Exploring the Impact of a Family-Based Health Intervention on Children’s Body Composition

by

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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

(Applied Human Nutrition)

Guelph, Ontario, Canada

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ABSTRACT

EXPLORING THE IMPACT OF A FAMILY-BASED HEALTH INTERVENTION ON CHILDREN’S BODY COMPOSITION

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University of Guelph, 2016

The purpose of this study was to explore the association between a home-based childhood obesity prevention intervention and preschooler body composition. The family-based intervention focused on the following obesity-related health behaviours: family meals, physical activity, screen time, sugar-sweetened beverage consumption, and sleep routines. Baseline and six-month follow-up data were collected from 42 families participating in the family-based obesity prevention intervention, the Guelph Family Health Study. Families were randomized into a two or four home visit group, or control group. Families randomized into the intervention groups received two or four home visits from a health educator, tailored weekly e-mails and mailed resources. The intervention was based on Motivational Interviewing counseling techniques. The majority of participants identified as Caucasian and were aged 18 months to 5 years. Using the World Health Organization (WHO) growth charts, 67.3% and 71.7% of children were classified as normal weight at baseline and six-month follow-up, respectively. At baseline, 3.9% of preschoolers were classified as overweight and this increased to 5.7% at six-month follow-up. No participants were classified as obese. The intervention was found to be associated with improved body composition outcomes for total body water for the two home visit and combined intervention groups, and for fat mass (%) and kg) for the two home visit group. The intervention showed no significant associations with body composition measures for the four home visit group. The findings from this study suggest that a smaller intervention dose may be
appropriate to achieve favourable changes in body composition and weight status. This study provides insight into how a family-based obesity prevention intervention in the home setting combined with MI counseling techniques can impact preschooler body composition outcomes.
ACKNOWLEDGEMENTS

I never thought I would go to graduate school. I imagined that I would feel so fulfilled and content once I finally achieved my designation as a registered dietitian that I would want for nothing more. But, when you find what you truly love to do in life you can’t help but want to enhance your learning and make a meaningful contribution. Having found my passion for pediatric care early on in my career, I couldn’t have imagined a more perfect research experience than with the Guelph Family Health Study. Having the opportunity to attend graduate school and work with this team has truly been one of the most enriching and valuable experiences of my life. It has not only contributed to my professional and academic career, but also to my personal growth. There are many people that deserve my most sincere thanks, for this achievement would not have been possible without their support and encouragement.

To my advisors, Drs. Jess Haines and Andrea Buchholz, thank you both for being such incredible mentors. Words cannot express how truly grateful I am to have had the opportunity to learn from such inspiring people in the field of dietetics and research. Your consistent guidance and encouragement allowed me to reach my highest potential, strengthening my love of research and learning. Thank you for seeing my potential and helping me to become the person that I am today.

I would also like to thank each and every member of the Guelph Family Health Study. I feel so fortunate to have had this wonderful family of people to support and encourage me throughout my time as a graduate student. Our team is a prime example of the amazing things that can happen when a group of people with the same passion work together to make a difference. I look forward to reading publications from all of our hard work for years to come!
I would also like to thank all of the families who participated in the Guelph Family Health Study – pilot study. Without you, none of this would be possible. Being your health educator was an invaluable experience and I am so grateful for all that I have learned from you. I hope to remember all of your parenting tips when I am in need one day!

To all of my amazing friends and fellow RDs - I am inspired by each of you. Thank you for continuing to support and encourage me throughout my many years of education and early career. You have always encouraged me to relentlessly pursue my goals and have believed in my potential.

The completion of this project would not have been possible without the love and encouragement of my family: Mom, Dad, Karen, Dave, Nate and Cameron. Special thanks to my parents, Tom and Beth, for instilling in me a love of learning and the importance of an education. Thank you for always encouraging me to chase my dreams and shaping me into the person I am today. I would also like to give a special thank you to my nephews, Nate and Cameron. Your photos, artwork, and videos always brighten my day and inspire me to make a meaningful impact in child health. And, to my roommate and good friend, Monica- thank you for always being there to listen, dance, laugh, and eat Indian food – I could not have gotten to this point without you.
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List of Abbreviations

AAP = American Academy of Pediatrics
ADP = Air Displacement Plethysmography
BIA = Bioelectrical Impedance Analysis
BMC = Bone Mineral Content
BMI = Body Mass Index
CCHS = Canadian Community Health Survey
CDC = U.S. Center for Disease Control
CHD = Coronary Heart Disease
CI = Confidence Interval
CT = Computed Tomography
DLW = Doubly Labeled Water
DRI = Dietary Reference Intakes
DXA = Dual-Energy X-ray Absorptiometry
EI = Energy Intake
FM = Fat Mass
FFM = Fat-Free Mass
GEE = Generalized Estimating Equations
GENMOD = Generalized Linear Model
GFHS = Guelph Family Health Study
HV = Home Visit
IOTF = International Obesity Task Force
LAUNCH = Learning about Activity and Understanding Nutrition for Child Health
LDL = Low-Density Lipoprotein
MC = Multi-Compartment
MI = Motivational Interviewing
MITI = Motivational Interviewing Treatment Integrity
MRI = Magnetic Resonance Imaging
MRS = Magnetic Resonance Spectroscopy
NHANES = National Health and Nutrition Examination Survey
QCT = Quantitative Computed Tomography
SDS = Standard Deviation Score
SSB = Sugar-Sweetened Beverage
TEE = Total Energy Expenditure
TBK = Total Body Potassium
TBW = Total Body Water
TV = Television
VPA = Vigorous Physical Activity
WC = Waist Circumference
WHtR = Waist-to-Height Ratio
WHO = World Health Organization
1.0 Introduction

In Canada, the number of children who are overweight and obese has increased rapidly over the past 30 years (Shields & Tremblay, 2010). Having excess weight gain early in life is associated with an increased risk of chronic disease such as heart disease, diabetes, and cancer, later in life (Campbell et al., 2014; Davison, Jurkowski, Li, Kranz, & Lawson, 2013; Shields et al., 2010). Obesity can be largely prevented through lifestyle interventions, however current strategies remain ineffective or unproven. Extensive empirical evidence shows that parents influence their young children’s risk of developing obesity through their feeding behaviours, their own weight-related behaviours, and providing a home environment that either facilitates or impedes children’s healthy eating and physical activity behaviours (Davison et al., 2013; O’Brien, McDonald, & Haines, 2013; O’Connor, Jago, & Baranowski, 2009; Persaud et al., 2013). These findings suggest that intervening to reduce obesity among young children requires engaging with and changing the behaviours of their parents.

The primary aims of the Guelph Family Health Study (GFHS) are to identify early life risk factors for disease and to test family-based interventions that promote healthy behavior change. It is a longitudinal, randomized control trial composed of Guelph area families with at least one child aged 18 months to 5 years. As an initial step to creating the GFHS, a pilot study of 42 families was performed to test the feasibility of the intervention and assessment protocols and to provide preliminary data regarding the effectiveness of the intervention. This research focused on analyzing the pilot study data, specifically looking at the effect of the intervention on children’s body composition and measures of weight status. Families were randomized to one of three arms: 1) Monthly e-mails with generic health information; 2) Tailored weekly health e-mails and two home visits with a health educator; or 3) Tailored weekly health e-mails and four
home visits with a health educator. The intervention lasted six months, with measures taken at baseline and six-month follow-up. We hypothesized that preschool-aged children from families randomized to the intervention group will have experienced healthy trends in growth as assessed by decreases in body mass index (BMI), fat mass (FM), waist circumference (WC) and waist-to-height ratio (WHtR) compared to preschoolers in the control group. As well, we hypothesized that preschoolers from families randomized to the four home visit group will have experienced greater decreases in body composition and weight status than preschoolers in the two home visit group.

Intervention early in life is essential to stopping the obesity epidemic. The GFHS is unique in that it provides families with personalized health information, it targets children at a young and impressionable age, and the fact that it is longitudinal will help to reveal over time whether the behavioural changes and healthy habits are sustained. It is anticipated that the results of this research will provide a new approach to obesity prevention in Canada that may result in effective ways to prevent disease early in life and may provide a foundation for lifelong health and quality of life for Canadian families.
2.0 Review of the Literature

2.1 Childhood Obesity

2.1.1 Prevalence and Consequences of Obesity in Preschool Children

On a global scale the prevalence of children who are overweight and obese has increased dramatically in recent decades. Survey data from 144 nationally representative countries found that the prevalence of children who are overweight and obese increased from 4.2% in 1990 to 6.7% in 2010, and is expected to reach 9.1% or approximately 60 million preschool children by 2020 (De Onis, Blössner, & Borghi, 2010). More specifically, in developed countries the prevalence of preschool-aged children who are overweight and obese is expected to nearly double, from 7.9% in 1990 to 14.1% in 2020 (De Onis et al., 2010).

In Canada, the number of children who are overweight and obese has rapidly increased over the past 30 years, with the most recent statistics from the 2004 Canadian Community Health Survey (CCHS) indicating that 15% of pre-school aged children are overweight and 6% are obese (Canning, Courage, & Frizzell, 2004; Shields, 2006).

Excess weight gain early in life has been shown to contribute to high rates of obesity and related chronic diseases including cancer, type 2 diabetes, and non-alcoholic fatty liver disease later in life (Campbell et al., 2014; Davison et al., 2013; L’Allemand-Jander, 2010; Lobstein, Baur, & Uauy, 2004). In addition, a higher body mass index (BMI) in childhood is positively associated with risks of developing coronary heart disease (CHD) in adulthood including hypertension, high low-density lipoprotein (LDL) cholesterol and triglyceride levels, and impaired glucose tolerance (Baker, Olsen, & Sørensen, 2007; Berenson, Srinivasan, Bao, Newman, & Tracy, 1998). Children who are carrying excess weight are also at a higher risk of orthopedic problems including bone fractures, musculoskeletal discomfort, and mobility issues;
all of which can lead to chronic issues in adulthood (Taylor et al., 2006). The presence of weight bias and stigmatization in society can also affect children socially, emotionally, and academically (Hayden-Wade, Stein, Ghaderi, Saelens, Zabinski, & Wilfley, 2005; Puhl & Latner, 2007; Warschburger, 2005).

2.1.2 Risk Factors Associated with Preschooler Obesity

It is widely recognized that a healthful diet plays a significant role in achieving optimal health and development. According to Eating Well with Canada’s Food Guide this includes eating a balanced diet rich in fruits and vegetables, whole grains, lean meats and alternatives, low-fat dairy products, and reduced consumption of trans- and saturated fats and oils (Health Canada, 2011). According to the 2004 CCHS, Canadian children are not eating a balanced diet. Despite meeting the appropriate macronutrient distribution ranges, Canadian children were found to eat fewer fruits, vegetables, and milk and alternatives, too few or too many servings of grains, and too many foods from the “other” food group category (Garriguet, 2004). According to a Canadian study, children with higher intakes of fast food were also found to be overweight or obese, and had higher waist circumference and fat mass (Wang, Shang, Gray-Donald, Lambert, O’Loughlin, & Tremblay, 2012). In a cross-sectional survey of U.S. preschoolers, Butte et al. (2010) found that on average, preschoolers had diets high in fat and sodium, and low in dietary fiber when compared to Dietary Reference Intake (DRI) recommendations. Fox and colleagues (2010) also found that 85% of U.S. children aged 2 and 3 years consumed some type of sweetened beverage, dessert, sweet or salty snack daily. Preschool-age is a critical period for optimal growth and development where children have high nutrient needs and minimal energy requirements thus, making it imperative to optimize consumption of healthy food and minimize the intake of less nutrient-dense foods (Fox et al., 2010).
2.1.2.1 Sugar-Sweetened Beverage Consumption

One strategy to discourage excess weight gain in preschoolers is to reduce the consumption of sugar-sweetened beverages (SSB). The American Academy of Pediatrics (AAP) (2001) recommends that children aged 1 to 6 years should consume no more than four to six ounces of 100% fruit juice per day. However, data from the 2004 CCHS indicate that the top sources of sugar intake for children aged 1 to 8 years are fruit juice at 14.6% of total sugar intake, fruit drinks at 6.2%, and soft drinks at 3.6% (Statistics Canada, 2014). Even more alarming, a recent U.S. study found that of children aged 3 to 5 years, nearly 94% usually consumed sweetened milk products, 88% had fruit drinks, 63% had soft drinks, and 56% usually consumed sport drinks and sweet tea (Nickelson, Lawrence, Parton, Knowlden, & McDermott, 2014).

Consuming SSBs is positively associated with a high caloric intake and increased BMI, and may be associated with obesity risk in both children and adults (De Ruyter, Oltorf, Seidell, & Katan, 2012; Fox et al., 2010; Malik, Popkin, Bray, Després, & Hu, 2010; Malik, Willett, & Hu, 2013). As well, greater consumption of SSBs in early childhood is found to be associated with higher consumption of SSBs and excess weight gain in early and mid-childhood, and into adulthood (Nissinen et al., 2009; Viner & Cole, 2006; Sonneville, Long, Rifas-Shiman, Kleinman, Gillman, & Taveras, 2015). A recent systematic review and meta-analysis by Te Morenga, Mallard, & Mann (2013) found that children who consumed at least one daily serving of a SSB had a significantly increased risk of being overweight compared to those who consumed little or none (odds ratio (OR) = 1.55; 95% confidence interval (CI): 1.32 to 1.82).
2.1.2.2 Physical Activity

Canadian physical activity guidelines (n.d.) recommend that preschoolers get at least 180 minutes of physical activity at any intensity level, and that school-aged children (aged 5 to 11 years) and youth (aged 12 to 17 years) engage in at least 60 minutes of moderate to vigorous physical activity on a daily basis. Recent Canadian statistics show that 84% of Canadian children aged 3 to 4 years are meeting the guidelines, however this declines to only 7% of children meeting guidelines at ages 5 to 11 years, and only 4% at ages 12 to 17 years (Colley et al., 2013; Active Healthy Kids Canada, 2013). Research by Ruiz and colleagues (2013) found that preschoolers tend to take most of the day attaining the recommended amount of physical activity since they tend to engage in short spurts of activity that are small in duration. Physical activity is not only linked to improved weight status, but also to other health benefits such as bone, heart, and mental health (Atkin & Davies, 2000; Brien, Katzmarzyk, Craig, & Gauvin, 2007; Janssen & LeBlanc, 2010; Moore et al., 2003). There is also evidence to suggest that physical activity in early childhood may be predictive of physical activity in adolescence and adulthood (Malina, 2001). However, a review by Sallis and colleagues (2000) found that parental overweight status, parents’ physical activity preferences and intention to be active, program and facility access, and time spent outside were consistently associated with children’s physical activity. A qualitative study of Canadian parents found that intrapersonal factors, including preschoolers’ health and preferences, played a role in their physical activity level. Reported interpersonal barriers included parents’ busy schedules, family structure, and their personal views on physical activity. Environmental barriers such as weather, safety, and community resources were also described as barriers to their preschoolers’ physical activity level (Dwyer, Needham, Randall Simpson, & Heeney, 2008).
2.1.2.3 Sleep Patterns

It is recommended that toddlers (1 to 2 years of age) and preschoolers (3 to 5 years of age) sleep between 11 to 14 hours, and 10 to 13 hours per 24 hour period, respectively (Hirshkowitz et al., 2015). Preschool-age is a time when children establish independent sleep habits and when their sleep patterns are still receptive to change, making this a critical age for establishing sound sleep routines (Miller et al., 2014). Like diet and physical activity, sleep plays a critical role in the growth, maturation, and healthy weight status of children (Chen, Baydoun, & Wang, 2008). There is strong evidence to support an inverse relationship between sleep duration, and overweight and obesity risk. Proposed associations between sleep and obesity include sleep deprivation leading to hormonal changes, including impaired glucose tolerance, elevated cortisol and ghrelin, and increased leptin and growth hormone levels; all of which can lead to an energy imbalance that can result in overweight and obesity (Spiegel et al., 2004; Spiegel, Leproult, & Van Cauter, 1999; Taheri, Lin, Austin, Young, & Mignot, 2004). As well, sleep deprivation can lead to weight gain through fatigue and decreased energy expenditure during the day, as well as allowing more time for eating throughout the day (Taheri, 2006).

Traveras and colleagues (2008) looked at measuring the longitudinal relationship between short sleep duration in children aged 6 months to 2 years with adiposity and overweight status at 3 years of age. Results indicated that infants who slept fewer than 12 hours per day were at increased risk of obesity (OR= 2.0) at 3 years of age. A systematic review and meta-analysis by Chen et al. (2008) found that children who did not receive the recommended amount of sleep had a significantly higher risk of overweight and obesity compared to children who met the recommendations (OR = 1.60; 95% CI: 1.22 to 2.10). They also found a significant linear dose-response relationship between sleep deprivation and childhood obesity in children less than 10 years of age.
2.1.2.4 Screen Time and Sedentary Activity

Lipnowski (2012) describes recreational screen time as television (TV) watching, video game playing, and using computers or other screens during non-work or school-based time while sedentary. Screen time has been found to be positively associated with overweight and obesity in childhood, with adverse health effects lasting into adulthood (Crespo et al., 2001; Dennison, Erb, & Jenkins, 2002; Gortmaker et al., 1996; Hancox, Milne, & Poulton, 2004; Jago, Baranowski, Baranowski, Thompson, & Greaves, 2005). Results of a Canadian study looking at grade 5 students found that frequent dinner consumption while watching TV is positively associated with increased sugar, fat, snack food, and soft drink intake (Liang, Kuhle, & Veugelers, 2008).

Increased screen time contributes to weight gain and poor health outcomes in children not only from increased consumption of energy-dense foods, but also from decreased energy expenditure (Blass et al., 2006; Husby, Heitmann, & O’Doherty, 2008; Jago et al., 2005). Canadian Sedentary Behaviour Guidelines (2012) recommends that children less than 2 years old avoid all screen time, children aged 2 to 4 years limit screen time no more than one hour per day, and children aged 5 to 17 years to limit screen time to no more than two hours per day. The 2009-2011 Canadian Health Measures Survey (Statistics Canada, 2013) found that 54.9% of Canadian children aged 3 to 17 years exceeded these guidelines. Moreover, 66% of preschoolers in the U.S. are exceeding the AAP (2001) guideline of no more than two hours of screen time per day (Tandon, Zhou, Lozano, & Christakis, 2011).

De Decker and colleagues (2012) published a qualitative study exploring parents’ perceptions of preschooler screen time, from six European countries. They found that weather conditions and parental habits at home are the most important factors influencing children’s screen time. Coupled with this, parents attributed education as the chief benefit to watching TV.
Researchers stressed the importance of helping families identify alternative activities in order to reduce TV and screen time (De Decker et al., 2012). Another major predictor of increased screen time in children is having a TV in the bedroom. According to a study by Dennison et al. (2002), the OR of having a BMI greater than the 85th percentile was 1.31 (95% CI: 1.01 to 1.69) among preschoolers with a TV in their room compared to those without, after adjusting for child age, sex, TV viewing hours per week, maternal BMI and education, and race/ethnicity.

2.1.2.5 Family Meals

The AAP (2013) recommends having regular family meals as a way to help with obesity prevention and to promote healthy habits in children and families. While the majority of family meal research is cross-sectional and adolescent-focused, family meals have been found to be associated with improved nutrient intake, positive psychosocial effects, and reduced disordered eating practices (Harrison et al., 2015; Martin-Biggers et al., 2015; Woodruff, Hanning, McGoldrick, & Brown, 2010). A review by Martin-Biggers and colleagues (2014) found that more frequent family meals are associated with greater consumption of healthy foods in children, adolescents, and adults. In particular, having children eat the same food as parents at mealtimes has been linked to improved dietary intake in children (Skafida, 2013). However, results have been inconsistent when looking at the relationship between family meals and childhood obesity. While some literature reports higher frequency of family meals being associated with reduced odds of being overweight or becoming overweight in the future (Goldfield et al., 2011; Sen, 2006), other research shows that family meals have an effect only on baseline weight and not on future weight status (Fulkerson, Neumark-Sztainer, Hannan, & Story, 2008; Taveras et al., 2005).
Data on Canadian family meal frequency is limited however; one Canadian study revealed that only 65% of children in grades 6 to 8 reported regularly having family meals six or seven days per week (Woodruff et al., 2010). While the literature is inconclusive on whether or not the frequency of family meals has decreased in recent decades, the research demonstrates an inverse relationship between frequency of family meals and age, such that children are consuming family meals more frequently than adolescents (Rockett, 2007).

2.1.3 Parental Influence on Childhood Obesity

Parents influence their young child’s risk of becoming overweight and obese through genetic, behavioural, and environmental factors. A review of cross-sectional observational studies suggest that parental weight status is strongly associated with the weight status of children, especially those less than 5 years of age, as well as a child’s risk of developing adult obesity later in life (Bouchard, 2009). However, even though a child may have a genetic predisposition for obesity, obesity may only develop in the presence of an obesogenic environment (Marti, Moreno-Aliaga, Hebebrand, & Martinez, 2004; Rank et al., 2012). A systematic review by Skouteris and colleagues (2011) examined parental variables associated with interventions intended to modify risk factors for obesity, through the promotion of healthy eating and physical activity in children aged 2 to 6 years. Researchers noted significant methodological limitations in the present literature given that this is a relatively new area of research. However, researchers concluded that teaching parents about nutrition and the adoption of a healthy lifestyle can lead to improved knowledge and behaviours, which subsequently can result in improved weight status for their children. Modifying parental cognitions, beliefs, and behaviours may show promise as an obesity prevention strategy (Skouteris et al., 2011).
Parents may influence their child’s food preferences and intake through parental modeling, child feeding behaviours, and by the type of food environment created in the home, such as parents exposing and encouraging their child to try new foods and including children in food preparation and selection (Benton, 2004; Birch & Fisher, 1998; Clark, Goyder, Bissell, Blank & Peters, 2007; Russell, Worsley, & Campbell, 2015; Skinner, Carruth, Bounds, & Ziegler, 2002). There is strong evidence to suggest that a child’s food preferences correspond with their food intake, and subsequently, their food preferences and intake during adolescence and adulthood (Benton, 2004; Birch et al., 1998; Fisher & Birch, 1995; Skinner et al., 2002). A randomized controlled trial by Van Allen and colleagues (2014) examined parent motivation and its influence on preschoolers’ BMI z-score and dietary intake as part of six month family-based intervention. Researchers found that increases in parent motivation were significantly associated with decreased BMI z-score ($R^2\Delta = .091, F [2,40] = 15.202, p < .001$), and lower consumption of sugar-sweetened beverages ($R^2\Delta = .102, F [2,40] = 3.580, p < .05$) and sweets ($R^2\Delta = .110, F [2,40] = 7.732, p < .05$). This study lends further support to the importance of having childhood obesity interventions include parents in order to help improve weight outcomes for young children.

Parents also influence their child’s weight status through screen time and sedentary activity. A study by Martin-Biggers and colleagues (2014) found that parents who got less sleep were more likely to permit increased screen time. In addition, child screen time hours were also positively correlated with parental BMI. Increased preschoooler screen time is associated with the number of televisions in the home, whether or not a television is in the bedroom, whether television watching is permitted at mealtimes, and also with increased parental screen time.
Additionally, having family rules enforced about screen time is associated with reduced screen time in children (Birken et al., 2011).

In addition to reducing screen time, parents can also influence their preschooler’s physical activity levels by providing support, such as by encouraging their child to participate, participating with their child, or telling their child why physical activity is important (Martin-Biggers et al., 2014). In a Canadian sample of preschool-aged children, children who received greater parental support to engage in physical activity were 6.3 times more likely to be highly active than inactive (Zecevic, Tremblay, Lovsin, & Michel, 2010).

Therefore, interventions are needed to help parents create healthful environments and household routines that support the development of healthful behaviours among their young children.

2.1.4 Family-Based Childhood Obesity Interventions

Parental involvement is an important aspect of childhood obesity prevention and care (West, Sanders, Cleghorn, & Davies, 2010). However, the best way to support families in managing and preventing obesity across childhood remains unclear. Existing treatment interventions have been primarily focused in primary care, community, and school-based settings. A systematic review by Staniford et al. (2012) on childhood obesity treatment found that interventions that are family-centered and involve lifestyle interventions incorporating diet, physical activity, and behavioural components are most effective in producing weight loss in children. The 2009 Cochrane review of childhood obesity treatment interventions found that children under age twelve who received family-based behavioural lifestyle interventions showed a significant decrease in BMI-Standard Deviation Score (SDS) compared to children who received standard care at six-month follow-up. However, at 12-month follow-up, the effect size
was no longer significant, although decreased BMI-SDS was still noted in some studies (Oude Luttikhuis et al., 2009). A systematic review and meta-analysis by Ho and colleagues (2012) found that lifestyle interventions used to treat childhood obesity produced significant weight loss compared to control groups (BMI -1.25kg/m², 95% CI: -2.18 to -0.32) and BMI z score (-0.10, 95% CI -0.18 to -0.02). Moreover, it was concluded that almost all effective interventions included a family-based component. In addition, lifestyle interventions vs. standard primary care treatment showed significantly better results on immediate and post-treatment effects on children’s BMI. However, the review could not conclude the optimal length, intensity, and long-term effectiveness of lifestyle interventions; warranting a need for future research in this area.

However, a notable finding in these reviews was the lack of interventions aimed at pre-school aged children. Summerbell and colleagues (2012) conducted a review to establish evidence-based recommendations for obesity prevention programs targeted at preschoolers. They concluded that focusing on parental engagement, physical activity and sedentary behaviour and healthy eating, and including general recommendations and simple messages are all crucial components to having a successful intervention. Systematic reviews by Blake-Lamb and colleagues (2016) and Wofford (2008) strongly emphasize the need for obesity prevention studies to begin as early in life as possible. Wofford (2008) also stresses the importance of parental involvement and the concept of building healthy habits related to nutrition and activity. The 2011 Cochrane review of childhood obesity prevention interventions found that for children aged 0 to 5 years, interventions outside of the school environment are more effective, including community, home, and health-service settings, likely due to an increased level of parental engagement (Waters et al., 2011). Consistent with the 2009 review on obesity treatment among children, this review also
found limited prevention interventions among preschool-aged children, and limited use of interventions that included a combination of health behaviours. Moreover, the 2011 Cochrane review emphasized the need for future trials to be larger and longer-term (Waters et al., 2011). Skouteris and colleagues (2016) developed a parent-based randomized controlled trial of 10 weekly workshops promoting healthy eating and physical activity in preschoolers. Although the study had no effect on child BMI, results demonstrated significant positive effects for increased vegetable intake ($p= 0.01$), less snack food ($p= 0.03$), and increased satiety responsiveness ($p= 0.047$) for children immediately post-intervention. A recent review by Showell et al. (2013) of home-based childhood obesity prevention interventions found that of a total six studies, none reported significant effects on weight outcomes. However, select combined interventions of diet and physical activity showed beneficial effects on sedentary behaviour and fruit and vegetable intake in children. However, a study by Haines and colleagues (2013) looking at the effects of a home-based obesity prevention program among low-income families with preschoolers did find a significant decrease in BMI ($-0.40; 95\% \text{ CI}: -0.79$ to $0.00; p= .05$) after a six-month intervention. Nevertheless, research in this area is limited, prompting the need for future, long-term childhood obesity prevention research in the home setting. Stark and colleagues (2014) conducted a study of obese preschoolers that were randomized to receive behavioural obesity treatment either through a 18-session intervention called Learning about Activity and Understanding Nutrition for Child Health in a clinic setting (LAUNCH - clinic), LAUNCH in a combined clinic and home visit setting (LAUNCH + HV), or through general pediatric counseling on diet and physical activity. The intervention lasted a total of six months. From pre- to post-treatment, only preschoolers randomized to the LAUNCH + HV group showed a significantly greater decrease in BMI z-score compared with pediatric counseling ($p= 0.007$).
Importantly, as Spence and colleagues (2015) mention, managing pediatric obesity through home visits can improve families’ access to health care and applicability of services, reduce attrition by minimizing participation barriers, and can create positive attitudes through a continuum of care approach that emphasizes good rapport building between health care providers and families. Although highlighting benefits for home-based services for obesity treatment, many of these benefits of home visits are relevant for obesity prevention as well.

Therefore, based on the current literature it is crucial to fill the gap in preschooler obesity prevention research; future studies are needed to study preschool-aged children in family-based lifestyle interventions in the home environment, especially in the long-term.

### 2.2 Motivational Interviewing

Motivational interviewing (MI) is a patient-centered counseling technique that helps individuals to explore and resolve ambivalence and discrepancies in their current values and behaviours in helping them to achieve future goals (Miller & Rollnick, 2004). The technique was first developed by Miller (1983) over three decades ago as a method to help treat alcoholism. Since then, MI has been applied to a variety of health behaviours including risk factors for overweight and obesity, nutrition, cholesterol, smoking cessation, blood pressure, and physical activity (Armstrong, Mottershead, Ronksley, Sigal, Campbell, & Hemmelgarn, 2011; Burke, Arkowiz, & Mechola, 2003; Heckman, Egleston, & Hoffman, 2010; VanBuskirk & Loebach Wetherell, 2014). Motivational Interviewing is based on five basic principles: 1) express empathy through reflective listening; 2) help client identify discrepancy between their goals and values, and their current behaviour; 3) avoid arguing with or confronting the client; 4) roll with client’s resistance; 5) support the client’s self-efficacy and optimism (Miller & Rollnick, 1991). Traditionally, MI has been practiced with adults and adolescents but in more recent years has
been showing promise with use in children, specifically in regards to changing health behaviours associated with overweight and obesity (Gayes & Steele, 2014). It is also suggested to help increase long term change outcomes in the treatment of pediatric obesity, as well as positive weight and health behaviour outcomes (Gayes et al., 2014; Limbers, Turner, & Varni, 2008; Woo Baidal et al., 2013; Wong & Cheng, 2012). However, research on using MI for obesity prevention with preschool-aged children is scarce and has been primarily focused in primary-care settings (Resnicow, Davis, & Rollnick, 2006).

2.3 Measuring Childhood Obesity

2.3.1 Lab-Based Methods

The assessment and tracking of body composition is critical to the understanding of overall health status, changes in health and disease, as well as the efficacy of nutrition and clinical interventions in individuals and populations (Lee & Gallagher, 2008). The gold standard measure of body composition is through cadaver analysis. However in living subjects, multicompartment (MC) models are considered highly accurate and the most appropriate way to establish body composition reference standards (Wells & Fewtrell, 2006). The most valid measure is the four-compartment model, which measures total body water (TBW), bone mineral content (BMC), fat mass (FM), and residual. While this method provides valid estimates, it is costly, and generally unfeasible and impractical in most research and clinical settings (Wells et al., 2006). Body composition analysis using a three-compartment model assesses fat-free dry mass, FM, and TBW; controlling for individual variability in fat-free mass (FFM) hydration. Two compartment models divide the body into FM and FFM. In order to capture these measures, BMC is assessed through dual-energy x-ray absorptiometry (DXA), body density through underwater weighing or BOD POD™, and TBW through isotope dilution or bioelectrical
impedance analysis (BIA). These methods will be discussed further in this section. Since three- and four-MC models are timely and costly to perform, two-compartment models that have been validated against more rigorous MC models are favourable for use in research and clinical settings. However, research on using MC models as a reference method for children and adolescents is limited (Lohman, Hingle, & Going, 2013). There are also few reliability studies in children using MC models, with the exception of Butte and colleagues (2000) who developed a MC model assessing TBW, total body potassium (TBK), and BMC for estimating body composition in children up to 2 years of age. Nevertheless, this method has been well validated and is found to have good reliability in adult populations (Friedl, DeLuca, Marchitelli, & Vogel, 1992; Withers, Laforgia, & Heymsfield, 1999).

Magnetic resonance imaging (MRI), magnetic resonance spectroscopy (MRS), computed tomography (CT), and quantitative computed tomography (QCT) are considered among the most accurate methods to estimate body composition in living subjects, especially among children, allowing for estimations of FM, skeletal muscle, tissue, organs, and bone density (Karlsson et al., 2013; Lee et al., 2008). Limitations of these methods include the high cost of equipment and trained personnel, potential for high radiation exposure with QCT, and the requirement of participants to be still for the duration of the procedure, typically lasting anywhere from 10 to 90 minutes (Lee et al., 2008). Therefore, young children often need to be sedated in order to lie still for the duration of these tests.

Underwater weighing, otherwise known as hydrostatic weighing or hydrodensitometry, was previously regarded as the gold standard for body composition assessment prior to the introduction of new and improved methods. This two-compartment model distinguishes FM from FFM using body volume, and assumes specific densities of FM and FFM (Wells et al.,
Body volume is determined through the displacement of water when a subject is submerged in an underwater weighing tank. Hydrodensitometry also requires the use of specialized equipment and trained personnel, making it a costly choice for body composition assessment. As well, due to the nature of being submerged in water, this method is largely unsuitable for use in young children. However, a better tolerated and improved method to measuring body volume is through air displacement plethysmography (ADP) (Lee et al., 2008). This method requires participants to sit quietly and still inside the ADP chamber for approximately one minute while wearing tightly fitted clothing. Participants then breathe as instructed through a tube in the ADP breathing circuit system (Nuñez et al., 1999). Advantages to this method include the fact that it is non-invasive, quick to perform, does not expose subjects to radiation, and it does not require sedation. There are two available options for measuring body volume through ADP; the BOD POD and the PEA POD™. The BOD POD, recommended for adults and children aged 5 years and older, has been successfully validated in adults and children, although results only included children aged 6 years and above, and child data was found to have greater variability in comparison to criterion methods (Collins & McCarthy, 2003; Nuñez et al., 1999; Wells & Fuller, 2001). As well, a study by Crook and colleagues (2012) of body composition in preschoolers found that compared with the doubly labeled water (DLW) method, ADP does not accurately assess fat mass. Since the PEA POD was developed for use in children less than 6 months of age who weigh less than 8 kg, there is a gap from ages 6 months to 5 years in which body composition cannot be accurately assessed using ADP (Crook et al., 2012).

Body composition can also be determined using DLW using isotope dilution, using an isotope of oxygen (\(^{18}\)O) and hydrogen (\(^{2}H\)). Doubly labeled water is considered the reference
method for estimating total energy expenditure (TEE) and energy intake (EI) (Burrows, Martin, & Collins, 2010; Butte, Wong, Wilson, Adolph, Puyau, & Zakeri, 2014; Schoeller, 1999).

Through labeling one of the minor isotopes of hydrogen or oxygen, body composition can be determined by taking initial and final samples of body water through blood or urine (Djafarian, Jackson, Milne, Roger, & Speakman, 2010). Although the DLW method is highly accurate, non-invasive, and appropriate for longitudinal studies, it is expensive, requires specialized equipment and expertise to be performed, and can impose greater participant burden through the collection of multiple timed samples (Djafarian et al., 2010; Wong et al., 2014).

Dual-energy x-ray absorptiometry (DXA) is also an established method for measuring body composition in children. Sopher and colleagues (2004) performed a large validation study with children and adolescents comparing DXA to a four-compartment model where the prediction error between DXA %fat and MC% fat was 3.7%. As well, Figueroa-Colon and colleagues (1998) demonstrated that DXA assessments of FM and FFM were highly reproducible. However, while DXA does provide good estimates of FFM and FFM, the validation study found that at high % FM (>30%) DXA overestimated and at low% FM (<15%) DXA underestimated FM in children (Lohman et al., 2013). Additional drawbacks to this method include low-dose radiation emission, high cost of equipment, and that children are required to lie still for the duration of the test (~5 minutes) which may prove to be challenging and uncomfortable for preschoolers.

A method of body composition analysis commonly used in clinical practice as a “field method” is skinfold thickness measures. Traditionally this method has been used to measure subcutaneous fat using the sum of four skinfolds, using calipers at the triceps, biceps, subscapular and supra-iliac sites. This method is quick and inexpensive to perform in almost all
age groups, however measures are more challenging to obtain from obese children (Kriemler et al., 2010; Wells et al., 2006). Skinfold measures are then compared to SDS that are reliable indicators of FM. However, skinfold measures are prone to significant measurement and prediction error, especially among prepubertal children (Deurenberg, Pieters, & Hautvast, 1990; Ulijaszek & Kerr, 1999; Wyatt, Winters, & Dubbert, 2006).

2.3.2 Proxy-Based Methods

In addition to lab-based methods of assessing body composition, proxy-based methods provide estimates of FM, FFM, and overall health status. Height- and weight-based measurements of body composition are relatively easy to conduct and have minimal associated costs. Body mass index (BMI), which is a ratio of weight (kg) to height (m$^2$), is recommended for use as a screening tool of overall health and body fatness in adults, as well as a way to track weight and growth status in children (Centers for Disease Control and Prevention, 2015a; Dietitians of Canada, 2010). However, BMI does not provide an indication of the amount of FM or fat distribution throughout the body.

There are currently three growth references used to assess and classify weight status in children and youth (Shields et al., 2010). One set of growth references is the U.S. Centers for Disease Control (CDC) growth charts for children 2 to 19 years of age, which is based on data from a nationally representative sample of U.S. children from the the National Health and Nutrition Examination Survey (NHANES). These sex-specific growth references classify a child as overweight if his or her weight is equal to or greater than the 85th percentile but less than the 95th and obese if it is equal to or greater than the 95th percentile for the same age and sex (Centers for Disease Control and Prevention, 2015b). In 2000, the International Obesity Task Force (IOTF) published BMI cut-points for defining overweight and obesity in children aged 2 to
18 years from a globally diverse sample of children. These references can be extrapolated to the overweight and obesity cut-points for adults of BMI $\geq 25$ kg/m$^2$ and $\geq 30$ kg/m$^2$, respectively. According to the IOTF growth charts, preschool-aged children would be considered overweight at a BMI percentile of $\geq 91^{st}$ and obese $\geq 99^{th}$ (Cole, Bellizzi, Flegal, & Dietz, 2000). In 2006, the World Health Organization (WHO) developed the most recent growth references for use as international growth standards for children 5 years and younger. Standards for children aged 5 to 19 years were released in 2007 (Shields et al., 2010). These BMI-for-age sex-specific growth charts are based on data from the WHO Multicentre Growth Reference Study that took place in Ghana, India, Brazil, United States, Oman, and Norway. Children used for the growth references were those that had been exposed to conditions allowing for optimal growth and development that included living in a non-smoking environment, exclusive or predominantly breastfeed for more than four months with continuation of breastfeeding to at least 12 months of age, received basic immunization, and had access to proper health care (Twells & Newhook, 2011). According to the WHO growth charts adapted for Canada, children aged 2 to 5 years are classified as overweight at a BMI-for-age $>97^{th}$ percentile, and as obese at a BMI-for-age $>99.9^{th}$ percentile. Currently, the Canadian adapted WHO growth charts are recommended for use by Dietitians of Canada, the Canadian Paediatric Society, the College of Family Physicians of Canada, and Community Health Nurses of Canada, making them the optimal choice for growth tracking and monitoring for Canadian preschoolers (Canadian Paediatric Society, 2010).

Waist circumference (WC) is an anthropometric measure that assesses FM in the upper body region. This measure has largely been used in adults as an indicator of overweight and obesity, and associated comorbidities (Janiszewski, Janssen, & Ross, 2007; Klein et al., 2007). Waist circumference has also been found to correlate ($r = 0.80$) with visceral adiposity in
children, as well as with overall greater weight and total body fat content (Brambilla et al., 2006). On a global scale, there is no universal consensus of the appropriate cut-off value for WC in children, and Canadian data on the collection and interpretation of WC in children is limited (Brannsether, Roelants, Bjerknes, & Júliusson, 2011; Patton & McPherson, 2013; Roswall et al., 2009; Schwandt, Kelishadi, & Haas, 2008). Currently, the majority of WC research is based on cohorts of European children and recommended WC cut-off points are population-specific (Fredriks, van Buuren, Fekkes, Verloove-Vanhorick, & Wit, 2005, Schwandt et al., 2008). Sharma and colleagues (2015) recently developed WC z-scores for children aged 5 to 19 years using NHANES III data. While this reference data is meaningful for older children, the need remains for a quantitative tool for preschoolers. Taylor and colleagues (2008) developed WC cut-off values based on a cohort of preschool-aged children in New Zealand. Values for girls aged 3 to 5 years range from 52.9-55.7cm and for boys 52.0-56.0cm. However, this data set was based on a relatively small and homogenous sample of Caucasian children. However in 2011, Messiah and colleagues developed age-, sex-, and ethnic-specific WC percentiles for use in American children and adolescents aged 2 to 18 years. Data was obtained from a large and ethnically diverse sample of participants from the combined 1999-2008 NHANES data. Waist circumference percentiles from this data set range from $10^{th}$, $25^{th}$, $50^{th}$, $75^{th}$, and $90^{th}$. For adolescent girls aged 12 years and above, a WC at or above the $90^{th}$ percentile (90.0cm); or for girls aged 16 years and above, a WC at or above the $75^{th}$ percentile (90.6cm), meets the adult WC cut-off criteria for metabolic syndrome (88.0cm). It was also concluded that for boys aged 16 years and above, a WC at or above the $90^{th}$ percentile (106.1cm) meets the adult WC cut-off criteria for metabolic syndrome (102.0cm). However, there is no cut-off criteria developed to evaluate these WC percentiles for preschoolers, nor were the percentiles developed on a
Canadian preschooler population. Nevertheless, given the limited Canadian preschooler data, the WC percentiles developed by Messiah and colleagues (2011) may serve to provide the best estimate of WC percentiles that are applicable to Canadian preschoolers.

Waist-to-height ratio (WHtR) is another simple and effective tool for screening overweight and obesity in children and adolescents (Mokha et al., 2010; Savva et al., 2000; Yan et al., 2006). As well, WHtR has been found to be a better predictor of cardiovascular disease risk factors in children than BMI (Savva et al., 2000). However, as with WC, WHtR does not have universally established cut-off values for overweight and obesity in preschool-aged children. As mentioned with WC, Sharma and colleagues (2015) recently developed WHtR z-scores from children aged 5 to 19 years using NHANES III data. For older children, these references allow standard comparisons to be made across age and genders and acts as a meaningful tool to quantitatively study pediatric obesity. Therefore, due to the lack of standardized data for preschoolers, there is an imminent need for age-specific WHtR cut-off values in order to effectively interpret this measure in a younger population.

A more practical, cost-effective, and child-friendly method to measuring body composition is through bioelectrical impedance analysis (BIA) (Talma et al., 2013). Other advantages to BIA include its portability, ease of use, and minimal participant burden, making it suitable for both cross-sectional and longitudinal studies (Lee et al., 2008). Bioelectrical impedance analysis estimates TBW by sending an electric current through the body that measures resistance and impedance. A current experiences resistance or impedance when it encounters FM. Therefore, the more body water one has, the less impedance or resistance the current experiences. In preschoolers, only a few prediction equations exist for estimations of TBW from BIA output (Ejlerskov et al., 2014). Fat-free mass is calculated from TBW using age-
and gender-specific fat-free mass hydration factors, as developed by Fomon and colleagues (1982). However, it is important to note that FFM hydration levels vary based on sex, growth, ethnicity, disease, and weight status (Fomon et al., 1982; Goran, 1998; Houtkooper, Lohman, Going, & Howell, 1996). A review of BIA in children and adolescents by Talma et al. (2013) found that there was conflicting evidence for criterion and convergent validity, but strong evidence for reliability (correlations ≥0.82) for BIA. The key limitation with criterion validity includes the limited number of studies that validated BIA against MC models. The use of age- and gender-specific hydration constants is critical to effectively assessing FFM in children. Since the majority of studies did not include these constants, convergent validity was also compromised (Talma et al., 2013). Kettaneh and colleagues (2005) found BIA to have good reproducibility in normal weight children. Furthermore, a review by Kyle and colleagues (2015) supports the use of body composition measures derived from BIA in the assessment of nutritional status and growth in children. Therefore, despite the need for improved validity, BIA demonstrates good reliability, ease of use, and minimal participant burden and cost, making it an appropriate choice for measuring body composition in preschool-aged children in cross-sectional and longitudinal research.

Given that many lab- and proxy-based body composition assessment methods lack validated standards or cut-off values to which to compare, it is more informative to take multiple body composition measures and to interpret them in conjunction with one another in order to provide an overall estimate of adiposity and health status in Canadian preschoolers.

3.0 Rationale, Research Objectives, and Hypotheses
3.1 Rationale

Preventing childhood obesity has increasingly become a priority of many health agencies and organizations. Obesity can be largely prevented through lifestyle interventions however
current strategies remain ineffective or unproven. Extensive empirical evidence shows that parents influence their young children’s risk of developing obesity through their feeding behaviours, modeling weight-related behaviours, and providing a home environment that either facilitates or impedes children’s healthful eating and physical activity behaviours, and their attitudes and behaviour related to work and sleep (Davison et al., 2013; O’Brien et al., 2013; O’Connor et al., 2009; Persaud et al., 2013). These findings suggest that intervening to reduce obesity among young children requires engaging and changing the behaviour of their parents. However, with the exception of a few intensive clinic-based treatment interventions that are not generalizable, obesity interventions have been unsuccessful in engaging parents (Hingle, O’Connor, Dave, & Baranowski, 2010; O’Brien et al., 2013; O’Connor et al., 2009).

Clinical practice guidelines for pediatric obesity management involve a multidisciplinary approach that focuses on family-centered care, including lifestyle, cognitive and behavioural factors that are known to contribute to excess weight gain in children. Home-based visits are proposed to be an alternative solution to traditional therapeutic care in an effort to improve initiation, decrease attrition, and enhance overall effectiveness of obesity management in children (Ball, 2015; Wen, De Domenico, Elliott, Bindon, & Rissel, 2009). Home-based health visits are unique in that they are especially accommodating to family’s schedules and that they capture a more accurate picture of a family’s lifestyle and home environment. They also serve as an additional way to promote healthy family functioning and social support to families in conjunction with primary care (Wen et al., 2007). Since research on preschooler body composition and weight status is scarce, it is essential to capture these measures in order to assess change in weight and adiposity over time. Moreover, assessing body composition will help to determine the overall effectiveness of a childhood obesity prevention intervention.
This study incorporates a longitudinal, family-based, lifestyle intervention approach to childhood obesity prevention aimed at families with preschoolers in the home environment. The results of this study provide insight into the effectiveness and feasibility of the intervention in shaping a future, larger, long-term cohort. Results from this research also provide insight into a sustainable model for early life disease prevention in Canada with the potential to affect the demand for and costs of health care in the long-term.

3.2 Research Objectives

The overall goal of the GFHS – Pilot Study was to test the feasibility and effectiveness of a family-centered intervention delivered in the home setting among families with preschool-aged children in an effort to create a long-term family cohort.

As part of this overall goal, the primary objective of this project was to examine the effect of a family-based behavior change intervention among families with preschool-aged children on children’s body composition and weight status through measures of BMI, BMI z-score, WC, WHtR, resistance, TBW, FM (kg and %) using BIA analysis.

3.2.1 Hypothesis

We hypothesized that preschool-aged children from families randomized to the intervention group will have experienced healthy trends in growth as assessed through decreases in BMI, BMI z-score, WC, WHtR, and FM compared to preschoolers in the control group. As well, we hypothesized that preschoolers from families randomized to the four home visit group will have experienced greater decreases in body composition and weight status than preschoolers in the two home visit group.

The results of this research have important implications on the future of family-based obesity prevention interventions for preschoolers and families. Results illustrate how families
who receive individualized coaching on obesity-related health behaviors of limiting sugar-sweetened beverage consumption, engaging in family physical activity, having children meet sleep recommendations, limiting children’s screen time and sedentary activity, and having more family meals together, impacts children’s body composition and weight status.

4.0 Guelph Family Health Study Design

4.1 Recruitment and Eligibility

A total of 65 families were recruited for the pilot phase of the GFHS through flyers, social media, a local family health team, the Guelph Community Health Centre, and word-of-mouth in Wellington County, Ontario, Canada. The Guelph Family Health Study is a primary prevention intervention focused on minimizing excess weight gain and adiposity, as opposed to interventions that target those already at risk. Therefore, children were eligible to participate regardless of their weight status entering the study. Families were eligible to participate in the study if they had at least one child aged 18 months to 5 years at the time of recruitment, if they lived in the Guelph area (i.e., Wellington County - includes Guelph, Rockwood, Fergus, Elora, Mount Forest, Puslinch), and if they did not plan to relocate within the first year of the study. Exclusion criteria for the study were not being located in the Guelph area, relocation within the first year, and having no children aged 18 months to 5 years at the time of recruitment. All study procedures were administered at the University of Guelph after the parents of the participants gave written, informed consent. The study was approved by the University of Guelph Research Ethics Board (RCT 14AP008).

4.2 Procedures

The study design is outlined below in Figure 1. Following the completion of the online eligibility screening, families who were considered eligible were then provided with online
consent forms and questionnaires. Questionnaires captured demographic information as well as information about family functioning, routines, and behaviours. The study coordinator then contacted families to arrange a home visit. The purpose of the initial home visit was to review and obtain written consent, to discuss study proceedings, and to instruct and provide families with 3-day food records and accelerometers to track their child’s food intake, and physical activity and sleep patterns, respectively.

Families were then asked to come to the University of Guelph’s Body Composition and Metabolism Lab for a health assessment where the following measures were taken: height, weight, waist circumference, body composition, DNA, and blood pressure. Families were also asked to provide a blood draw at LifeLabs™ medical laboratory services. Once baseline data collection was complete, families were randomly assigned to the intervention or control group using a random number generator. Following the six-month intervention period, families were asked to repeat the baseline questionnaires, 3-day food records, accelerometry, health assessment visit, and blood draw. Families received grocery gift card incentives in the amount of $300 per assessment (family of 2 parents, 1 child). Children received small toys as non-monetary gifts for participating.
4.3 Treatment Groups

Families were randomized to one of three treatment groups: 1) Two home visits plus weekly emails and mailed incentives (Two Home Visits); 2) Four home visits plus weekly emails and mailed incentives (Four Home Visits); or 3) Control.

Two home visits: Families randomized to the two home visit intervention arm received: 1) two home visits with a health educator; 2) weekly health e-mails tailored to their specific family health goals; and 3) monthly mailed incentives (e.g., ball, crazy straw, book) tailored to the family’s health behavior goal(s).

Home visits were performed by a health educator who received a 2-day level one training (Intensive Introduction to MI) from MI experts at the Monarch System™. Initial home visits typically lasted one hour and began with health educators briefly describing the structure of the
home visits. Health educators then described the behavioural goals of the study (e.g., limiting sugar-sweetened beverage consumption, engaging in family physical activity, establishing sleep routines to increase child sleep duration, limiting children’s screen time, and having more family meals) using a GFHS behavioural goal sheet (Appendix B). Using an MI technique, health educators had families rate their satisfaction with their current routines and behaviours regarding each of the target behaviours. Health educators then asked families if they wanted to set any behaviour change goals. If families identified a behaviour change goal, health educators worked with families to identify specific steps required to implement the desired change and to discuss possible challenges and potential workarounds to address the identified challenges. Families were also asked if they wanted an accountability process for the behaviour change (e.g., to have the health educators email to check on progress mid-week). To facilitate self-monitoring of behaviour, families were provided a family routine tracker where they could record their behaviour and identify possible facilitators or barriers to their behaviour change. If families did not choose to set a behaviour change goal, health educators continued to provide support and guidance around adopting and maintaining these family routines. Fidelity to MI counseling techniques was assessed by the MI experts through audio recordings of 15 home visits. Motivational Interviewing fidelity was evaluated using the Motivational Interviewing Treatment Integrity (MITI) version 4.2.1 developed by Moyers and colleagues (2014). This tool is typically used to evaluate individual counseling sessions in a clinical environment. Health educators were given an overall grade of 85.2% for MI adherence. While basic proficiency is typically demonstrated at an MI adherence level of ≥90%, researchers were satisfied with the level of adherence achieved given that the nature of the visits involved multiple people and were based in the home environment.
Follow-up home visits typically lasted 30 to 60 minutes and involved health educators discussing progress towards the goals that were previously set by the families, possible challenges and workarounds for identified challenges. Families were asked if they wanted to set a new goal or revise a previously established behaviour change goal. Families were also sent weekly emails that were tailored based on the health behaviour goal set by the family. Emails included suggested tips and strategies to help support behaviour change. Mailed incentives were intended to help families succeed in their behavior change goals and included the following: child-friendly healthy eating stickers, a “crazy” straw to encourage drinking water over sugar-sweetened beverages, Canada’s Food Guide to Healthy Eating and colourful plates to promote consumption of healthy family meals, a storybook for adopting appropriate bedtime routines, colouring books and sidewalk chalk to discourage screen time, and a small inflatable beach ball to encourage family physical activity.

Four home visits: Families randomized to the four home visit intervention arm received the same intervention as those in the two home visit arm, with the only difference being they received four home visits with the health educator rather than two.

Control: Families randomized to the control arm received generic health e-mails, which are based on publically-available health information (e.g., Canada’s Food Guide), on a monthly basis for six months.

4.4 Measures
4.4.1 Bioelectrical Impedance Analysis

We used BIA to assess FM by measuring children’s TBW. Trained research assistants used the Quantum IV – Body Composition Analyzer™ (RJL Systems, Clinton Township, MI) using single-frequency, with electrodes placed on the right hand and foot. The Quantum IV measures resistance and reactance at 50 kHZ. Prior to being tested children were required to fast
and avoid vigorous physical activity for two hours, and to void their bladder at least half an hour before. Children were also required to remove any clothing with metal so as to avoid interference with the BIA current. Children were required to lie still for the duration of the test, which takes approximately one minute to perform. Raw data output of reactance, impedance, resistance, and phase angle were provided after the test and research assistants were required to make note of children who were uncooperative during testing (i.e., not lying still) to assist in the interpretation of the data. In order to get a measure of FM, raw data needs to be entered into an appropriate BIA equation however, equations validated for preschool-aged children are limited (Talma et al., 2013). The following equation by Kushner and colleagues (1992) was chosen as the most appropriate equation for use in the GFHS–Pilot Study as it has been validated for use in preschool-aged children of similar race using the gold standard isotope-dilution method. H represents height in centimetres (cm), R is resistance in ohms (Ω) and W is weight in kilograms (kg).

\[
TBW = 0.593H^2/R + 0.065W + 0.04,
\]

A common issue with BIA equations validated in preschoolers is validation with small sample sizes, which is a limitation with the Kushner (1992) equation (n = 44) (Ejlerskov et al., 2014). Nevertheless, this equation has been recommended for use in preschool-aged children in the literature (De Beer, Timmers, Weijs, & Gemke, 2011; Goran et al., 1993; Kushner et al., 1992; Kyle et al., 2015).

In order to determine FM from the equation, TBW needs to be divided by an age- and gender-specific hydration factor. To date, the TBW references developed for children from birth to age 10 years by Fomon and colleagues (1982) remains the reference standard for preschoolers and therefore, were used to calculate FM from the Kushner (1992) equation in our study (see
Table 4.1. The value of TBW (%) represents a combination of intracellular and extracellular water. Bioelectrical impedance analysis was performed on a sample of six adult participants in order to test the reliability of BIA methodology. Participants were tested under the same conditions for two consecutive days. No significant differences were found between day one (M= 538.902, SD= 100.991) and day two (M= 534.053, SD= 101.383) of testing (t(5)= 0.710, p= 0.510). Reliability results indicated a Cronbach’s alpha of 0.995.

Table 4.1. Fomon's (1982) Hydration Constants from Age 18-months to 6 Years

<table>
<thead>
<tr>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (mo)</td>
<td>TBW (%)</td>
</tr>
<tr>
<td>18 mo</td>
<td>78.5</td>
</tr>
<tr>
<td>24 mo</td>
<td>78.1</td>
</tr>
<tr>
<td>3 yr</td>
<td>77.5</td>
</tr>
<tr>
<td>4 yr</td>
<td>77.0</td>
</tr>
<tr>
<td>5 yr</td>
<td>76.6</td>
</tr>
<tr>
<td>6 yr</td>
<td>76.3</td>
</tr>
</tbody>
</table>

4.4.2 Anthropometrics

The following measures were obtained from children in the GFHS–Pilot Study: height/length, weight, WC, and WHtR. All measures were performed by trained research assistants.

Height/Length

Height measures were performed on children aged 2 years and older using a pediatric length board in a standing position, measured to the nearest 0.1cm. Participants were barefoot or
in sock feet, wearing minimal clothing, and had hair ornaments removed. Participants stood with heels together, arms at the side, legs straight, shoulders relaxed, and head in Frankfort horizontal plane position with heels, buttocks, scapulae, and back of head against the length board. Length measures were performed on children less than 2 years of age. This measure required children to lie on the pediatric length board with legs straight and feet flat against the base of the board, with the child looking up at the ceiling. The average of two height and/or length measures were performed if the values are within 0.5cm, if not, a third measure was taken and used in the overall average.

Weight

Child weight measures were performed using the BOD POD scale, with children standing still, with arms at the side, either barefoot or in sock feet. Collectively, child weight and height and/or length measures were used to calculate BMI by taking weight in kilograms (kg) and dividing that by height in metres squared (m\(^2\)). Body mass index values were then converted to BMI z-scores to capture children’s overall weight status using WHO Anthro 3.2.2 software (2011).

Waist Circumference

Waist circumference was measured at the top of the iliac crest using a Gulick II measuring tape, after normal expiration, as per the recommended protocol from Statistics Canada, NHANES, and the Canadian Health Measures Survey (Patry-Parisien, Shields, & Bryan, 2012). Participants’ abdomens were clear of all clothing, with feet placed shoulder-width apart and arms crossed at the chest. The average of two WC measures were performed if the values are within 0.5cm, if not, a third measure was taken and used in the overall WC average.
**Waist-to-Height Ratio**

A measure of WHtR was calculated by dividing WC by height and/or length (Savva et al., 2000).

**4.0.5 Data Analysis**

All statistical analyses were conducted using SAS University Edition for Windows (SAS Institute Inc., 2015). Data was analyzed using the generalized linear model (GENMOD) procedure with a generalized estimating equations (GEE) approach, using z-tests to investigate the intervention effects. The GEE approach was used since it takes into account correlated data (i.e., sibling participants) (Hanley, Negassa, Edwardes, & Forrester, 2003). This procedure was used to test for differences in BMI, BMI z-score, WC, WHtR, resistance, TBW, FM (kg and %) across the intervention and control groups, adjusting for baseline values, as well as age and sex in all measures except BMI z-score. A p-value of \(<0.05\) was considered statistically significant.

**5.0 Results**

Information on participant demographics is outlined in Table 5.2. The majority of parents identified in the study were mothers (55.7%), with 88.6% being married. Overall, 50.0% of mothers in the study were normal weight, 25.0% were classified as overweight, and 20.5% as obese. The majority of fathers in the study were identified as overweight (31.4%) and obese (31.8%). The bulk of participating families (53.6%) had an average household income ranging from $20,000 to $99,999. This is in close comparison to the average household income in Canada, where the majority of families (60.8%) have an average income ranging from $20,000 to $99,999 (Statistics Canada, 2016). When looking at preschooler data, there were slightly more females (52.7%) than males (47.3%), with the average age being 3.96 years. The four home visit
and control groups contained an equal number of males and females however, the two home visit
group contained more females (58.8%) than males (41.2%). The majority of children were white
(87.3%) ethnicity.

Table 5.2. Participant Demographics

<table>
<thead>
<tr>
<th>Relation to Child</th>
<th>Overall (n= 44 families)</th>
<th>Intervention 4HV (n= 17 families)</th>
<th>Intervention 2HV (n= 14 families)</th>
<th>Control (n= 13 families)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mother</td>
<td>44 (55.7%)</td>
<td>16 (36.4%)</td>
<td>14 (31.8%)</td>
<td>14 (31.8%)</td>
</tr>
<tr>
<td>Father</td>
<td>35 (44.3%)</td>
<td>12 (34.3%)</td>
<td>11 (31.4%)</td>
<td>12 (34.3%)</td>
</tr>
<tr>
<td>Maternal Marital Status</td>
<td>n= 17</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>39 (88.6%)</td>
<td>15 (88.2%)</td>
<td>12 (85.7%)</td>
<td>12 (92.3%)</td>
</tr>
<tr>
<td>Not married, but living with partner</td>
<td>3 (6.8%)</td>
<td>1 (5.9%)</td>
<td>1 (7.1%)</td>
<td>1 (76.9%)</td>
</tr>
<tr>
<td>Single, never married</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Divorced</td>
<td>1 (2.3%)</td>
<td></td>
<td>1 (7.1%)</td>
<td></td>
</tr>
<tr>
<td>Separated</td>
<td>1 (2.3%)</td>
<td>1 (5.9%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Widowed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mother Weight Status</td>
<td>n= 44</td>
<td>n= 16</td>
<td>n= 14</td>
<td>n= 14</td>
</tr>
<tr>
<td>Normal Weight</td>
<td>22 (50.0%)</td>
<td>6 (40.0%)</td>
<td>9 (64.3%)</td>
<td>7 (53.8%)</td>
</tr>
<tr>
<td>Overweight</td>
<td>11 (25.0%)</td>
<td>4 (26.7%)</td>
<td>3 (21.4%)</td>
<td>3 (21.4%)</td>
</tr>
<tr>
<td>Obese</td>
<td>9 (20.5%)</td>
<td>5 (33.3%)</td>
<td>2 (14.3%)</td>
<td>2 (15.4%)</td>
</tr>
<tr>
<td>N/A (Pregnant)</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Father Weight Status</td>
<td>n= 35</td>
<td>n= 12</td>
<td>n= 11</td>
<td>n= 12</td>
</tr>
<tr>
<td>Normal Weight</td>
<td>9 (25.7%)</td>
<td>2 (18.2%)</td>
<td>4 (36.4%)</td>
<td>3 (25.0%)</td>
</tr>
<tr>
<td>Overweight</td>
<td>11 (31.4%)</td>
<td>4 (36.4%)</td>
<td>2 (18.2%)</td>
<td>5 (41.7%)</td>
</tr>
<tr>
<td>Obese</td>
<td>14 (31.8%)</td>
<td>5 (45.5%)</td>
<td>5 (45.5%)</td>
<td>4 (33.3%)</td>
</tr>
<tr>
<td>N/A (Opted out)</td>
<td>1 (2.9%)</td>
<td>1 (8.3%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Household Income</td>
<td>n= 44</td>
<td>n= 16</td>
<td>n= 14</td>
<td>n= 14</td>
</tr>
<tr>
<td>Less than $10,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$10,000 to $19,999</td>
<td>1 (2.3%)</td>
<td></td>
<td>1 (7.1%)</td>
<td></td>
</tr>
<tr>
<td>$20,000 to $29,999</td>
<td>1 (2.3%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$30,000 to $39,999</td>
<td>2 (4.7%)</td>
<td>1 (6.7%)</td>
<td>1 (7.1%)</td>
<td></td>
</tr>
<tr>
<td>$40,000 to $49,999</td>
<td>7 (7.0%)</td>
<td>3 (20.0%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$50,000 to $59,999</td>
<td>4 (9.3%)</td>
<td></td>
<td>3 (21.4%)</td>
<td>1 (7.1%)</td>
</tr>
<tr>
<td>$60,000 to $69,999</td>
<td>1 (2.3%)</td>
<td></td>
<td>1 (7.1%)</td>
<td></td>
</tr>
<tr>
<td>$70,000 to $79,999</td>
<td>3 (7.0%)</td>
<td>1 (6.7%)</td>
<td>1 (7.1%)</td>
<td>1 (7.1%)</td>
</tr>
<tr>
<td>$80,000 to $89,999</td>
<td>6 (14.0%)</td>
<td>3 (20.0%)</td>
<td>2 (14.3%)</td>
<td>1 (7.1%)</td>
</tr>
<tr>
<td>$90,000 to $99,999</td>
<td>3 (7.0%)</td>
<td>1 (6.7%)</td>
<td>1 (7.1%)</td>
<td>1 (7.1%)</td>
</tr>
<tr>
<td>$100,000 to $149,999</td>
<td>12 (27.9%)</td>
<td>5 (33.3%)</td>
<td>4 (28.6%)</td>
<td>3 (21.4%)</td>
</tr>
</tbody>
</table>
$150,000 or more | 4 (9.3%) | 1 (6.7%) | 1 (7.1%) | 2 (14.3%)  
--- | --- | --- | --- | ---  
I don’t know |  |  |  |  
N/A |  |  |  | 1  
**Child Characteristics** | **n= 55** | **n= 20** | **n= 17** | **n= 18**  
Female children | 29 (52.7%) | 10 (50.0%) | 10 (58.8%) | 9 (50.0%)  
Male Children | 26 (47.3%) | 10 (50.0%) | 7 (41.2%) | 9 (50.0%)  
Average age (years) | 3.96 | 3.65 | 4.29 | 4.00  
**Child Race/Ethnicity** | **n= 55** | **n= 20** | **n= 17** | **n= 18**  
White | 48 (87.3%) | 18 (90.0%) | 15 (88.2%) | 15 (83.3%)  
Aboriginal/First Nations peoples |  |  |  |  
Chinese | 2 (4.2%) | 1 (5.9%) | 1 (5.6%) |  
Black |  |  |  |  
Korean or Japanese |  |  |  |  
Latin American | 1 (1.8%) |  |  | 1 (5.6%)  
South Asian (for example:, East Indian, Pakistani, Sri Lankan, etc.) | 2 (4.2%) | 1 (5.0%) | 1 (5.9%) |  
Southeast Asian (for example:, Vietnamese, Cambodian, Filipino, Malaysian, Laotian,etc.) |  |  |  |  
West Asian (for example: Arab, Iranian, Afghan, etc.) |  |  |  |  
Other | 2 (4.2%) | 1 (5.0%) |  | 1 (5.6%)
The overall goal of the GFHS – Pilot Study was to test the feasibility and effectiveness of a family-centered intervention delivered in the home setting among families with preschool-aged children in an effort to create a long-term family cohort. As part of this overall goal, the primary objective of this study was to examine the effect of a family-based behavior change intervention among families with preschool-aged children on children’s body composition and weight status through measures of BMI, BMI z-score, WC, WHtR, resistance, TBW, FM (kg and %) using BIA analysis.

We hypothesized that preschool-aged children from families randomized to the intervention group will have experienced lower BMI and BMI z-score; lower FM as assessed through BIA; and lower WC and WHtR, indicative of abdominal adiposity, compared to preschoolers in the control group at six months. As well, we hypothesized that preschoolers from
families randomized to the four home visit group will have experienced greater decreases in body composition and weight status to a greater extent than preschoolers in the two home visit group at six months.

Preschoolers’ weight status at baseline and at six-month follow-up are outlined in Table 5.3. Weight status was determined using the recommended cut-off criteria from WHO which indicate that children aged 2 to 5 years with a BMI-for-age <0.1 percentile (<3 SD) are considered severely wasted, <3rd percentile (<-2 SD) are considered wasted, >85th percentile (>1 SD) are at risk for overweight, >97th percentile (>2 SD) are overweight, and >99.9th percentile (>3 SD) are obese. For children aged 5 to 19 years, a BMI-for-age <0.1 percentile (<3 SD) are considered severely wasted, <3rd percentile (<-2 SD) are considered wasted, >85th percentile (>1 SD) indicates overweight, >97th obese (>2 SD), and >99.9th (>3 SD) severe obesity. Normal weight status is defined as having a BMI-for-age between the 15th-85th percentile (>2<1 SD) (Dietitians of Canada, 2014). At baseline, 67.3% of participants were normal weight, with children in the two home visit group having the highest percentage who were normal weight (76.5%). At follow-up, 71.7% of participants were normal weight, with the four home visit group having the highest percentage who were normal weight (75.0%). The proportion of children who were categorized as at risk of overweight decreased from 26.9% of all participants at baseline to 20.8% at six-month follow-up. Of this, the control group had the highest percentage of participants at risk for overweight at baseline (47.1%), and at six-month follow-up (25.0%). Only two participants were classified as overweight (3.9%) at baseline; these were both from the four home visit group. At six-month follow-up this increased slightly to three participants (5.7%), where the four home visit group continued to have the highest percentage of
overweight participants (10%). There were no obese participants in any group identified at baseline or six-month follow-up.

Data on absolute change for the control, two home visit, four home visit and combined intervention (two and four home visits) groups are outlined in Tables 5.4 and 5.5. For BMI, the two home visit group experienced the greatest decrease in BMI (-0.5kg/m^2), whereas the four home visit showed an increase in BMI (0.02kg/m^2) from baseline to six-month follow-up. The control and combined intervention groups decreased by -0.4kg/m^2 and -0.3kg/m^2, respectively, from baseline to six-month follow-up.

For BMI z-score, the two home visit group showed the greatest decrease in BMI z-score (-0.3), whereas the four home visit showed an increase in BMI z-score (0.1) from baseline to six-month follow-up. The control and combined intervention groups decreased by -0.2 and -0.1, respectively, from baseline to six-month follow-up.

The control group showed the smallest increase in WC at 0.6cm, whereas the four home visit group showed the greatest increase at 1.8cm, from baseline to six-month follow-up. The two home visit group showed an increase in WC of 1.4cm, and the combined intervention group of 1.7cm from baseline to six-month follow-up.

For WHtR, the control group showed the greatest decrease in WHtR (-0.02). The four home visit, two home visit, and control groups all showed decreases in WHtR of -0.01 from baseline to six-month follow-up.

The two home visit group showed the greatest decrease in resistance (-37.5Ω), with the control group showing the smallest decrease (-17.7Ω) from baseline to six-month follow-up. The four home visit and control groups also showed decreases in resistance from baseline to six-month follow-up at -24.4Ω and -31.1Ω, respectively.
For TBW, the control group reflected the smallest change from baseline to six-month follow-up at 0.9kg, whereas the two and four home visit, and combined intervention groups all showed the greatest change at 1.2kg.

The control group showed the smallest decrease in FM (kg) at -0.1kg, whereas the four home visit group demonstrated an increase in FM of 0.2kg from baseline to six-month follow-up. The two home visit and combined intervention groups both showed decreases in FM from baseline to six-month follow-up at -0.5kg and -0.2kg, respectively.

The four home visit group reflected the smallest decrease in FM (%) at -2.6%, whereas the two home visit group showed the greatest decrease at 4.8%, from baseline to six-month follow-up. The control and combined intervention groups both showed decreased in FM (%) at -2.7% and -3.8%, respectively, from baseline to six-month follow-up.

The hypothesis tests based on the GEE approach examining the relationships among the intervention and control groups, and each outcome variable can be found in Tables 5.4 and 5.5. There were no significant differences in BMI between the two ($\hat{\beta} = -0.2$, 95% CI: -0.7 to 0.3) and four ($\hat{\beta} = 0.3$, 95% CI: -0.1 to 0.8) home visit groups, and combined intervention ($\hat{\beta} = 0.1$, 95% CI: -0.4 to 0.5) groups compared to the control group at six-month follow-up.

There were no significant differences in BMI z-score between the two ($\hat{\beta} = -0.1$, 95% CI: -0.5 to 0.2) and four ($\hat{\beta} = 0.3$, 95% CI: -0.04 to 0.6) home visit, and combined intervention ($\hat{\beta} = 0.1$, 95% CI: -0.2 to 0.3) groups compared to the control group at six-month follow-up.

There were no significant differences in WC between the two ($\hat{\beta} = 0.8$, 95% CI: -1.1 to 2.7) and four ($\hat{\beta} = 1.2$, 95% CI: -0.4 to 2.7) home visit, and combined intervention ($\hat{\beta} = 1.0$, 95% CI: -0.5 to 2.4) groups compared to the control group at six-month follow-up.
There were no significant differences in WHtR between the two ($\hat{\beta} = 0.002, 95\% \text{ CI: } -0.02$ to $0.02$) and four ($\hat{\beta} = 0.01, 95\% \text{ CI: } -0.01$ to $0.03$) home visit, and combined intervention ($\hat{\beta} = 0.01, 95\% \text{ CI: } -0.01$ to $0.02$) groups compared to the control group at six-month follow-up.

There were no significant differences in resistance between the two ($\hat{\beta} = -20.9, 95\% \text{ CI: } -45.4$ to $3.7$) and four ($\hat{\beta} = -10.9, 95\% \text{ CI: } -48.8$ to $27.0$) home visit, and combined intervention ($\hat{\beta} = -16.5, 95\% \text{ CI: } -42.2$ to $9.3$) groups compared to the control group at six-month follow-up.

The effect of the two home visit intervention was significantly associated with changes in TBW compared to the control group ($\hat{\beta} = 0.3, 95\% \text{ CI: } 0.1$ to $0.6$). The effect of the combined intervention was significantly associated with changes in TBW compared to the control group ($\hat{\beta} = 0.3, 95\% \text{ CI: } 0.03$ to $0.6$). There were no significant differences in TBW between the four ($\hat{\beta} = 0.3, 95\% \text{ CI: } -0.1$ to $0.7$) home visit group and the control group.

The effect of the two home visit intervention was significantly associated with changes in FM (kg) compared to the control group ($\hat{\beta} = -0.6, 95\% \text{ CI: } -1.2$ to $-0.1$). There were no significant differences between the four ($\hat{\beta} = 0.02, 95\% \text{ CI: } -0.7$ to $0.7$) or combined intervention ($\hat{\beta} = -0.3, 95\% \text{ CI: } -0.9$ to $0.3$) groups compared to the control group.

Similarly, the two home visit group was significantly associated with changes in FM (%) compared to the control group ($\hat{\beta} = -3.2, 95\% \text{ CI: } -5.5$ to $-0.8$). There were no significant differences between the four ($\hat{\beta} = -0.6, -3.3$ to $2.2$) and the combined intervention ($\hat{\beta} = -1.8, 95\% \text{ CI: } -4.2$ to $0.6$) groups compared to the control group.
The results of the GEE analyses on measures of body composition did reveal some significant differences between the two and four home visit groups, as outlined in Table 5.6. Compared to children in the two home visit group, children in the four home visit group experienced significant increases in BMI ($\hat{\beta} = 0.5, p = 0.03$), BMI z-score ($\hat{\beta} = 0.4, p = 0.04$), FM (kg) ($\hat{\beta} = 0.6, p = 0.01$), and FM (%) ($\hat{\beta} = 2.6, p = 0.01$).

Overall, the two home visit group achieved the most favourable outcomes compared to the control group on the following body composition measures: BMI, BMI z-score, resistance, TBW, FM (kg) and FM (%). The two home visit group also fared significantly better than the four home visit group on the following outcomes: BMI, BMI z-score, FM (kg) and FM (%).

Table 5.3. Weight Status of Preschoolers at Baseline and 6-month Follow-up Compared to National Average

<table>
<thead>
<tr>
<th></th>
<th>Baseline (n=52)</th>
<th>6-Months (n=53)**</th>
<th>National Average*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Weight</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Home Visit</td>
<td>n=35</td>
<td>67.3%</td>
<td>n=38</td>
</tr>
<tr>
<td>(nB=17; n6M=17)</td>
<td>n=13</td>
<td>76.5%</td>
<td>n=12</td>
</tr>
<tr>
<td>4 Home Visit</td>
<td>n=13</td>
<td>72.2%</td>
<td>n=15</td>
</tr>
<tr>
<td>(nB=18; n6M=20)</td>
<td>n=9</td>
<td>52.9%</td>
<td>n=11</td>
</tr>
<tr>
<td>Control</td>
<td>n=9</td>
<td>52.9%</td>
<td>n=11</td>
</tr>
<tr>
<td>Wasted</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Home Visit</td>
<td>n=1</td>
<td>1.9%</td>
<td>n=1</td>
</tr>
<tr>
<td>(nB=17; n6M=17)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Home Visit</td>
<td>n=1</td>
<td>5.6%</td>
<td></td>
</tr>
<tr>
<td>(nB=18; n6M=20)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk of Overweight</td>
<td>n=14</td>
<td>26.9%</td>
<td>n=11</td>
</tr>
<tr>
<td>2 Home Visit</td>
<td>n=4</td>
<td>23.5%</td>
<td>n=4</td>
</tr>
<tr>
<td>(nB=17; n6M=17)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Home Visit</td>
<td>n=2</td>
<td>11.1%</td>
<td>n=3</td>
</tr>
<tr>
<td>(nB=18; n6M=20)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>n=8</td>
<td>47.1%</td>
<td>n=4</td>
</tr>
<tr>
<td>Overweight</td>
<td>n=2</td>
<td>3.9%</td>
<td>n=3</td>
</tr>
<tr>
<td>Outcome</td>
<td>Mean (SD)</td>
<td>Effect estimate of intervention compared to control ( \hat{\beta} ) (95% CI)</td>
<td>( P ) Value</td>
</tr>
<tr>
<td>------------------</td>
<td>-----------</td>
<td>--------------------------------------------------------------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td></td>
<td>Baseline</td>
<td>6-Months</td>
<td>Change</td>
</tr>
<tr>
<td><strong>BMI (kg/m²)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control (n=16)</td>
<td>16.8 (1.2)</td>
<td>16.4 (1.4)</td>
<td>-0.4 (0.2)</td>
</tr>
<tr>
<td>2 HV (n=17)</td>
<td>15.9 (1.1)</td>
<td>15.4 (1.2)</td>
<td>-0.5 (0.2)</td>
</tr>
<tr>
<td>4 HV (n=18)</td>
<td>16.1 (1.9)</td>
<td>16.1 (1.7)</td>
<td>0.02 (-0.1)</td>
</tr>
<tr>
<td>2 HV + 4 HV (n=35)</td>
<td>16.0 (1.5)</td>
<td>15.7 (1.5)</td>
<td>-0.3 (0.03)</td>
</tr>
<tr>
<td><strong>BMI z-score</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control (n=16)</td>
<td>0.9 (0.7)</td>
<td>0.7 (0.7)</td>
<td>-0.2 (0.04)</td>
</tr>
<tr>
<td>2 HV (n=17)</td>
<td>0.3 (0.8)</td>
<td>0.01 (1.0)</td>
<td>-0.3 (0.2)</td>
</tr>
<tr>
<td>4 HV (n=18)</td>
<td>0.2 (1.3)</td>
<td>0.3 (1.2)</td>
<td>0.1 (-0.1)</td>
</tr>
<tr>
<td>2 HV + 4 HV (n=35)</td>
<td>0.3 (1.1)</td>
<td>0.2 (1.1)</td>
<td>-0.1 (0.02)</td>
</tr>
<tr>
<td><strong>WC (cm)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>50.7 (4.6)</td>
<td>51.3 (5.7)</td>
<td>0.6 (1.1)</td>
</tr>
</tbody>
</table>

*Canadian Community Health Survey (CCHS), 2004 – based on children aged 2-5 years.
**The change in sample size from baseline to six-month follow-up occurred because there was an increase in cooperation by child participants during measurements at six-months.

Table 5.4. Results of GEE Analyses on Anthropometric Measures at 6-months
<table>
<thead>
<tr>
<th>Outcome</th>
<th>Mean (SD)</th>
<th>Effect estimate of intervention compared to control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>6-Months</td>
</tr>
<tr>
<td>Resistance (Ω)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control (n=9)</td>
<td>775.4 (47.9)</td>
<td>757.7 (35.5)</td>
</tr>
<tr>
<td>2 HV (n=13)</td>
<td>797.3 (62.4)</td>
<td>759.8 (68.9)</td>
</tr>
<tr>
<td>4 HV (n=12)</td>
<td>799.1 (63.6)</td>
<td>774.7 (73.3)</td>
</tr>
</tbody>
</table>

*significant at p<0.05

Table 5.5. Results of GEE Analyses on Measures of Body Composition at 6-months
<table>
<thead>
<tr>
<th></th>
<th>2 HV + 4 HV</th>
<th>2 HV</th>
<th>4 HV</th>
<th>2 HV + 4 HV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n=25)</td>
<td>(n=13)</td>
<td>(n=12)</td>
<td>(n=25)</td>
</tr>
<tr>
<td>TBW (kg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control (n=9)</td>
<td>9.1 (1.7)</td>
<td>10.0 (2.0)</td>
<td>0.9 (0.3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9.0 (1.3)</td>
<td>10.2 (1.7)</td>
<td>1.2 (0.4)</td>
<td>0.3 (0.1 to 0.6)</td>
</tr>
<tr>
<td></td>
<td>8.6 (2.0)</td>
<td>9.8 (2.5)</td>
<td>1.2 (0.5)</td>
<td>0.3 (-0.1 to 0.7)</td>
</tr>
<tr>
<td></td>
<td>8.8 (1.7)</td>
<td>10.0 (2.1)</td>
<td>1.2 (0.4)</td>
<td>0.3 (0.03 to 0.6)</td>
</tr>
<tr>
<td>FM (kg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control (n=9)</td>
<td>5.5 (1.8)</td>
<td>5.4 (2.4)</td>
<td>-0.1 (0.6)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.7 (0.8)</td>
<td>4.2 (0.7)</td>
<td>-0.5 (-0.04)</td>
<td>-0.6 (-1.2 to -0.1)</td>
</tr>
<tr>
<td></td>
<td>4.9 (1.2)</td>
<td>5.1 (1.0)</td>
<td>0.2 (-0.3)</td>
<td>0.02 (-0.7 to 0.7)</td>
</tr>
<tr>
<td></td>
<td>4.8 (1.01)</td>
<td>4.6 (0.9)</td>
<td>-0.2 (-0.1)</td>
<td>-0.3 (-0.9 to 0.3)</td>
</tr>
<tr>
<td>FM (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control (n=9)</td>
<td>31.6 (4.6)</td>
<td>28.9 (5.7)</td>
<td>-2.7 (1.1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>29.1 (4.1)</td>
<td>24.3 (4.4)</td>
<td>-4.8 (0.3)</td>
<td>-3.2 (-5.5 to -0.8)</td>
</tr>
<tr>
<td></td>
<td>31.5 (3.6)</td>
<td>28.9 (3.2)</td>
<td>-2.6 (-0.4)</td>
<td>-0.6 (-3.3 to 2.2)</td>
</tr>
<tr>
<td></td>
<td>30.3 (4.0)</td>
<td>26.5 (4.5)</td>
<td>-3.8 (0.5)</td>
<td>-1.8 (-4.2 to 0.6)</td>
</tr>
</tbody>
</table>

*significant at p<0.05
Table 5.6. Results of GEE Analyses Investigating the Effects of the Intervention on Measures of Body Composition: 4 Home Visit Group vs. 2 Home Visit Group

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Effect estimate of intervention compared to control $\hat{\beta}$ (95% CI)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI (kg/m²)</td>
<td>0.5</td>
<td>0.03*</td>
</tr>
<tr>
<td>BMI z-score</td>
<td>0.4</td>
<td>0.04*</td>
</tr>
<tr>
<td>Resistance (Ω)</td>
<td>9.9</td>
<td>0.6</td>
</tr>
<tr>
<td>TBW (kg)</td>
<td>-0.1</td>
<td>0.8</td>
</tr>
<tr>
<td>FM (kg)</td>
<td>0.6</td>
<td>0.01*</td>
</tr>
<tr>
<td>FM (%)</td>
<td>2.6</td>
<td>0.01*</td>
</tr>
<tr>
<td>WC (cm)</td>
<td>0.4</td>
<td>0.7</td>
</tr>
<tr>
<td>WHtR</td>
<td>0.01</td>
<td>0.6</td>
</tr>
</tbody>
</table>

*significant at p<0.05

6.0 Discussion
Research has demonstrated that intervening early in life and engaging parents to promote healthful behaviours among their children is essential to reducing the prevalence of childhood obesity. While it is known that lifestyle interventions can aid in obesity prevention, less is known about the effect of home-based interventions and the use of MI techniques. The overall goal of this study was to test the feasibility and effectiveness of a family-centered intervention delivered in the home setting among families with preschool-aged children. The objective of this study was to examine the effect of the intervention on children’s body composition and weight status.
through measures of BMI, BMI z-score, WC, WHtR, resistance, TBW, and FM (kg and %). We hypothesized that preschool-aged children whose families were randomized to the intervention group will have experienced healthy trends in growth as assessed by decreases in BMI, BMI z-score, FM, WC, and WHtR compared to preschoolers in the control group. As well, we hypothesized that preschoolers whose families were randomized to the four home visit group will have experienced these decreases in body composition and weight status to a greater extent than preschoolers in the two home visit group. We also assessed the intervention both individually (i.e., two home visits vs. control, four home visits vs. control) and in combination (i.e., two and four home visits vs. control) in order to see if the larger sample size in the combined group would produce significant differences in comparison to the control group. To our knowledge, this was the first study to examine the impact of an MI-focused, home-based obesity prevention intervention on child body composition.

The main finding of this study was that the intervention had the greatest effect on the body composition of children in the two home visit group compared to control, where significant associations were found between measures of TBW and FM (kg and %). The two home visit and combined intervention groups had significantly greater decreases in TBW than the control group at six-month follow-up. Furthermore, decreases in FM were significantly greater for the two home visit group compared to the control group at six-month follow-up. Therefore, it can be concluded that participants from the two home visit group showed the most favourable changes in body composition outcomes in comparison to the four home visit and control groups. This is contrary to our hypothesis that the four home visit group would experience the largest decreases in body composition and weight status in comparison to the two home visit and control groups. There was little to no variance in BMI, BMI z-score, WC and WHtR for participants at baseline.
between the two home visit, four home visit, and control groups. However, baseline resistance values showed some variance between the two (797.3\(\Omega\)) and four (799.1\(\Omega\)) home visit groups and the control group (775.4\(\Omega\)). However, when resistance values were computed into the Kushner (1992) equation, FM values had minimal variance of 0.5kg or 2.5% between groups at baseline. The fact that the two home visit was more successful than the four home visit group is counterintuitive to the majority of dose-response research that emphasizes that the more exposure there is to a given treatment, the more likely you are to see a change in outcomes (Hansen, Lambert, & Forman, 2002; Jørgensen et al., 2015). Proposed reasons as to why this occurred include having a very small sample size and because the intervention was individually tailored, not all families worked on the same health behaviours. For example, the majority of two home visit families may have chosen multiple health behaviours to work on, or have chosen one that has a more direct effect on body composition, such as physical activity. As well, perhaps knowing that they were assigned to only two home visits may have increased parent motivation to be more proactive in establishing new healthful routines, whereas the four home visit group may have been less motivated to establish and work on their health behaviour goals as they were entitled to more support from a health educator.

It is challenging to compare these findings to existing research as most studies targeting the preschooler population use dietary improvement as the main outcome measure, as opposed to body composition. A systematic review of home-based childhood prevention studies by Showell et al. (2013) identified six studies focused on childhood overweight and obesity prevention that targeted diet, physical activity, or both in the home-setting. Three of these studies reported significant desirable intervention effects on diet and physical activity however; no studies showed significant changes in BMI or BMI z-score outcomes at follow-up. Skouteris and
colleagues (2011) conducted a systematic review of interventions focused on the modification of parental influence (i.e., parental beliefs, attitudes, perceptions, and behaviour) and obesity prevention in pre-schoolers. Researchers concluded that of 11 intervention studies, all reported a positive difference in at least one obesity-promoting behaviour at post-intervention however, only one intervention showed changes in BMI. The study by Klohe-Lehman and colleagues (2007) involved a 24-week intervention with low-income, overweight and obese mothers as agents of change to improve obesity-related health behaviours in children aged 1 to 3 years. The intervention was a weight loss program that used concepts from the Social Cognitive Theory, with a focus on changing mother’s cognitions and behaviours around adopting a healthier lifestyle. It was delivered by registered dietitians in a group community setting in the U.S. The only significant outcome was for BMI-for-age percentile for children aged 2 to 3 years, which unfavourably increased by week 24 (p < 0.001). The 2011 Cochrane Review (Waters et al., 2011) produced a meta-analysis of obesity interventions that targeted children in the 0 to 5 year age group. Waters and colleagues (2011) found that the average intervention effect on children’s in BMI/BMI z-score was 0.3 (95% CI: -0.5 to 0.0). Compared to our study, this effect size is similar to the effect of the intervention on the four home visit group (BMI= 0.3; 95% CI: -0.1 to 0.8; BMI z-score= 0.3; 95% CI: -0.04 to 0.6), and larger than the effect of the intervention on the two home visit (BMI= -0.2; 95% CI: -0.7 to 0.3; BMI z-score= -0.1; 95% CI: -0.5 to 0.2) and combined intervention groups (BMI= 0.1; 95% CI: -0.4 to 0.5; BMI z-score= 0.1; 95% CI: -0.2 to 0.2). While according to researchers, this just failed to reach significance (p= 0.05), results did indicate a trend towards a small intervention effect. Researchers from this study also conducted a sub-group analysis of one home-based and one combined home-based and healthcare interventions. Both study interventions were informed by behaviour change theory, focused on
educating parents on dietary and physical activity habits, and assessed BMI as an outcome measure. The sub-group analysis showed a highly significant post-intervention effect size of -1.1 (-1.4 to -0.8; \( p = 0.0001 \)) for BMI when compared to the control group. Haines and colleagues (2013) also found a significant decrease in BMI post-intervention when looking at the effects of a home-based obesity prevention program among low-income families with preschoolers (-0.4; 95% CI: -0.8 to 0.0; \( p = 0.05 \)). Moreover, Stark and colleagues (2014) conducted a study of obese preschoolers randomized to receive behavioural obesity treatment either through a 18-session intervention called Learning about Activity and Understanding Nutrition for Child Health in a clinic setting (LAUNCH - clinic), or in a combined clinic and home visit setting (LAUNCH + HV), or through general pediatric counseling on diet and physical activity. The intervention lasted a total of six months, and focused on modifying lifestyle behaviour and improving parenting skills. The intervention was delivered by a physician, psychology fellow, and trained research coordinator. From pre- to post-treatment, only preschoolers randomized to the LAUNCH + HV group showed a significantly greater decrease in BMI z-score compared with pediatric counseling (\( p = 0.007 \)).

In summary, similar to our study, many studies did not find a significant association between an obesity prevention intervention and BMI at post-intervention (Showell et al., 2013; Skouteris et al., 2011). However, research by Waters (2011), Haines et al. (2013) and Stark et al. (2014) did find significant decreases in BMI post-intervention for interventions that involved home visits. Some main differences between the sub-group meta-analysis by Waters et al. (2011) and the current study include the fact that the interventions ranged from 16-weeks to 12-months, and populations were composed primarily of Native-American or German families. The study by Haines et al. (2013) and the current study also had vast differences in sample size, 121 families
compared to 42 in our study, as well as ethnic and socioeconomic differences. In addition, the intervention by Haines et al. (2013) also included text messaging and MI over the phone which may have led to more successful behaviour change. Participants in the study by Stark et al. (2014) received a total of 18-sessions in their six-month intervention, which alternated between group clinic and individual home sessions. This is a much larger intervention dose than participants received in the current study. Other differences include the fact that Stark and colleagues (2014) primarily focused on dietary and physical activity, whereas the current study focused on increasing physical activity and family meal consumption, reducing SSBs and screen time, and having a healthy bedtime routine. However, the studies were similar in that Stark et al. (2014) did focus on the same age group of children aged 2 to 5 years, and also had a comparable sample size (n= 42).

While all of the aforementioned studies assessed BMI as an outcome measure, none reported to have also measured WC, WHtR, or FM. Since these measures are not often evaluated in childhood obesity prevention research, there are few comparative data. A one-year school-based obesity intervention of 6 to 13 year olds (n= 3,183) by Hollar and colleagues (2012) found that WC among boys (p<0.0001) and girls (p<0.0001) in the intervention group was significantly less than the control group post-intervention. Similarly, WHtR was significantly less in boys (p<0.0002) and girls (p<0.0001) in the intervention group compared to control after one year. While the current study did not result in significant changes in WC and WHtR, research by Hollar and colleagues (2012) was successful in producing significant changes post-intervention. This study is also challenging to compare to the current study as it focused on older children and was based in a school setting.
In a UK study of 398 preschoolers examining objectively measured physical activity and FM, time spent in vigorous PA (VPA) was strongly and independently associated with lower adiposity ($p < 0.001$). Interestingly though, researchers found that time spent in sedentary and low-to-moderate physical activity was not related to adiposity (Collings et al., 2013). It is important to note that researchers in this study were seeking to identify associations between physical activity and body composition as opposed to the current study which was looking at the effect of an intervention. Moreover, Collings and colleagues (2013) used DXA to assess FM, whereas the current study used BIA.

**6.1 Comparison of Study Participants to General Canadian Population**

The gender distribution of preschoolers in this study (47.3% males; 52.7% females) is similar to that of the general Canadian population aged 0 to 9 years (51.2% males; 48.8% females) (Statistics Canada, 2015).

According to the 2011 National Household Survey, the median household income for Canadians was $61,072 (Statistics Canada, 2016). In comparison, a greater proportion of families in this study earned greater than $60,000 per year (67.5% in this study vs. 50.9% in the Canadian population).

According to self-reported height and weight data, 57.3% of males aged 18 years and older are classified as overweight or obese; with 42.7% of females being classified as overweight or obese (Statistics Canada, 2016). Parents in the current study were slightly above this with 63.2% and 45.5% of fathers and mothers being classified as overweight or obese, respectfully. It is important to note that in the current study, height and weight values were objectively measured, as opposed to being self-reported in the Statistics Canada census (2016). This is a critical difference to note as self-reported data are subject to respondent biases, where people
may report data that is consistent with perceived cultural and social norms, and as a result, are likely to overestimate their height and underestimate their weight which can ultimately lead to an underestimation of obesity prevalence (Connor Gorber & Tremblay, 2010; Connor Gorber, Tremblay, Moher, & Gorber, 2007; Shields, Gorber, & Tremblay, 2008). Preschoolers in the current study had much lower incidence of overweight and obesity both at baseline (overweight=3.9%; obesity=0%) and at six-month follow-up (overweight=5.7%; obesity=0%) compared to national data (overweight=15%; obesity=6%) (Shields, 2006).

According to the most recent census by Statistics Canada (2009), 79.5% of children aged 0 to 14 years are Caucasian. The largest visible minority population for children in this age group is South Asian, at 5.5% of the population. Similarly, it was identified that 87.3% of preschoolers in the current study are Caucasian, with Chinese, South Asian, and “other” each making up 4.2% of the minority population.

In summary, the current study population is similar to the Canadian population in terms of child gender distribution and identified race/ethnicity, with the majority identifying as Caucasian. As well, the number of parents classified as overweight or obese was similar to the Canadian population of adults, aged 18 years and above. However, families in the GFHS tended to earn more money than the average Canadian household income.

6.2 Contribution to the Literature

The findings presented in previous studies illustrate the need for a clearer understanding of how different lifestyle interventions impact child body composition. This is especially true for interventions in the home environment and those that involve MI counseling. The current study is an important addition to this growing body of literature. The GFHS is novel in that it is the first study in Canada to combine both of these techniques which are showing promise in areas of
childhood obesity prevention research (Gayes et al., 2014; Spence et al., 2015; Stark et al., 2014). This study demonstrates that a tailored MI-focused obesity prevention intervention in the home environment can produce notable improvements in preschooler body composition, specifically with measures of FM.

This study also helps to contribute to the overall lack of child body composition research. Currently, such research is scarce, particularly in the preschooler population. This study is valuable in helping to contribute more child body composition data to the literature. It is novel in that it includes multiple body composition measures (i.e., FM, BMI, BMI z-score, WC, WHtR, etc.) to track and assess growth and weight status; something rarely seen in published literature. It is imperative for body composition reference data to be created for use in both research and clinical practice in order to better assess child health. This study provides meaningful data that may contribute to the future development of child body composition reference standards.

6.3 Strengths

There are many strengths to the current study. First, this study was novel in that it used a combination of MI and home-based techniques, contributing to the dearth of research exploring preschooler obesity prevention. Coupled with this, all health educators were registered dietitians who were professionally trained in MI techniques, adding rigour to study methodology.

Related to this, a second strength to the study includes measuring the fidelity to MI techniques. This was assessed through audio recordings of home visits by trained MI professionals using the widely used MITI version 4.2.1 developed by Moyers and colleagues (2014). Evaluating MI fidelity was imperative to ensure that GFHS families were receiving the intervention as intended.
Third, this study also serves to contribute to the research gap in child body composition. Few studies exist on obesity and preschooler body composition, and when they do, they often only take into account single measures, such as BMI or BMI z-score (Showell et al., 2013). This study takes into account multiple measures of body composition including BMI, BMI z-score, WC, WHtR and FM, contributing to a strong methodology. Coupled with this, body composition measures were taken multiple times in order to determine an average at each health assessment. This is imperative to ensure intra-rater reliability and higher accuracy in measures. This is especially important when working with young children, as they tend to be more challenging to measure compared to adults.

Fourth, this study involves the objective anthropometric measurements of the preschoolers. Children’s weights and heights change more frequently than adult heights and weights, especially during the preschool age when periods of growth are rapid, which may make it more challenging for parents to accurately report their measurements (Dubois, Farmer, Girard, & Peterson, 2007). Dubois and colleagues (2007) found that child weight overestimation was more apparent for mothers and found that it was more common for sons to have their weight overestimated than daughters. This inaccuracy is concerning since a difference of just 0.5 kg can affect BMI categorization in young children (Dubois et al., 2007). In this study however, child heights and weights were measured by trained research assistants using a pediatric length board or stadiometer, and calibrated scale, respectively.

The fifth strength of this study is that child BMI z-scores were calculated using the WHO growth charts. These growth charts may be more reflective of current obesity rates as they were created using children from longitudinal data from six diverse international reference countries and describe how children should grow when living in optimal conditions. The WHO growth
charts report slightly higher rates of childhood obesity than those reported by the CDC charts using the same population (Shields et al., 2010). Because the WHO growth charts are based on a variety of different populations, they are more likely to provide a realistic description of the current childhood obesity epidemic.

6.4 Limitations

While there are many strengths to the current study, this research is not without limitations. First, given that this was a pilot study, some elements were altered as the study progressed in order to improve methodology and delivery of the intervention. For example, it was found that some preliminary BIA electrodes were faulty and not sticking optimally to participants’ hands and feet and therefore, had to be replaced. There was also more body composition data collected at post-intervention compared to baseline as research assistants improved their ability to capture measures on more uncooperative participants.

A second limitation of the current study is the small sample size (n= 42). This is undesirable as smaller data sets can have a greater likelihood of Type 2 error. However, data collection is currently ongoing and the sample size is anticipated to reach into the hundreds.

A third limitation of the study is the use of BIA methodology to capture measures of FM and FFM. The most valid measure is the four-compartment model, which measures TBW, BMC, FM, and residual. While this method provides valid estimates, it is costly, and generally unfeasible and impractical in most research and clinical settings (Wells et al., 2006). Bioelectrical impedance analysis is a more practical, cost-effective, and child-friendly method to measuring body composition (Talma et al., 2013). It is also portable, easy to use, inexpensive, and has minimal participant burden, making it suitable for both cross-sectional and longitudinal studies (Lee et al., 2008).
A fourth limitation of the study is the self-selection process by which participants were recruited for the GFHS. Families were recruited through the use of flyers, social media, a local family health team, the Guelph Community Health Centre, and word-of-mouth in Wellington County, Ontario, Canada. There may be systematic differences between those who choose to sign up for an obesity-related health behaviour program and those who do not. Parents who were interested in participating may have had a heightened interest in, or concern about their family’s health. This may have resulted in reduced ability to demonstrate impact of the intervention as the control group may have been highly motivated to make changes regardless of their intervention status.

Lastly, while the GFHS study population mirrors the larger Canadian population from a number of perspectives, the fact that our child participants are predominantly normal weight and have lower rates of overweight and obesity makes the study population less representative of the average Canadian preschooler population. While these findings may not be generalizable to all Canadian families, the overall goal of the study was to test the feasibility and effectiveness of the intervention in an effort to create a long-term family cohort, which will eventually produce a more generalizable sample.

6.5 Next Steps

While this research aimed to fill gaps in the existing literature examining home-based obesity prevention interventions and preschooler body composition, it also serves as a foundation for future research. To our knowledge, there is currently no research in Canada investigating the combined use of MI and home-visit based obesity prevention in preschoolers. While home-visit based interventions and MI counseling techniques by themselves have been found to be associated with positive health outcomes, the concept of combining the two is relatively new in
obesity research (Gayes et al., 2014; Haines et al., 2013; Limbers et al., 2008; Spence et al., 2015; Stark et al., 2014). Future research in this area should focus on having larger and more diverse family cohorts, as well as longitudinal design in order to establish long-term effectiveness of the intervention into adolescence and adulthood.

Perhaps most scarce in the literature is body composition reference data for preschoolers, especially in the Canadian population where no reference data exists. The hope is that the larger and more diverse GFHS family cohort will help to produce much needed reference data for resistance, TBW, FM, WC, and WHtR values. It would also be beneficial to develop an equation specific to Canadian children to convert BIA resistance values into a TBW water value, since current published equations are validated in a variety of age and ethnic groups (Ejlerskov et al., 2014).

As the GFHS continues, it will also be important to consider what goal(s) each family chose to work on as it may help identify which health behaviours make the biggest impact on body composition outcomes in the long-term. Furthermore, it is imperative to evaluate body composition measures longitudinally in order to assess whether outcomes have decreased, maintained, or improved since baseline in order to assess the long-term effectiveness of the intervention.

6.6 Implications for Practice

The results from the current study demonstrate the need for future research on obesity prevention interventions and child body composition. Current strategies in primary care, or in community and school-based settings, remain ineffective or unproven in helping to decrease the prevalence of overweight and obesity in the Canadian population and worldwide. Therefore, it is imperative to identify and explore new strategies for obesity prevention, such as through the use
of home visits and MI counseling techniques which have shown promising results in the literature thus far. Based on current literature and the present study, we know that focusing on parental engagement, a young population, and on multiple obesity-related health behaviours (i.e., reducing TV/screen time, increasing physical activity, increasing frequency of family meals, etc.) are key components to success for obesity prevention (Summerbell et al., 2012; Waters et al., 2011; Wofford, 2008). Coupled with this, it is important for clinicians to treat each family as an individual unit and provide strategies that are tailored to their self-identified health behaviour issues. For example, having the family self-identify physical activity as an area in need of improvement rather than telling the family what health behaviour they should work on is likely to have a greater impact on behaviour change.

While few changes in body composition were deemed to be statistically significant, we can note some practical significance between changes in resistance, TBW, and FM (kg and %) values. For example, changes at six-month follow-up for FM (%) ranged from -4.8% (2 home visit group) to -2.6% (4 home visit group), which may be of clinical significance. It is important for both clinicians and researchers to take into account multiple body composition measures when assessing children in order to properly track growth and to help create a larger data set for the future development of reference standards. While it is known in the literature and in clinical settings how difficult it can be to capture such data from children, perhaps what is most important is that methods are consistent and are completed by as few practitioners as possible in order to improve reliability.
7.0 Conclusions

In summary, this thesis explored the association between a home-based childhood obesity prevention intervention and preschooler body composition. This was a randomized controlled trial that was completed using data collected from 42 families participating in the family-based obesity prevention intervention, the Guelph Family Health Study. The intervention was found to be associated with improved body composition outcomes for TBW for the two home visit and combined intervention groups, and for FM (% and kg) for only the two home visit group. The intervention showed no significant associations with body composition measures for the four home visit group. Our results reinforce the need to target obesity-related health behaviours around family meals, physical activity, screen time, SSB consumption, and sleep routines among young children. The findings from this study suggest that a smaller intervention dose may be appropriate to achieve favourable changes in body composition and weight status. This study provides insight into how a family-based obesity prevention intervention in the home setting combined with MI counseling techniques can impact preschooler body composition outcomes. The results of this study will not only help inform future obesity prevention interventions, but they will also provide a groundwork upon which future research exploring obesity prevention and child body composition can build.
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9.0 Appendices

Appendix A: GFHS Parental Consent Forms

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 $20 grocery gift card as a thank you for each questionnaire 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 that looks like a wrist watch for four 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. **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.

**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 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 – Pilot 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 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 _________________
Guelph Family Health Study – Pilot 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 – Pilot Study 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 Pilot Study will 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 will 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-judgemental 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 – Pilot Study, 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) 1 e-mail each week that provides specific health information for my family, plus 2 home visits with a health educator, or
  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 __________________
Appendix B: GFHS Health Behaviour Goal Sheet

- **Eat more meals together as a family (TV off).**
- **Set a bedtime routine and get 11 hours of sleep.**
- **Choose water.** Limit juice to 125 mL (1/2 cup) per day and no soda.
- **Remove the TV from the room where your child sleeps.**
- **Make time to be physically active each day.**
- **Limit TV/screen time to 1-2 hours per day or less.**
Appendix C: Bioelectrical Impedance Analysis (BIA) Standard Operating Procedure

Instructions for Bioelectrical Impedance Analysis (BIA)

The body composition of children will be measured using bioelectrical impedance (BIA). Tell the participant/parent:

“BIA is a method that measures the resistance of our body tissues (like body water and body fat) to a weak electrical current. The current is less than what is in a dying 9V battery. The test is quick and painless. To do the test, we will put sticky pads on your hands and feet, and ask you to lie still.”

The GFHS uses the Quantum IV BIA Analyzer System. Disposable foil electrodes are required for BIA. The GFHS uses Stay Fresh Electrodes Packs (or similar) from RJL Systems.

1. The BIA analyzer must be tested once each study day using the test resistor and BIA test instructions.

2. Confirm that the participant does not have an artificial pacemaker or an implantable cardioverter-defibrillator (ICD). Confirm that that participant has not consumed any food or beverage for 30 minutes prior to the BIA. If so, make a note in the Comment section of the Health Assessment Form.

3. Ask participant to use the nearest washroom to void their bladder within 30 minutes prior to the BIA test.

4. Have the participant remove their right shoe and sock, and any jewelry (small earrings are fine) and/or metal from their pockets. There should be no metal on the participant from the neck/clavicle down to their feet. This includes taking off jeans with metal zippers_snaps.

5. Ask the participant to lie down on the bed (ideally flat, no pillow). Ask the participant to be as still as possible. Ensure that the participant’s arms and legs are abducted about 30’ from their torso. If required, a rolled-up towel can be used to separate legs.

Note: If necessary, one parent can stand at the head of the bed and put a hand on the child’s forehead to comfort the child during the test. The medical bed can also be lowered or raised for convenience.
6. Clean the electrode sites with an alcohol swab. See the diagram on the BIA Instruction Sheet for electrode locations.

7. Prepare the gel electrodes by cutting them in half. You will need 4 half electrodes for each participant (2 for the right foot and 2 for the right hand).

8. Attach the electrodes and cables as shown in the diagram on the BIA Instruction Sheet.

   **Note:** For the children in the GFHS, place the electrode at the base of the middle finger on the right hand, instead of wrapping the electrode about the finger. Remember, for the electrode placement “red to head”.

9. Turn on the BIA analyzer, let the measurements stabilize for a few seconds and then record the Reactance, Resistance, Impedance and Phase Angle measurements on the Health Assessment Form.

10. Turn off the BIA analyzer.

11. Turn on the BIA analyzer and repeat the measurements for a second reading.

   **Note:** If there is a greater than 5% difference between the two resistance results, a third BIA measurement should be taken.

12. Remove the cables and the electrodes. Dispose of the electrodes in the garbage.

   **BIA Supplies – Ordering Information**
Appendix D: Waist Circumference (WC) Measurement Protocol

Waist Circumference Measurement Protocol

1. Participant should clear abdomen of all clothing.
2. Participant should stand with feet shoulder-width apart and arms crossed over chest.
3. On the **RIGHT** side of the participant, on **BENDED KNEE**, palpate the **TOP** of the right iliac crest (think of the crest of a wave). You are aiming for the uppermost lateral border of the right hipbone.

Requires **TWO** technicians:
- One to do the landmarking and measurement
- The other to ensure measuring tape is parallel with the floor, and to record the values

Measuring waist circumference at the top of the iliac crest:
4. Draw a horizontal line at this landmark, using eyeliner.

5. Wrap a Gulick II measuring tape around the abdomen. The bottom of the measuring tape should be level with the line. It should be **horizontal** all the way around.

6. Apply tension to the tape to make sure the tape is snug, but not so tight as to compress tissue. One of the two red balls of the spring mechanism should be visible. See “How to take a measurement” in the Gulick II Instruction Manual.

7. At the end of normal expiration (after expiration, before inspiration), take the measurement to the nearest 0.1 cm.

8. Repeat steps 5 to 7 for a second measurement.
   - If the two values are within 0.5 cm, take the mean.
   - If the two values diverge by more than 0.5 cm, take a third measurement, and record the mean of the two closest values.

References

1. Canadian Society for Exercise Physiology

Appendix E: Weight Measurement Protocol

To measure weight using the BODPOD:

1. Instruct the participant to remove his/her footwear and outer garments (e.g. jackets, hats, heavy sweaters, etc).

2. Turn on POD (green button on white box and computer).

3. Login to the BODPOD software
   Username = bodycomp
   Password = bodycomp

4. Be sure the scale has been calibrated in the last 2 weeks.

5. Click on PRACTISE>MASS. The scale will tare and then prompt you to ask participant to stand on the scale for measurement.

If participant is too young or too nervous to stand on the scale, measure the mass one parent holding the child and then measure the parent alone. The child’s mass can be calculated from these two measurements.

If the BODPOD scale is unavailable, use the Seca scale in the back room to take a manual weight measurement.
GFHS Height Measurement Protocol

For Adults and Older Children

Measuring Height Using a Stadiometer

1. The participant should be barefoot or in sock feet, and be wearing minimal clothing to facilitate the correct position during measurement. Any hair ornaments (barrettes, etc.) should be removed.

2. The participant should stand with heels together (the toes can be pointed outward slightly), arms to the side, legs straight, shoulders relaxed, head in Frankfort horizontal plane (“look straight ahead”).

3. There should be four points of contact between the participant and stadiometer/wall: heels, buttocks, scapulae, back of head.
4. Just prior to measurement, instruct the participant to inhale deeply & hold their breath with shoulders up, back and down to maintain an erect posture (“stand up tall”), while the headboard is lowered on the highest point of the head with enough pressure to compress the hair.

5. Measure to the nearest 0.1 cm. Participant can exhale.

6. Reposition the participant and repeat steps 2 to 5 for a second measurement.
   - If the two values are within 0.5 cm, take the mean.
   - If the two values diverge by more than 0.5 cm, take a third measurement, and record the mean of the two closest values.

References

GFHS Pediatric Height/Length Measurement Protocol

Participants shorter than 130 cm, will be too small for the wall-mounted stadiometer.

In this case, and if the participant can stand, use the pediatric length board in a standing position, shown below.

Follow the GFHS Height Measurement Protocol.
GFHS Pediatric Height/Length Measurement Protocol
(cont’d)

If Participant is Unable/Unwilling to Stand

- Ask participant to lie on the bed, on pediatric length board.
- Ensure participant’s right leg is extended and right foot is parallel with foot board, and that s/he is looking up at the ceiling.
- Measure in duplicate.

If participant is unable/unwilling to lie on the length board, run the measuring along the mattress on the right side of the participant’s body, from the right heel to the crown.