this protocol terminates on the EXPIRY DATE, or the term of your appointment or employment at the University of Guelph whichever comes first.

Signature: 

Date: October 27, 2015

A. Papdopoulos
Chair, Research Ethics Board-NPES
Guelph Family Health Study – Intervention Consent to Participate – Parent #1

The purpose of this form is to provide you with the information you need to make an informed decision for you and your family about participating in this research study. Participation in this study is voluntary.

**Part 1: Understanding The Study**

**About the study:**
The Guelph Family Health Study – Intervention is a unique research study that is developing and testing ways to help families maintain healthy behaviours over many years. Parents that participate in the Intervention may receive personalized information on how to help their family live a healthy life.

The study and its related costs are funded through the Better Planet Project at the University of Guelph.

**Definitions**

Parents: We define parents as the main caregivers of children. Parents can be biological, related or adoptive.

Family: For this study we define family as parents and their children who are 18 months to five years of age. Families can have one or many parents. A maximum of two parents from each family can register in this study.

**What’s required?**
Your family will be chosen by chance to receive one of our study programs for healthy family lifestyle. You will receive information from us in the form of e-mails and/or home visits with a health educator for the next 6 months.

**What benefits are associated with this study?**
If you choose to participate in this study, you will be part of an important project that is helping us better understand the human behaviours that affect health. We will use this information to develop programs that reduce the risk for disease in families.

In addition, your family may receive 6 months of customized health advice from our research experts.

**What risks are associated with this study?**
Although we have designed our interventions so that they support families in a non-judgmental way, you may feel concerned that you are not doing a good job parenting and/or managing your children’s diet and exercise. You can choose to not participate in any part of the interventions. We can also refer you to other agencies within the area that can provide additional support, if you feel it is needed.

**Who is conducting this study?**
This study is being conducted by a team of researchers at the University of Guelph.

**Lead Researchers**
David Ma, Associate Professor, Human Health & Nutritional Sciences
Jess Haines, Assistant Professor, Family Relations & Applied Nutrition

**Research Team**
Emma Allen Vercoe, Associate Professor, Molecular and Cellular Biology
Paula Brauer, Associate Professor, Family Relations & Applied Nutrition
Andrea Buchholz, Associate Professor, Family Relations & Applied Nutrition
Alison Duncan, Professor, Human Health & Nutritional Sciences
David Mutch, Associate Professor, Human Health & Nutritional Sciences
Lawrence Spriet, Professor and Chair, Human Health & Nutritional Sciences

**Study Coordinator**
Angela Annis, Human Health & Nutritional Sciences and Family Relations & Applied Nutrition

**Contact us**
You can contact the Study Coordinator for the Guelph Family Health Study by email at coordinator@guelphfamilyhealthstudy.com or by telephone at 519-824-4120 extension 56168.

This study has been approved by the University of Guelph Research Ethics Board. If you have questions about your rights as a research participant, please contact this group by email at reb@uoguelph.ca or by telephone at 519-824-4120 extension 56606.
Part 2: Agreeing to the study

Check the box next to each statement that you agree with.

By completing this consent form, I declare that:

☐ I understand the Guelph Family Health Study – Intervention, what’s required of my family if we participate, and the benefits and risks. I have had the opportunity to ask questions about the study and have received adequate answers. **I am making an informed decision for myself and on behalf of my children to participate in this study, as listed below.**

Please provide us with the names of your children:

Child #1 ________________Child #2 ________________Child #3 ________________

☐ I understand that participation in this study is voluntary. I know I can refuse to participate, refuse to answer questions, or withdraw myself or my children from the study at any time with no effect on our future healthcare or relationship with the University of Guelph. I understand that any information I do not ask to be destroyed will remain with the study for future research.

☐ I understand that the study team may withdraw my family from this research at their discretion.

☐ I understand that the program my family receives is not an established therapy shown to improve health and there may be no clinical benefit to me or to my children for participating in this study.

☐ I understand that our family will be chosen by chance to receive one of the following 6-month programs:

1) 1 e-mail each month that provides general health information, or

2) 3) 1 e-mail each week that provides specific health information for my family, plus 4 home visits with a health educator.

☐ I understand that each home visit will take approximately 1 hour and will be completed at a convenient time.

☐ I understand that my family may be contacted after the completion of this study to participate in future assessments. I understand that I will receive a new form that describes these future assessments, including possible risk and benefits, and I will be able to decide at that time whether my family would like to participate.

Parent #1 Name ______________________________

Parent #1 Signature_______________________________ Date __________________
Study Coordinator Signature _______________________   Date _________________
Guelph Family Health Study – Longitudinal Study
Consent to Participate – Parent #1

The purpose of this form is to provide you with the information you need to make an informed decision for you and your family about participating in this research study. Participation in this study is voluntary.

Part 1: Understanding The Study

About the study
The Guelph Family Health Study is a unique research study that is following a large group of families with young children in Guelph over many years.

The study and its related costs are funded through the Better Planet Project at the University of Guelph.

Definitions

Parents: We define parents as the main caregivers of children. Parents can be biological, related or adoptive.

Family: For this study we define family as parents and their children who are 18 months to five years of age. Families can have one or many parents. A maximum of two parents from each family can register in this study.

What’s required?
After you and your family complete your registration in this study, you will be asked to:

1. Complete online questionnaires Estimated time: 40 minutes per questionnaire
   This study requires you to answer questions that will help us understand your family’s health behaviours. You will receive a $60 grocery gift card as a thank you for the questionnaires you complete. For more information, visit what’s required
2. Meet with a member of our study team at your home
   Estimated time: 1 hour
   The Study Coordinator will meet you at a convenient time to provide instructions on how to complete the rest of the study.

3. Track food and activity for a few days Estimated time: 15 minutes per day
   At your home visit we will teach you how to keep a three-day record of the food eaten by your children. We will also ask your children to wear an activity monitor on their waist and/or their wrist for seven days. For more information, visit what’s required.

4. Come to the University of Guelph for a family health assessment Estimated time: 1.5 hours + travel time
   Your family will be asked to visit the University of Guelph for a health assessment to:
   • Measure your height and weight using a scale and height board, similar to the ones at your doctor’s office.
   • Measure waist using a tape measure.
   • Measure body fat and muscle.
     For adults, this will be done using a machine called a BOD POD™. For more information, visit How do you measure body fat and muscle?
     For children, this will be done using a machine called a Bioelectric Impedance Analyzer (BIA). BIA uses small patches that produce an electrical signal. For more information, visit How do you measure body fat and muscle?
   • Measure blood pressure using a cuff that wraps around your arm, similar to the one at your doctor’s office.
   • Collect a saliva sample. For more information, visit How do you collect saliva?
   You will receive a $75 grocery gift card if one parent attends the health assessment or a $100 grocery gift card if two parents attend the health assessment.

5. Provide a blood sample at a local laboratory Estimated time: 15 minutes per family member + travel time
   You can choose for your family to provide blood samples at a local medical laboratory within three weeks of your health assessment. Giving a blood sample is optional and is not a requirement of the study. You and your family can still participate in the study even if you choose not to provide blood samples. You will receive a $50 grocery gift card as a thank you for completing the laboratory visit. For more information, visit giving blood.
6. Provide a fecal sample
   Estimated time: 5 minutes
   You can choose for your family to provide fecal samples for the study. Giving a fecal sample is optional and is not a requirement of the study. You and your family can still participate in the study even if you choose not to provide fecal samples.

7. Participate in follow up assessments
   Your family will be invited to complete a combination of questionnaires, home visits, food and activity tracking, health assessments and blood samples every six or 12 months for up to 20 years. Your follow up assessments will help us learn how human behaviours affect health over time.

What benefits are associated with this study?
If you choose to participate in this study, you will be part of an important project that is helping us better understand the human behaviours that affect health. We will use this information to develop programs that reduce the risk for disease in families.

What risks are associated with this study?

Measuring body fat and muscle:
   • For parents: You may experience claustrophobia while sitting in the BOD POD™. You can exit the BOD POD™ at any time. You may feel slightly embarrassed about wearing a bathing suit in the BOD POD™. The BOD POD™ is located in a private room. For more information, visit How do you measure body fat and muscle?
   • For children: There is a very small risk that your child’s skin may be sensitive to the glue we use to apply the patches. Your child can ask us to remove the patches at any time, if they are uncomfortable.

Giving blood: You may experience the usual pain and bruising that people get when they give blood. You may also experience dizziness. Rarely, giving blood can cause an unusually small vein to collapse. The laboratory staff who will collect your blood have extensive training and experience taking blood in adults and young children.

Fecal sample: You may come in physical contact with the fecal sample, but this is a small risk. Full instructions for fecal donation collection, including an explicit statement suggesting hand-washing after collection, will be provided.

Privacy: The privacy of your information is very important to us. Any time you allow someone to access your information, there is a small risk to your privacy from human error or technical error. We have taken many precautions to ensure that the information and samples you provide us will remain safe and private, and that your identity will be protected to the extent required by law. For more information, visit privacy.
Who is conducting this study?
This study is being conducted by a team of researchers at the University of Guelph.

Lead Researchers
David Ma, Associate Professor, Human Health & Nutritional Sciences
Jess Haines, Assistant Professor, Family Relations & Applied Nutrition

Research Team
Emma Allen Vercoe, Associate Professor, Molecular and Cellular Biology
Paula Brauer, Associate Professor, Family Relations & Applied Nutrition
Andrea Buchholz, Associate Professor, Family Relations & Applied Nutrition
Alison Duncan, Professor, Human Health & Nutritional Sciences
David Mutch, Associate Professor, Human Health & Nutritional Sciences
Lawrence Spriet, Professor and Chair, Human Health & Nutritional Sciences

Study Coordinator
Angela Annis, Human Health & Nutritional Sciences and Family Relations & Applied Nutrition

Contact us
You can contact the Study Coordinator for the Guelph Family Health Study by email at coordinator@guelphfamilyhealthstudy.com or by telephone at 519-824-4120 ext. 56168.

This study has been approved by the University of Guelph Research Ethics Board. If you have questions about your rights as a research participant, please contact this group by email at reb@uoguelph.ca or by telephone at 519-824-4120 ext. 56606.
Part 2: Agreeing to the study

Click on the box next to each statement that you agree with. When you are done, click ‘Submit’ at the bottom of the page.

By completing this consent form, I declare that:

☐ I understand the Guelph Family Health Study – Longitudinal Study, what is required of my family if we participate, and the benefits and risks. I have had the opportunity to ask questions about the study and have received adequate answers. **I am making an informed decision for myself and on behalf of my children to participate in this study.**

Please provide us with the names of your children:

Child #1 ___________________ Child #2 ___________________ Child #3 ___________________

☐ I understand that participation in this study is voluntary. I know that I can refuse to participate, refuse to answer questions, or withdraw myself or my children from the study at any time with no effect on our future healthcare or relationship with the University of Guelph. I understand that any information or samples I do not ask to be destroyed will remain with the study for future research.

☐ I understand that the study team may withdraw my family from this research at their discretion.

☐ I understand that there may be no clinical benefit to my family by participating in this study.

☐ I understand that the results of my body fat and muscle analysis will be provided to me, if requested. I understand that the results my children’s body fat and muscle analysis will not be provided to me since we do not yet have standards for level of fat and muscle for children.

☐ I understand that our saliva samples will be used to extract DNA and study how the genes we were born with affect our behaviours and responses to food. I understand that the results of our saliva tests will not be provided to me. This is to protect my family from having to potentially provide genetic information to a third party, such as an insurance provider or employer.

☐ I accept that if we provide blood samples, they will be tested for sugars, fats and hormones. I understand that some of my blood tests results will be provided to me if I request them. I understand that my children’s blood test results will not be provided to me because we don’t yet have standards for healthy blood ranges in children. I accept that if any of my blood tests are significantly abnormal, they will be reported to me for discussion with my doctor.

☐ I understand that if we provide fecal samples, they will be tested for gut bacteria. The results of the fecal tests will not be provided to me, unless they are significantly abnormal results.

☐ I understand that our tests will not be provided by a medical doctor and cannot be used to diagnose a disease or condition.

☐ I accept that the results of my family’s tests may be used in publications and at conferences for the purpose of learning, only after any information that can identify us has been removed.
☐ I understand that since I could be receiving over $500 worth of incentives for participating in this study, I may need to provide my Social Insurance Number (SIN). I understand my SIN will be kept confidential and will only be shared with the University of Guelph financial office.

☐ I understand that my family will have the opportunity to participate in the Guelph Family Health Study – Intervention Program. This study program will provide 6-months of support to my family for healthy lifestyle choices. I will discuss this with the Study Coordinator during our home visit and I will be able to choose to participate at that time.

☐ I understand that I will have the option to have my family’s blood, fecal and saliva samples stored in the Guelph Family Health Study – BioBank. The samples will be used for future research to help better understand the human behaviours that affect health. I will discuss this with the Study Coordinator during our home visit and I will be able to choose to participate at that time.

Parent #1 Name ______________________________

Parent #1 Signature_______________________________   Date __________________

Study Coordinator Signature _______________________   Date __________________

89
APPENDIX C: GUELPH FAMILY HEALTH STUDY PILOT PHASE 2 PARENT 1 – CHILD SURVEY (SELECT ITEMS)

Q1 Thank you for your interest in the Guelph Family Health Study!

Parent 1 - Child Survey

This study requires you to answer questions that will help us understand your family’s health behaviours. You will be asked to confirm your eligibility to participate in the study by providing your first name, last name and family code. You will also receive a grocery gift card as a thank you once you have completed the study questionnaires.

This questionnaire will take approximately 30 minutes, for each child you have between the ages of 18 months and 5 years. This is the target age range for the children in the study.

Q4 Please confirm how many children do you have in total:

- 1 (2)
- 2 (3)
- 3 (4)
- 4 (5)
- 5 (6)
Q5 Please confirm how many children you have between the ages of 18 months and 5 years old:

○ 1 (1)
○ 2 (2)
○ 3 (3)

Q8 How would you describe $Q6/ChoiceTextEntryValue/2$’s ethnicity/race? Please select all that apply.

☐ White (1)
☐ Aboriginal/First Nations peoples (2)
☐ Chinese (3)
☐ Black (4)
☐ Korean or Japanese (5)
☐ Latin American (6)
☐ South Asian (for example: East Indian, Pakistani, Sri Lankan, etc.) (7)
☐ Southeast Asian (for example: Vietnamese, Cambodian, Filipino, Malaysian, Laotian, etc.) (8)
☐ West Asian (for example: Arab, Iranian, Afghan, etc.) (9)
☐ Other, please specify (10) ____________________________________________
☐ I am not comfortable answering this question (11)

Q9 How are you related to $Q6/ChoiceTextEntryValue/2$?

○ Mother (1)
Q26 Next are questions about ${Q6/ChoiceTextEntryValue/2}’s physical activity. Please let us know how much you agree or disagree with the following statements.

- Stepfather (5)
- Fosterfather (6)
- Grandmother (7)
- Grandfather (8)
- Other, please specify (9) ________________________________________________
- I am not comfortable answering this question (10)
<table>
<thead>
<tr>
<th>I encourage ${Q6/ChoiceTextEntryValue/2} to be physically active by being active myself leading by example (by role modelling). (1)</th>
<th>Strongly disagree (1)</th>
<th>Disagree (2)</th>
<th>Agree (4)</th>
<th>Strongly Agree (5)</th>
<th>I am not comfortable answering this question. (6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I make sure ${Q6/ChoiceTextEntryValue/2} is aware that I am physically active. (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I exercise or am physically active on a regular basis. (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I enjoy exercise and physical activity. (4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I enroll ${Q6/ChoiceTextEntryValue/2} in sport teams or activities such as soccer, basketball, and dance. (5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I take ${Q6/ChoiceTextEntryValue/2} to places where he/she can be active. (6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I take ${Q6/ChoiceTextEntryValue/2} outside to play when the weather is nice. (8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I would rather ${Q6/ChoiceTextEntryValue/2} play indoors because I don't want to sit outside and watch him/her play. (10)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I offer sports or physical activities to ${Q6/ChoiceTextEntryValue/2} as a reward for good behaviour. (11)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I use sports and physical activities to get ${Q6/ChoiceTextEntryValue/2} to do something (e.g. &quot;you can't go outside to play until you eat all your peas&quot;). (13)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
I offer extra outdoor time as a reward for good behaviour. (14)

I take away outside time for bad behaviour. (15)

${Q6/ChoiceTextEntryValue/2}$ travels (for example: to childcare, to school, to run errands) by walking, riding a bicycle, or taking public transportation. (16)

${Q6/ChoiceTextEntryValue/2}$ travels (for example: to childcare, to school, to run errands) by car or by riding in a stroller. (17)

Q58 Is your child currently in elementary school (ex. Kindergarten, Grade 1, Grade 2…)?

○ Yes (1)

○ No (2)

○ I not comfortable answering this question (3)

*Skip To: Q64 If Q58 = Yes (1)*

Q59 Is ${Q6/ChoiceTextEntryValue/2}$ currently in childcare, day care or preschool?

○ Yes (1)

○ No (2)

○ I am not comfortable answering this question (3)

*Skip To: Q64 If Q59 != Yes (1)*
Q60 What type of care does \(Q6\) receive?

- In a day care center or preschool (1)
- In out-of-home family daycare (2)
- In in-home care, for example with a babysitter, nanny or relative (3)
- I am not comfortable answering this question (4)
Q1 Thank you for registering for the Guelph Family Health Study!

This study requires you to answer questions that will help us understand your family’s health behaviours. You will be asked to confirm your eligibility to participate in the study by providing your first name, last name and family code.

You will receive a grocery gift card as a thank you once you complete all of the study questionnaires. This questionnaire will take approximately 60 minutes.

Q4 Do you live with a partner or spouse?
   Yes (1)
   No (2)
   I am not comfortable answering this question (3)

Q195 Please indicate your gender:
   Male (1)
   Female (2)
   I am not comfortable answering this question (3)
Q9 Which of the following best describes your current marital status?

- Married (1)
- Not married, but living with partner (2)
- Single, never been married (3)
- Divorced (4)
- Separated (5)
- Widowed (6)
- I am not comfortable answering this question (7)

Q11 What is the total annual income of your household before taxes? Your household includes income from you and anyone who lives with you who depends on the same income. Be sure to include income from all sources, such as salary and wages, child support, interest, public assistance and pensions.

- Less than $10,000 (1)
- $10,000 to $19,999 (2)
- $20,000 to $29,999 (3)
- $30,000 to $39,999 (4)
- $40,000 to $49,999 (5)
- $50,000 to $59,999 (6)
- $60,000 to $69,999 (7)
- $70,000 to $79,999 (8)
- $80,000 to $89,999 (9)
- $90,000 to $99,999 (10)
- $100,000 to $149,999 (11)
Q25 Physical Activity

Q26 We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives.

The following questions will ask you about the time you spent being physically active in the last 7 days.

Please answer each question even if you do not consider yourself to be an active person. Think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Q27 Think about all the vigorous activities that you did in the last 7 days. Vigorous physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time. During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, digging, aerobics, or fast bicycling?
Q28 On one of those days how much time did you usually spend doing **vigorous** physical activities like heavy lifting, digging, aerobics or fast bicycling?

________________________________________________________________

Q29

- Minutes (1)
- Hours (2)
- I am not comfortable answering this question (4)

Q30 Think about all the **moderate** activities that you did in the last 7 days. Moderate physical activities refer to activities that take hard moderate effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time. During the last 7
days, on how many days did you do **moderate** physical activities like heavy carrying light loads, bicycling at a regular pace, or doubles tennis?

- 0 (1)
- 1 (2)
- 2 (3)
- 3 (4)
- 4 (5)
- 5 (6)
- 6 (7)
- 7 (8)
- I am not comfortable answering this question (9)

Q31 How much time did you usually spend doing **moderate** physical activities on one of those days?

________________________________________________________________

Q32

- Minutes (1)
- Hours (2)
- I am not comfortable answering this question (3)

Q33 Think about the time you spent **walking** in the last 7 days. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation,
During the last 7 days, on how many days did you walk for at least 10 minutes at a time? __________ days per week

- 0 (1)
- 1 (2)
- 2 (3)
- 3 (4)
- 4 (5)
- 5 (6)
- 6 (7)
- 7 (8)
- I am not comfortable answering this question (9)

Q34 How much time did you spend walking on one of those days?

________________________________________________________________

Q35

- Minutes (1)
- Hours (2)
- I am not comfortable answering this question (3)
Q90 Is there a children’s playground within 10-minutes walking distance of your house?

- Yes (1)
- No (2)
- I am not comfortable answering this question (3)