The Mother-Child Relationship Between Motor Skills and Physical Activity

By

Emma DePasquale

A Thesis Submitted in Partial Fulfillment
Of the Requirements for the Degree of

Master of Health Sciences

In

The Faculty of Health Sciences

Kinesiology

University of Ontario Institute of Technology

April 2017

CERTIFICATE OF APPROVAL

The Mother-Child Relationship Between Motor Skills and Physical Activity

Chairperson of the Supervisory Committee: Dr. Meghann Lloyd
Faculty of Health Sciences

ABSTRACT

Physical activity (PA) can promote health benefits for both children and adults. Important factors that encourage PA levels include fundamental motor skills (FMS), and parental PA patterns. Children who are more proficient at their FMS, tend to be more physically active. Parents who are more physically active, also have children who are more active. The purpose of this study was to examine the parent-child relationship between FMS and PA. The results indicate that dynamic balance in mothers could influence the FMS of their children. In addition, mother PA was not related to child PA engagement. Yet, dynamic balance in mothers influenced their own self-reported PA and when the boys and girls were analyzed separately, the children's FMS were related to their pedometer-determined PA. The results indicate that mothers can influence the FMS of their children; however, not their PA engagement. Although some aspects of this study did not indicate a relationship between mothers and their children, this could indicate that the mother-child relationship may not be biologically driven. If parents provide opportunity, experience and access, their children may be able to be proficient at their FMS and live a physically active lifestyle.

Keywords: physical activity, fundamental motor skills, adult motor skills, children, perceived motor competence

Emma L. M. DePasquale (2017)

STATEMENT OF ORIGINALITY

I, Emma DePasquale, hereby declare that this thesis is, to the best of my knowledge, original, except as acknowledged in the text. I further declare that the material contained in this thesis has not been previously submitted, either whole or in part, for a degree at this, or any other university.

Emma L. M. DePasquale (2017)

ACKNOWLEDGEMENTS

Thank you to supervisor, Dr. Meghann Lloyd for your support throughout the past two years. You have taught me more than I could have ever imagined, and supported me through all my ups and downs, and I am truly grateful for everything you have done for me.

Thank you to my supervisory committee members, Dr. Rob Balogh and Dr. Shilpa Dogra for all your help as I was developing my thesis. Rob, thank you so much for all your help with my statistics. I really, really appreciate it! Shilpa, thank you so much for your insight on how we could measure motor skills in adults and for allowing me for using your equipment for my thesis.

Thank you very much to all the children and parents who participated in my study, and making data collection a blast! I had so much fun working with you all! This study could not have happened without you!

Thank you to the volunteers for taking the time out of their busy schedules to help me with the assessments. Shagini and Ayra, you two are wonderful people, and I wish nothing but the best for you both, and congratulations on completing your undergraduate degrees!

Thank you to the graduate students and faculty for being supportive throughout my time here at UOIT. Thank you to my "kin family" Carley, David, Josh, Sinead, Ryan G, Ryan S, and Loujain for making these past two years so much fun. Thank you guys so much for being there for me and sharing your grad student experiences; it really made me feel like I wasn't alone.

Emma L. M. DePasquale (2017)

Lastly, thank you to my family for all the love and support during my Master's and undergraduate degrees. I know having been away for so long has taken a toll on you, but nonetheless you still supported me no matter what. Becca and Olly, thank you so much for making me laugh and spending time with me while I was home. It really helped me decompress at times, and I really appreciate it. Mom and Dad, thank you so much for your constant love and support. I don't think I would have made it through it without you guys! I love you all so very much!!

LIST OF ABBREVIATIONS

ADC Adult Developmental Coordination Disorder/Dyspraxia Checklist

BOTMP Bruininks-Oseretsky Test of Motor Proficiency

CHMS Canadian Health Measure Survey

CSAPPA Children's Self-Perceptions of Adequacy in and Predilection for Physical Activity Scale

DCDQ Developmental Coordination Disorder Questionnaire

DCDQ – A Developmental Coordination Disorder Questionnaire for Adults

FMS Fundamental motor skills

GMQ Gross Motor Quotient

HMP High motor proficiency

ICF International Classification of Functioning

IPAQ International Physical Activity Questionnaire

LMP Low motor proficiency

M-ABC Movement Assessment Battery for Children

MET Metabolic Equivalent of Task

MET-hours Metabolic equivalent hours

MVPA Moderate to vigorous physical activity

PA Physical Activity

PDMS – 2 Peabody Developmental Motor Scales – 2

PSPM Pictorial Scale of Perceived Movement Skill Competence

QDPE Quality Daily Physical Education

TGMD – 2 Test of Gross Motor Development – 2

WHO World Health Organization

WHO-ICF World Health Organization International Classification of Functioning

YBT Y Balance Test

TABLE OF CONTENTS

ABSTRACT ..... **iii**
STATEMENT OF ORIGINALITY ..... **iv**
ACKNOWLEDGEMENTS ..... **v**
LIST OF ABBREVIATIONS ..... **vii**
TABLE OF CONTENTS ..... **ix**
LIST OF TABLES ..... **xiv**
LIST OF FIGURES ..... **xv**
OVERVIEW **16**
CHAPTER 1: INTRODUCTION **17**
Introduction 18
Research Questions 20
Significance of the Study: Addressing the Gaps in the Literature 20
Purpose and Overall Contribution 21
Theoretical Framework: World Health Organization – International Classification of Functioning 21
Physical Inactivity and the ICF 22
Health Condition 23
Body Functions and Structures 23
Activity 23
Participation 24
Environmental Factors 24
Personal Factors 25
Conclusion 25
References 27
CHAPTER 2: LITERATURE REVIEW **29**
Literature Review 30
Physical Activity 30
Child Physical Activity 30
Parental Influence on Child PA 33
Physical Activity of Adults 36
Fundamental Motor Skills 38
Importance of FMS for PA in Childhood 39

Perceived Competence of FMS and PA in Children 43
Fundamental Motor Skills in Adults 44
Conclusion 46
References 48
CHAPTER 3: MANUSCRIPT 1 53
Abstract 54
Introduction 55
Fundamental motor skills in childhood 55
Fundamental Motor Skills in Adulthood 57
Perceived and Actual Motor Competence in Children 58
Perceived Motor Competence of Adults and Fundamental Motor Skills 60
Summary 61
Purpose 62
Methods 62
Study Design 62
Recruitment 63
Participants 63
Measurements 63
Mother Measures 64
Child Measures 64
Motor skill assessments 64
Child Motor Skill Measures 64
Test of Gross Motor Development-2 64
Development Coordination Disorder Questionnaire 65
The Pictorial Scale for Perceived Movement Skill Competence 65
Parent Motor Skill Measures 65
Developmental Coordination Disorder Questionnaire for Adults 65
Adult Developmental Coordination Disorders/Dyspraxia Checklist 66
Mother and child motor skill measures 66
The Y-Balance Test – Lower Quadrant 66
Statistical Analyses 67
Are the fundamental motor skills of mothers related to fundamental motor skills of children? 67
Is perceived motor competence related to actual motor competence in children? 68

Is perceived motor competence related to actual motor competence in the mothers? 68
Results 69
Mother and child motor skills 73
Perceived and actual motor competence in children 78
Perceived and actual motor competence in mothers 79
Discussion 79
Strengths and Limitations 90
Future Research 91
Conclusion 92
References 94
CHAPTER 4: MANUSCRIPT 2 99
Abstract 100
Introduction 101
Parental Influence on Children's Physical Activity 102
The Impact of Fundamental Motor Skills on Physical Activity in Children 103
Summary 105
Purpose 105
Methods 106
Study Design 106
Recruitment 106
Participants 106
Measurements 107
Mother Measures 107
Child Measures 107
Motor skill assessments 107
Physical activity assessments 107
Child Motor Skill Measures 108
Test of Gross Motor Development – 2 108
Development Coordination Disorder Questionnaire 108
Developmental Coordination Disorder Questionnaire for Adults 109
Adult Developmental Coordination Disorders/Dyspraxia Checklist 109
Mother and Child Motor Skill and Physical Activity Measures 109
Pedometer 109
International Physical Activity Questionnaire 110

Y – Balance Test Lower Quadrant 110
Statistical Analysis 111
Is there an association between the physical activity levels of mothers and their children? 111
Is there an association between motor proficiency and physical activity in mothers? 111
Is there an association between fundamental motor skill proficiency and physical activity in children? 112
Results 112
The relationship between mother physical activity and child physical activity. 118
The relationship between child fundamental motor skills and physical activity 118
The relationship between mother motor proficiency and physical activity 121
Discussion 122
Future Research 128
Conclusion 129
References 130
CHAPTER 5: THESIS CONCLUSIONS 134
Thesis Conclusions 135
Summary 135
Physical Inactivity and the WHO-ICF 138
Recommendations 139
Conclusion 141
References 142
CHAPTER 6: APPENDICES 144
Appendix 1: Certificate of Approval from the University of Ontario Institute of Technology Research Ethics Board 145
Appendix 2: Informed Consent for Parents 146
Appendix 3: Informed Consent for Children 152
Appendix 4: Child Assent 158
Appendix 5: Recruitment Flyer 159
Appendix 6: Supplemental Information Form 160
Appendix 7: Developmental Coordination Disorder Questionnaire 163
Appendix 8: The Pictorial Scale for Perceived Movement Skill Competence 166
Appendix 9: Developmental Coordination Disorder Questionnaire for Adults 171
Appendix 10: Adult Developmental Coordination Disorder/Dyspraxia Checklist 175

Appendix 11: The Y-Balance Test ... 178
Appendix 12: Pearson product correlations between mother and child YBT scores . 181
Appendix 13: Pearson product correlation tables between mothers' YBT scores and child TGMD-2 scores. ... 187
Appendix 14: Pearson product correlation tables between the mothers' YBT scores and the TGMD-2 scores of all female children. ... 190
Appendix 15: Pearson product correlations between the mothers' YBT scores and the TGMD-2 scores of the male children ... 193
Appendix 16: Pearson product correlations between the TGMD-2 and DCDQ ... 196
Appendix 17: Pearson product correlations between the TGMD-2 and the PSPM.... 197
Appendix 18: Correlations between mother YBT scores and the ADC. ... 198
Appendix 19: Correlations between the mother YBT scores and the DCDQ-A ... 199
Appendix 20: Pedometer step log for the parents ... 200
Appendix 21: Pedometer step log for the children ... 201
Appendix 22: IPAQ questionnaire ... 202
Appendix 23: Pearson product correlations between mother and child average steps per day. ... 204
Appendix 24: Pearson product correlations between mother and child IPAQ continuous scores. ... 205
Appendix 25: Pearson product correlations between the average steps per day for the mothers and IPAQ continuous scores for the children ... 205
Appendix 26: Pearson product correlations between the average steps per day of the children and the IPAQ continuous scores for the mothers ... 206
Appendix 27: Pearson product correlations between child IPAQ and TGMD-2 variables. ... 207
Appendix 28: Pearson product correlations between child IPAQ and YBT ... 208
Appendix 29: Pearson product correlations between the IPAQ and the DCDQ ... 210
Appendix 30: Pearson product correlations between the TGMD-2 and the child average steps per day. ... 210
Appendix 31: Pearson product correlations between the DCDQ and the average steps taken per day by the children. ... 212
Appendix 32: Pearson product correlations between the ADC and the mothers' average steps per day, and the IPAQ continuous score. ... 212
Appendix 33: Pearson product correlations between the DCDQ-A and the mothers' pedometer steps, and the mothers' IPAQ continuous score. ... 213
Appendix 34: Pearson product correlations between the mothers' IPAQ and YBT scores. ... 213
Appendix 35: Correlations between the mothers' pedometer steps and YBT scores. 214

LIST OF TABLES

Table 1. Motor skill measures 64

Table 2. Participant characteristics for both the mothers and children 69

Table 3. Descriptive results for motor proficiency, and perceived motor competence of the children 71

Table 4. Descriptive statistics for motor proficiency and perceived motor competence of the mothers. 73

Table 5. Pearson correlation results between mothers' YBT reach percentages and child TGMD-2 GMQ scores 75

Table 6. Pearson correlations between mothers' YBT reach percentages and females TGMD-2 GMQ scores 76

Table 7. Pearson correlations between mothers' YBT reach percentages and female TGMD-2 object control raw scores 77

Table 8. Pearson correlations between mothers' YBT reach percentages and male TGMD-2 locomotor raw scores 78

Table 9. Mother and child physical activity and motor skill measures. 107

Table 10. Mother and child participant characteristics. 113

Table 11. Child descriptive statistics for the motor skill measures. 114

Table 12. Descriptive statistics for the child physical activity measures. 115

Table 13. Mother descriptive statistics for the ADC, DCDQ-A, YBT, pedometer average steps per day, and the IPAQ 116

LIST OF FIGURES

Figure 1. WHO-ICF model 23

Figure 2. Average pedometer steps per day for mothers and their children 117

OVERVIEW

This thesis is divided into six sections:

1. Introduction
2. Literature review
3. Manuscript 1
4. Manuscript 2
5. Thesis Conclusions
6. Appendices that include ethics approval, consent forms, recruitment flyer, questionnaires, and raw data

CHAPTER 1: INTRODUCTION

Introduction

Physical activity (PA) engagement is an effective way to promote overall health across all ages, genders, ethnic and socioeconomic subgroups (Colley et al., 2011a, 2011b; Tremblay et al., 2011). Studies show that children should achieve a minimum of 60 minutes moderate to vigorous (MVPA) (Colley et al., 2011b), or 13, 500 steps per day (Vander Ploeg, Biao, McGavock, & Veugelers, 2012) in order to gain these health benefits. Physical activity is a public health concern for Canada because only nine percent of boys, and four percent of girls achieve these recommended guidelines (Colley et al., 2011b). Studies have also shown that parents can influence their children's PA; evidence indicates that parents who are more physically active tend to have children who are also physically active (Craig, Cameron, & Tudor-Locke, 2013; Fuemmeler, Anderson, & Masse, 2011; Jago et al., 2014). By understanding the ways in which parents influence their children's PA, programs and policies can be developed that are family-centered and promote PA for everyone.

Fundamental motor skills (FMS) are the basic movements that lead to more specialized and complex skills that are often used during PA (Lubans, Morgan, Cliff, Barnett, & Okely, 2010). The components that make up FMS consist of locomotor, stability and object control skills (Lubans et al., 2010). Evidence suggests that children with high motor proficiency are more likely to engage in PA (Barnett, van Beurden, Morgan, Brooks, & Beard, 2009; Lubans et al., 2010). In contrast, those who are not proficient in their FMS are less likely to have a physically active lifestyle (Lloyd, Saunders, Bremer, & Tremblay, 2014; Lubans et al., 2010). By understanding the implications for children who demonstrate poor FMS and PA levels, researchers will be able to create interventions to help promote these skills in children.

Adults between the ages of 18 and 64 years of age are recommended to achieve at least 150 minutes of moderate to vigorous intensity PA each week, with each session lasting ten minutes or more (Tremblay et al., 2011). Adults who engage in regular PA are able to reduce the risk of developing, and the impact of, chronic conditions (Warburton, Charlesworth, Ivey, Nettlefold, & Bredin, 2010). Additionally, the more active adults become, the greater these positive results will be (Warburton et al., 2010). In contrast, those who display low PA levels have an increased risk for the development of chronic conditions, as well as premature all-cause and disease-specific mortality (Warburton et al., 2010). The challenge is to understand the predictors of PA engagement to design programs to promote lifelong PA engagement.

Motor proficiency in childhood can predict proficiency in adulthood (Cousins & Smyth, 2003; Lloyd et al., 2014). Research on adult FMS is lacking; however, research that has been conducted on adult motor proficiency often examines those who appear to be at the lowest end of the spectrum (Cousins & Smyth, 2003; Hill, Brown, & Sorgardt, 2011). Since children with poor FMS often grow up retaining these poor motor skills as adults (Hill et al., 2011), the consequences of having poor FMS may remain beyond childhood. Understanding the impact of poor FMS in adulthood is important to address the need for interventions for both adults and children. In addition, understanding the role of FMS in parents could be an important factor to investigate in order to determine the effects it has on their children.

Evidence suggests that parental PA levels influence the PA levels of their children (Craig et al., 2013; Fuemmeler et al., 2011), and it is possible that a similar relationship exists between parent and child FMS. This complex, multifaceted relationship between the characteristics of both parents and their children that has yet to be studied. Many of these relationships such as parent and child PA, and child PA and FMS have been examined separately; however, there has yet to be one comprehensive study that has looked at how these individual relationships interact with one another.

Research Questions

The parent-child relationship between physical activity and motor skill proficiency was investigated. The two primary research questions investigated were:

1. Do children with high fundamental motor skills have mothers with high fundamental motor skills?
2. Do children with low fundamental motor skills have mothers with low fundamental motor skills?

In addition, several secondary research questions will be investigated, including:

1. How does perceived motor competence affect fundamental motor skills in children and their mothers?
2. Does physical activity participation in mothers affect the physical activity engagement of their children?
3. How does motor skill proficiency of both children and their mothers affect their physical activity levels?

Significance of the Study: Addressing the Gaps in the Literature

This study adds further knowledge to the literature concerning the FMS and PA levels of mothers, and how it relates to that of their children. The literature shows that child PA is highly associated with parent PA (Craig et al., 2013; Fogelholm, Nuutinen, Pasanen, Myöhänen, & Säätelä, 1999; Fuemmeler et al., 2011; Sigmundová, Sigmund, Vokácová, & Kopcáková, 2014) and that children's FMS proficiency is associated with their PA levels (Barnett et al., 2009; Hands, Larkin, Parker, Straker, & Perry, 2009; Hay & Missiuna, 1998; Iivonen et al., 2013); however, it is not yet known as to how parents' FMS are related to that of their children. This relationship is important to establish because family-based interventions could be developed to promote adequate development of FMS and PA.

Purpose and Overall Contribution

The overall purpose of this study was to examine the relationship between FMS and PA of parents and their children. The literature is well-established about the relationship of PA levels between parents and their children, as well as FMS and PA levels in children; however, there is no known research on how FMS of parents influences the FMS of their children, or how FMS of parents affects their PA levels. By understanding this relationship, future research can focus on creating interventions that target both parents and children to promote PA.

Theoretical Framework: World Health Organization – International Classification of Functioning

The importance of FMS development and participation in PA is well established in children (Lubans et al., 2010); with children demonstrating higher FMS also participating in higher amounts of PA (Barnett et al., 2009). In contrast, those with poor FMS development participate in less PA. In addition, the literature has established that parent PA has a positive relationship with PA levels in their children (Fuemmeler et al., 2011). As children and adults are becoming increasingly inactive, we need to know where to intervene. In order to help explain the physical inactivity seen in children and adults, the International Classification of Functioning, Disability and Health (ICF) created by the World Health Organization (WHO) will be used.

The WHO-ICF was created as a multi-purpose framework to describe health and health related conditions with its domains being described from the perspective of the individual (WHO, 2001). These domains were developed from body, individual and societal perspectives through the use of body functions and structure list, and a list of activity and participation (WHO, 2002). The term functioning refers to the body functions, activities and participation; whereas, disability refers to impairments, limitations during activity, and restrictions in participation (WHO, 2002). In addition, the ICF also takes the environment into consideration and determines how it interacts with its other components (WHO, 2002). The aim of this framework is to create a common dialogue in order to have a discussion about health between interdisplinary professionals (WHO, 2002). The ICF is also applicable to many different aspects of healthcare such as research, clinical and social population, and educational settings (WHO, 2002). This framework can serve as a more inclusive model of health as is takes the biopsychosocial model into account; where the social and medical models are integrated into one model (WHO, 2002).

Physical Inactivity and the ICF

In order to explain the ICF and its application to physical inactivity, refer to Figure 1.

Each theme will be discussed concerning physical inactivity.

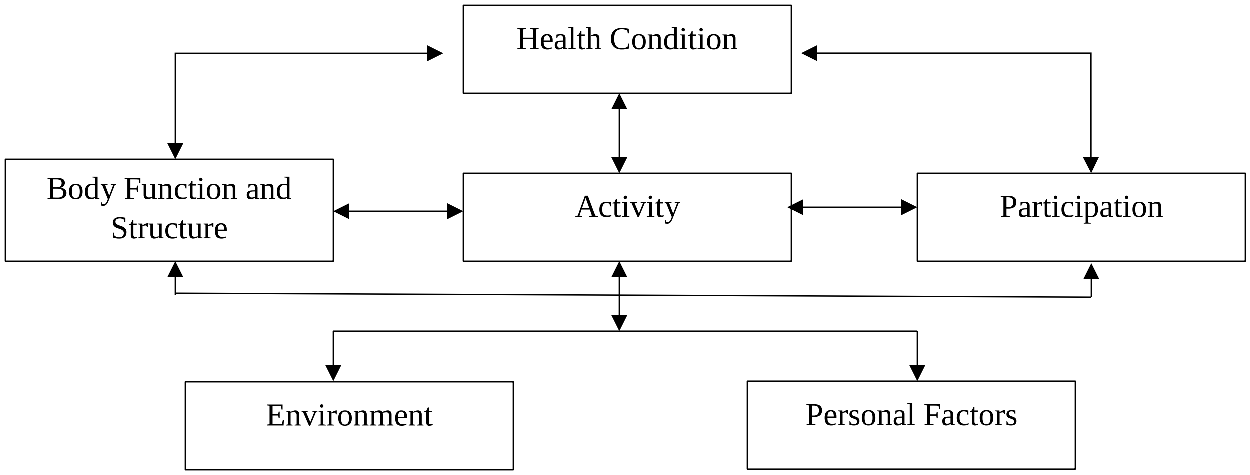


Figure 1. WHO-ICF model

Health Condition

Participants in this study consisted of 19 children with typical development between the ages of eight and ten years, as well as their mothers (n=15). No two participants (child or adult) could have had the same PA experience or daily behaviour because they all have their own PA history, experiences in PA, unique barriers and facilitators to daily PA as well as motor skill proficiency. Canadian children and adults do not generally meet the PA guidelines; therefore, we need to understand the factors that promote and inhibit PA engagement.

Body Functions and Structures

All participants, both adults and children, were considered to have typical development, be able to ambulate independently, have no known neurodegenerative disorders, and have no injuries that could impede the ability to walk (e.g. broken leg).

Activity

This aspect of the ICF model assesses the ability to perform a task or action by the participant (WHO, 2002). It can be applied to this study because the level of PA may be inhibited by proficiency in FMS. Children who are more proficient in their FMS tend to be more physically active. Since FMS serves as the foundation for more complex motor skills and participation in sport, the mastery of these skills is very important. How they perceive their motor competence can also impact their PA engagement. Child FMS was measured using the Test of Gross Motor Development – 2, Y Balance Test (YBT), and self-reported measures; whereas, for mothers, the YBT self-report measures was used to assess motor skill proficiency. It was hypothesized that if parents have proficient motor skills, than their children could as well.

Participation

The participation component is how the individual is engaged in a life situation (WHO, 2002). In this context, engagement in PA was considered to be in the "Participation" component of the ICF model. In order for children to be able to master their FMS, they require the ability to practice these skills. Children who engage in high levels of PA will have optimal chances to practice their FMS, and as their skills gradually become more proficient; the increased skill will also promote higher levels of PA engagement. PA was measured using pedometers for seven days and self-reported measures. The relationships between perceived competence, PA behaviour and FMS between children and parents were explored. It was hypothesized that children who are more physically active on a regular basis, have more proficient FMS.

Environmental Factors

The environment factors encompasses the physical, social and attitudinal environment where individuals live their lives (WHO, 2002). This is an important aspect of the human experience as it can influence FMS and PA. Barriers to PA can prevent both parents and their children from engaging in sufficient PA. Though children and parents may have the physical abilities to be physically active, external barriers could prevent them from engaging in PA. Specifically for children, parental encouragement about PA may also play a factor. If parents are more supportive of a physically active lifestyle, their children may receive positive motivation to pursue PA. By studying the environmental factors that influence PA and FMS in children and their parents, this could lead to future interventions that can see improvements in the 'Activity' and 'Participation' components of the ICF.

Personal Factors

The personal factors for each participant are non-modifiable components of the ICF. All children who participated in the study were between the ages of eight and ten years of age, with approximately half being boys and the other half girls. Since each participant came from his or her own unique family dynamic, this could have impacted his or her PA engagement and FMS development. In addition, the sex of the participants was an unmodifiable factor that can impact their PA and FMS. Although these are non-modifiable factors, they were collected and taken into account when determining the factors that promote and inhibit PA behaviour and FMS proficiency of parents and children.

Conclusion

In conclusion, the use of this model allows for researchers to better understand how parent PA and FMS is related to their children's FMS and PA behaviours. The goal of this study was to assess the mother-child relationship between PA and FMS; which will help to create future motor skill and PA interventions for both children and adults. Since

Canadian children and adults are becoming inactive, these interventions could help to stop the cycle of physical inactivity for pursuing any longer.

References

Barnett, L. M., van Beurden, E., Morgan, P. J., Brooks, L. O., & Beard, J. R. (2009). Childhood Motor Skill Proficiency as a Predictor of Adolescent Physical Activity. *Journal of Adolescent Health, 44*(3), 252-259. doi:http://dx.doi.org/10.1016/j.jadohealth.2008.07.004

Colley, R. C., Garriguet, D., Janssen, I., Craig, C. L., Clarke, J., & Tremblay, M. S. (2011a). Physical activity of Canadian adults: Accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. *Health Reports, 22*(1), 7-14. doi:10.1139/h07-130

Colley, R. C., Garriguet, D., Janssen, I., Craig, C. L., Clarke, J., & Tremblay, M. S. (2011b). Physical activity of Canadian children and youth: Accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. *Health Reports, 22*(1), 15-23.

Cousins, M., & Smyth, M. M. (2003). Developmental coordination impairments in adulthood. *Human Movement Science, 22*(4–5), 433-459. doi:http://dx.doi.org/10.1016/j.humov.2003.09.003

Craig, C. L., Cameron, C., & Tudor-Locke, C. (2013). Relationship between parent and child pedometer-determined physical activity: a sub-study of the CANPLAY surveillance study. *The International Journal of Behavioral Nutrition and Physical Activity, 10*, 8.

Fogelholm, M., Nuutinen, O., Pasanen, M., Myöhänen, E., & Säätelä, T. (1999). Parent–child relationship of physical activity patterns and obesity. *International Journal of Obesity & Related Metabolic Disorders, 23*(12), 1262.

Fuemmeler, B. F., Anderson, C. B., & Masse, L. C. (2011). Parent-child relationship of directly measured physical activity. *The International Journal of Behavioral Nutrition and Physical Activity, 8*, 17.

Hands, B., Larkin, D., Parker, H., Straker, L., & Perry, M. (2009). The relationship among physical activity, motor competence and health-related fitness in 14-year-old adolescents. *Scandinavian Journal of Medicine & Science in Sports, 19*(5), 655-663. doi:10.1111/j.1600-0838.2008.00847.x

Hay, J., & Missiuna, C. (1998). Motor proficiency in children reporting low levels of participation in physical activity. *Canadian Journal of Occupational Therapy, 65*, 64+.

Hill, E., Brown, D., & Sorgardt, K. S. (2011). A preliminary investigation of quality of life satisfaction reports in emerging adults with and without Developmental Coordination Disorder. *Journal of Adult Development, 18*(3), 130-134 135p. doi:10.1007/s10804-011-9122-2

Iivonen, K. S., SÄÄKslahti, A. K., MehtÄLÄ, A., Villberg, J. J., Tammelin, T. H., Kulmala, J. S., & Poskiparta, M. (2013). Relationship between fundamental motor skills and physical activity in 4-year-old preschool children. *Perceptual & Motor Skills, 117*(2), 627-646. doi:10.2466/10.06.PMS.117x22z7

Jago, R., Sebire, S. J., Wood, L., Pool, L., Zahra, J., Thompson, J. L., & Lawlor, D. A. (2014). Associations between objectively assessed child and parental physical activity: a cross-sectional study of families with 5-6 year old children. *BMC Public Health, 14,* 655. doi:10.1186/1471-2458-14-655

Lloyd, M., Saunders, T. J., Bremer, E., & Tremblay, M. S. (2014). Long-term importance of fundamental motor skills: A 20-Year follow-up study. *Adapted Physical Activity Quarterly, 31*(1), 67-78.

Lubans, D., Morgan, P., Cliff, D., Barnett, L., & Okely, A. (2010). Fundamental movement skills in children and adolescents. *Sports Medicine, 40*(12), 1019-1035. doi:10.2165/11536850-000000000-00000

Sigmundová, D., Sigmund, E., Vokácová, J., & Kopcáková, J. (2014). Parent-child associations in pedometer-determined physical activity and sedentary behaviour on weekdays and weekends in random samples of families in the Czech Republic. *International Journal of Environmental Research and Public Health, 11*(7), 7163-7181.

Tremblay, M. S., Warburton, D. E. R., Janssen, I., Paterson, D. H., Latimer, A. E., Rhodes, R. E., . . . Duggan, M. (2011). New Canadian physical activity guidelines. *Applied Physiology, Nutrition & Metabolism, 36*(1), 36-46. doi:10.1139/H11-009

Vander Ploeg, K. A., Biao, W., McGavock, J., & Veugelers, P. J. (2012). Physical activity among Canadian children on school days and nonschool days. *Journal of Physical Activity & Health, 9*(8), 1138-1145.

Warburton, D. E. R., Charlesworth, S., Ivey, A., Nettlefold, L., & Bredin, S. S. D. (2010). A systematic review of the evidence for Canada's Physical Activity Guidelines for Adults. *The International Journal of Behavioral Nutrition and Physical Activity, 7*, 39. doi:10.1186/1479-5868-7-39

WHO. (2001). *International Classification of Functioning, Disability and Health*. Geneva: World Health Organization.

WHO. (2002). *Towards a common language for functioning, disability and health*. Geneva: World Health Organization.

CHAPTER 2: LITERATURE REVIEW

Literature Review

Physical Activity

Regular engagement in physical activity (PA) is associated with health benefits in all population regardless of age; such as the prevention of disease, and the promotion of physical and emotional well-being (Aaltonen et al., 2015; Colley et al., 2011a, 2011b; Rintala et al., 2011; Vander Ploeg et al., 2012). In order to achieve these health benefits, it is recommended that Canadian children accumulate 60 minutes of moderate to vigorous physical activity (MVPA) each day with additional evidence suggesting that children engage in a minimum of three days of vigorous PA per week for ten minutes or more per session (Colley et al., 2011b; Tremblay et al., 2011). Evidence indicates that only nine percent of Canadian boys and four percent of girls meet the recommended guidelines for PA (Colley et al., 2011b). As children are becoming increasingly inactive, they are at increased risk for developing chronic conditions such as cardiovascular disease, type two diabetes, and obesity (Kambas et al., 2012). PA has become an important factor for the health of Canadians; thus, the importance for research on the factors that promote PA in both children and adults is necessary.

Child Physical Activity

Evidence suggests that Canadian children are becoming increasingly inactive (Colley et al., 2011b). In order to assess the level of PA in Canadian children, Colley et al. (2011b) analyzed the Canadian Health Measure Survey (CHMS) where accelerometers were used to measure PA in a nationally representative sample of Canadian children and youth between 6 to 19 years of age. The results indicated that only seven percent of children meet this recommendation. Boys averaged approximately an hour of MVPA per day, and girls averaged 47 minutes. In addition, as children age the level of children who accumulate 60 minutes of MVPA declines. These findings suggests that PA in Canadian children is low, with this being especially apparent in females. In addition, youth aged 11 to 19 years accumulated fewer steps compared to children 6 to 10 years of age (Colley et al., 2011b), which suggests that as children age, their PA levels decrease. Therefore, Canadian children are not physically active enough and this trend worsens as children become older.

A study conducted by (Vander Ploeg et al., 2012) yielded similar results with Canadian children. The objectives of this study were to objectively assess PA using pedometers over seven days. The researchers hypothesized that PA would be the lowest while children were at school compared to non-school days. To measure PA, 973 participants aged 10 to 11 were asked to wear pedometers for nine consecutive days, with seven days being used for the analysis, as well as to record their daily activities in an activity log during this time frame. Results of this study showed that only 37% of boys and 19% of girls were able to meet the recommended 60 minutes of MVPA throughout the week (Vander Ploeg et al., 2012). Boys achieved significantly more steps per day and per hour than girls during school days, as well as during non-school days. In addition, children took more steps per day during school days compared to non-school days. Lastly, children were less active on weekends and this was more pronounced for boys than girls (Vander Ploeg et al., 2012). The findings indicate that the majority of children are not meeting the recommended PA levels, especially for girls. In addition, this study highlights that children display a greater decline in PA on the weekends compared to weekdays.

Achieving the recommended PA levels is not only important for older children; younger children and infants should achieve 180 minutes of PA per day at any given intensity (Tremblay et al., 2012). Borkhoff et al. (2015) aimed to objectively measure PA, adherence to PA guidelines and sedentary time of Canadian infants, toddlers, and preschool-aged children. 90 children wore accelerometers for seven days. The results from this study showed that children less than 18 months of age were significantly less active than the 18 to 59 month and over 60 month age groups (Borkhoff et al., 2015). Only 23 percent of children that were less than 18 months of age met the guidelines; whereas, 76 percent of children aged 18-59 months were able to meet the guidelines. For children greater than 60 months of age, only 13 percent were able to meet the recommended 60 minutes of MVPA per day (Borkhoff et al., 2015). Although the children in the 15-59 month age group were more physically active compared to the other two groups, most children had spent time in low-intensity PA (Borkhoff et al., 2015). In addition, the reason for the decrease in PA levels from the 15-59 month age group to the 60 month and older age group was potentially due to the change in guidelines between the two age groups (Borkhoff et al., 2015). For children older than 60 months, only MVPA was taken into consideration; whereas, for the younger age groups, PA at any intensity was included. Through engaging in PA at an earlier age, this could potentially predict PA later on in childhood.

Although PA is associated with many health benefits (Colley et al., 2011b), many children are not meeting the recommended guidelines (Borkhoff et al., 2015; Colley et al., 2011b; Vander Ploeg et al., 2012). In addition, boys have shown to be more active than girls (Colley et al., 2011b; Vander Ploeg et al., 2012); however, when viewing weekend periods, children were less active during this period and this decline was noticed more in boys (Vander Ploeg et al., 2012). This pattern of physical inactivity may begin during early childhood as children as young as 60 months are not meeting the recommended guidelines for PA (Borkhoff et al., 2015). Therefore, it is imperative to establish positive PA patterns in children to promote a healthy lifestyle throughout their development and understand how best to intervene to promote healthy PA patterns in children.

Parental Influence on Child PA

Parents play an important role in the PA levels of their children (Fuemmeler et al., 2011; Jago et al., 2010; Sigmundová et al., 2014). Therefore, the parent-child relationship dynamic is an important factor for study to understand all possible factors that influence PA throughout the life-cycle. Craig et al. (2013) examined whether parent PA levels were associated with their children's PA. The participants of this study consisted of 620 families with 1187 children that were recruited from a sub-sample within the Canadian Physical Activity Levels Among Youth surveillance study. All participants were asked to wear a pedometer for seven consecutive days and record their daily steps in a provided log book. The results showed that boys took a greater number of steps compared to girls. In addition, the steps/day for the boys was related to their parents' steps/day (Craig et al., 2013). Each 1000 step increase in a fathers' steps/day was associated with an addition 329 steps in his son's activity level (Craig et al., 2013). Concerning girls, their steps/day were associated with their mothers' steps/day with each 1000 step increase in a mother's steps/day resulting in an increase of 195 to 219 steps/day for her daughter (Craig et al., 2013). In addition, each 1000 step increase for mothers' was associated with an increase of 263 to 439 steps/day for her son (Craig et al., 2013). This study was able to demonstrate a clear association between parent and child PA levels, with parents who are more active generally have more active children.

Fuemmeler et al. (2011) conducted a similar study where accelerometers were used to determine the degree to which PA and sedentary time correlate among parents and children. The researchers recruited 45 parent-child triads who all wore accelerometers for four consecutive days. The results of this study showed that the MVPA of fathers and sons was significantly and positively correlated during the weekend and weekday afternoon; however, mothers' and sons' MVPA was not significantly correlated (Fuemmeler et al., 2011). In addition, the MVPA of the children was significantly greater when both parents were participating in high levels of MVPA. Concerning daughters, MVPA was significantly correlated with that of their fathers during the weekdays; however, not on the weekends. Despite this, MVPA of mothers and daughters was significantly correlated at all points during the week (Fuemmeler et al., 2011). This highlights the importance of parents being physically active. If parents were to improve their PA levels, this could encourage their children to do the same.

Evidence has shown that the PA levels of the parents is associated with the PA levels of their children (Craig et al., 2013; Fuemmeler et al., 2011; Jago et al., 2014), and that both children (Colley et al., 2011b) and adults (Colley et al., 2011a; Rhodes & Pfaeffli, 2010) are failing to meet the recommended PA guidelines. Parental support may be a key determinant of PA in children (Biddle & Goudas, 1996). Biddle and Goudas (1996) examined the relationships between parent encouragement of PA and self-reported PA. It was hypothesized that adult encouragement was associated with both the intended and actual PA levels of the children. The participants consisted of 147 children between the ages of 13 and 14 years. All participants completed a questionnaire with the following measures: self-reported PA, intentions, goal orientations, perceived sport competence, perceived adult PA and encouragement, and knowledge of exercise. The results of this study showed the PA of the children was significantly associated with adult encouragement, intentions and perceived sport competence (Biddle & Goudas, 1996). Therefore, if parents encourage their children to be physically active, their children might be more likely to engage in PA regularly; therefore, increasing the ability to achieve the recommended guidelines.

Ling, Robbins, and Hines-Martin (2016) explored the perceived parental barriers of PA as well as ideas for supporting PA among children. A focus group was used to gather ideas from 32 participants that were parents between the ages of 22 and 63 years. The results of this study found that parents perceive their children to have very low attention spans when it came to PA; however, when parents were able to have PA become fun and interesting, the children were willing to participate (Ling et al., 2016). Many parents also considered lack of time as a prevalent barrier to encourage PA engagement in their children (Ling et al., 2016). In addition, the cost of PA may have been too greater for some parents to afford (Ling et al., 2016). Lastly, environmental barriers such as inaccessible programs due to location and age restrictions, as well as an unsafe environments were reported (Ling et al., 2016), indicating the promoting PA in children is complex and multi-faceted.

A study conducted by Vander Ploeg et al. (2013) examined the parental beliefs and support for PA for their children's PA engagement on school days and weekend-days. The participants consisted of 1,573 fifth grade students. In order to measure parental beliefs and support, three validated questions that were adapted from the activity-related parenting practices scale were used. PA of the children was assessed using pedometers and they were worn for nine consecutive days. The results from this study showed that parents encouraged boys to be more active significantly more than girls (Vander Ploeg et al., 2013). For girls, parental encouragement and participation in PA were significantly and positively associated with girls' steps per day on school days. In addition, when parents said they encouraged PA, those girls took an additional 632 steps per day. Parents who participated with their daughters more frequently resulted in a further increase in steps per day. On weekends, the only positive association with girls' daily step counts that was statistically significant was parental encouragement of PA. Concerning boys, increased parental encouragement of PA was associated with daily step counts on weekends. On weekends, parents who perceived their physical fitness as important resulted in a positive association with boys' daily step counts. In addition, decreased parental engagement in PA was negatively associated with the daily step counts of boys (Vander Ploeg et al., 2013). This demonstrates that when parents encourage their children to be physically active, these children could be more likely to participate in PA. The differences in encouragement between boys and girls could be one of the reasons for the differences between PA levels. Colley et al. (2011b) reported that nine percent of boys, and four percent of girls are achieving the PA guidelines; therefore, since parents encouraged their sons more than their daughters to be physically active, this could partially explain differences of PA engagement.

Physical Activity of Adults

The Canadian guidelines for PA levels in adulthood recommends that adults ages 20 to 55 years should achieve a minimum of 150 minutes of MVPA per week in bouts of ten minutes or more (Colley et al., 2011a). In addition, a dose-response relationship exists for adults between PA and its health benefits, with the greatest benefits seen in adults who become more physically active (Warburton et al., 2010). Colley et al. (2011a) examined PA of Canadian adults aged 20 to 79 years; data were analyzed from the 2007 to 2009 CHMS survey, and PA was measured using accelerometers. The results showed that men and women participate in approximately four hours of light PA per day. In addition, men participated in more MVPA compared to women between the ages of 20 and 39 years. Lastly, only 15 percent of adults were able to accumulate 150 minutes of MVPA per week in ten minute bouts, with an additional five percent achieving bouts of 30 minutes on at least five days per week. In addition, 47 percent of adults are not achieving 30 minutes of MVPA at least one day per week (Colley et al., 2011a). Since adults are not achieving the recommended PA guidelines, creative interventions and/or opportunities are needed.

In 1997, the Canadian and provincial governments created a PA monitoring program, called the Canada Fitness Survey with the hopes of reducing physical inactivity. In order to measure the trends of PA levels in Canada, Craig, Russell, Cameron, and Bauman (2004) analyzed the data collected over a 20 year period from 1981 until 2000 from the Canada Fitness Survey. Each survey had used an adaptation of the Minnesota Leisure-Time Physical Activity Questionnaire. PA was calculated using metabolic equivalent-hours (MET-hours) per week. The results of this study showed that PA levels had a significant increase for adults from the 1980s to the 1990s (Craig et al., 2004). Specifically, adults were 1.6 times more likely to be sufficiently active in 1988 compared to 1981, and 1.2 times likely to be more active in 2000 compared to 1995 (Craig et al., 2004). In addition, a significant change occurred with an increase in the median PA score and a decrease in participants reporting that they did not participate in PA (Craig et al., 2004). Interestingly, sex differences showed that men became more active from 1995 to 2000; however, there was no change for women during this time period (Craig et al., 2004). This demonstrates that PA in Canadian adults has improved from 1981 to 2000; however, this differs from findings by Colley et al. (2011a) which reported that only five percent of Canadian adults were able to achieve 30 minutes of MVPA five days per week. If parents are achieving the recommended PA guidelines, then this might influence their children to also be physically active. More efforts are needed in order to further promote PA in adults.

Fundamental Motor Skills

Fundamental motor skills are the basic movements that are required to perform more complex skills later on in life and may be the only modifiable barrier to PA engagement (Lubans et al., 2010). These skills are developed in childhood and often evolve as children age and include skills such as locomotor, object control and stability skills (Lubans et al., 2010). In order to have proficient motor skills, children must be given the opportunity to practice and refine their skills (Lubans et al., 2010). Evidence has established that children who are proficient in their FMS become more physically active compared to those with poor FMS (Robinson, 2011). How children perceive their motor skill proficiency can also impact their PA levels, where those who feel that they are more physically competent are generally more physically active (Hay & Missiuna, 1998; Robinson, 2011). Additionally, children with low motor proficiency have been found to have higher rates of obesity (Cliff et al., 2012), lower ability to perform activities of daily living (ADL) (Summers, Larkin, & Dewey, 2008; Van der Linde et al., 2015), and both poorer academic performance (Henderson & Hall, 1982; Pagani, Fitzpatrick, Archambault, & Janosz, 2010), and social skills (Campbell, Missiuna, & Vaillancourt, 2012; Sylvestre, Nadeau, Charron, Larose, & Lepage, 2013). The importance of FMS in childhood stretches beyond just mere motor competence, as its effect impacts many different aspects of child development.

Importance of FMS for PA in Childhood

A systematic review conducted by Lubans et al. (2010) examined the psychological, physiological and behavioural health benefits that are associated with FMS competency in children. This review found strong evidence from cross-sectional studies that reported positive associations between competency in FMS and PA in children (Lubans et al., 2010). In addition to the association between competency of FMS and PA, this review also noted the association between FMS competency and physical fitness with those who have higher FMS. Lastly, an inverse relationship was detected between FMS proficiency and weight status (Lubans et al., 2010). Understanding the relationship between FMS and PA in children is important to design feasible interventions for those who are not proficient in their motor skills.

Children need opportunities to practice their motor skills, and often receive these opportunities through physical education classes (Marshall & Bouffard, 1997). Marshall and Bouffard (1997) examined the benefits of regular PA that is provided through a school setting and its importance in the development of movement proficiency. This study recruited 100 participants with obesity, as well as 100 age and sex matched nonobese participants to serve as the control group. Two different age groups were used for this study with children being between the ages of five and six years of age (n=118), as well as nine to ten years of age (n=82). It was also noted if the participants participated in Quality Daily Physical Education (QDPE) programs. After all participants were categorized, the TGMD was used to assess the FMS of the participants. The results from this study showed that nonobese males were significantly more competent in their FMS than nonobese females that did not participate in this program (Marshall & Bouffard, 1997). Nonobese females in QDPE programs also had higher FMS proficiency compared to non-obese females who did not participate in PE programs. Lastly, obese males in QDPE programs had more proficient FMS than obese males in non-QDPE programs (Marshall & Bouffard, 1997). This study demonstrates that when given the opportunity to practice their motor skills through programs such as a physical education, children have the capability to be more proficient in their motor skills.

Those with movement difficulties often avoid participation in PA due to a negative cycle of incompetence, and loss of self-confidence due to a history of failure and negative experiences concerning their motor competence (Bouffard, Watkinson, Thompson, Dunn, & Romanow, 1996). Bouffard et al. (1996) investigated if children with movement impairments experienced an activity deficit compared to children without movement impairment during recess. The study recruited 26 children with movement impairments, as well as 26 children without movement impairments. The observations took place on school playgrounds during recess and behaviours were observed and recorded in ten second intervals for a total of 45 observations being conducted for each participant. The results showed that children with movement impairments participated in less vigorous activity compared to the control group (Bouffard et al., 1996). Since these children with poor motor skill proficiency engaged in less vigorous PA, this supports the activity deficit hypothesis, as they avoided PA due to their poor motor skills. In addition, this study provides further evidence to support that children with motor impairments participate in less PA, and that they continued to withdraw from PA (Bouffard et al., 1996).

A cross-sectional study conducted by Barnett et al. (2009) examined the relationship between motor skill proficiency in childhood and PA behaviour in adolescence. The participants consisted of 1048 children aged 14 to 18 years. The "Get Skilled Get Active" was used to assess the motor skills of the students, whereas, the Adolescence PA Recall Questionnaire was used to assess PA participation. The results of this study showed that object control proficiency in childhood was significantly associated with time in MVPA in adolescence (Barnett et al., 2009). In addition, those with more proficient object control skills have at least a 20 percent greater chance of participating in vigorous activity compared to those with poor object control skills. High object control proficiency may be an essential aspect of PA promotion because these skills often translate into sport settings (Barnett et al., 2009). For example, children who are proficient with kicking may adapt to playing soccer at an easier rate compared to those with poor kicking skills.

A study conducted by Lloyd et al. (2014) investigated the potential long-term association of motor skills at age six and self-reported PA at age 26. This study was a longitudinal cohort beginning in 1991 with 699 six year old, first-grade children. All children were administered the Test of Gross Motor Development (TGMD) and screened into two groups: A low motor proficiency (LMP) group and a high motor proficiency group (HMP). At the 20 year follow up, six individuals from the original LMP group and 11 individuals from the original HMP group participated. PA was measured using the International Physical Activity Questionnaire and the Developmental Coordination Disorder Questionnaire for Adults (DCDQ-A) was used for both groups. The DCDQ-A was used to determine if the participants from the original LMP group were still experiencing difficulties with motor proficiency as adults. For the HMP group, the DCDQ-A was administered to determine if these participants still had proficient motor skills. The results showed that there were significant positive correlations between motor skill proficiency at age six and perceived motor competence at age 16 (Lloyd et al., 2014). In addition, perceived motor competence at age 16 was positively associated with perceived motor competence at age 26. The findings from this study suggest that motor proficiency during childhood will predict the level of motor proficiency as an adult. This is a key piece of information because children who are at risk for low motor proficiency should be identified and targeted for interventions.

The quality of balance may also play a role in how well children are able to execute their motor skills (Hammami, Chaouachi, Makhlouf, Granacher, & Behm, 2016). Hammami et al. (2016) assessed the association between dynamic balance with complex, physical fitness measures in 130 children between the ages of 10 and 16 years. These measures included the Y-Balance Test (YBT), to measure dynamic balance, horizontal jump, and the countermovement jump. The results of this study indicated that the YBT was the best predictor that could explain muscle strength. Since balance is a component of fundamental motor skills, it still has a role to play in developing more complex skills. Therefore, it is important that children have adequate balance to promote the development of their motor skills.

FMS are an important aspect of child development as evidence indicates that children who lack proficient FMS generally have poor PA levels (Lubans et al., 2010). In addition, this may trigger a negative cycle as children who feel that they lack the necessary motor skills often refrain from PA due to their motor incompetence (Bouffard et al., 1996). This negative cycle may be influencing the physical inactivity patterns that are seen in Canadian children today. Lastly, FMS patterns in childhood have been documented to track into adulthood (Lloyd et al., 2014); therefore, adequate FMS development in childhood is important to promote high motor proficiency in adulthood. Since FMS plays such a large role in PA behaviours, it is essential that children become proficient in these skills, especially as they become adults.

Perceived Competence of FMS and PA in Children

How children perceive their motor skills is associated with PA participation (Robinson, 2011). If children believe that they are competent in their motor skills, this can lead to increased engagement in PA. In contrast, children with lower perceived competence may become discouraged during PA due to their inability to perform FMS correctly and efficiently, resulting in them no longer engaging in PA (Bouffard et al., 1996; Robinson, 2011). A study conducted by Robinson (2011) examined the relationship between perceived physical competence and FMS in preschool-age children. The participants consisted of 54 girls and 65 boys; with four years being the mean age. Each participant was measured using the TGMD-2 and the Pictorial Scale or Perceived Competence and Social Acceptance. The results of this study showed that there was a significant correlation between motor proficiency and perceived motor competence (Robinson, 2011). Between boys and girls, boys demonstrated more proficient motor skills and higher perceived physical competence compared to girls (Robinson, 2011). Children who felt that they were more proficient in their motor competence are more likely to have higher motor skill development. If children perceive themselves to be proficient in their motor competence, this could increase engagement in activities that both develop skill and are physically active.

Hay and Missiuna (1998) examined 48 children, between the ages of 9 and 13, who reported low self-perception about PA participation. To measure children's self-perceptions of their competence while performing PA, as well as their desire to participate in PA, the Children's Self-Perceptions of Adequacy in and Predilection for Physical Activity Scale (CSAPPA) was used. The Bruininks-Oseretsky Test of Motor Proficiency (BOTMP) was used to measure motor proficiency. In addition to these two assessment tools, a Participation Questionnaire for the participants and a Teacher Evaluation for the physical education teachers were also included. Those who scored the lowest five percent on the CSAPPA were screened into the Low group; whereas, the top five percent were screened into the High group. Those who scored in between the two cut-off points were in the Middle group. The results from the teacher observations stated that children with poor motor skills were less likely to have competent participation in PA, and enjoyed PA less compared to their peers (Hay & Missiuna, 1998). In addition, a moderate correlation was found between the CSAPPA score and the BOTMP (Hay & Missiuna, 1998). This indicates that perceived motor competence is related to motor performance and can predict participation in PA. Children who demonstrated poor perceptions of the motor abilities were less likely to be proficient in their motor skills and physically active. Therefore, understanding how children perceive their motor competence is an important factor that can impact their FMS, and in turn, their PA levels.

Fundamental Motor Skills in Adults

Many children who displayed significant motor difficulties in childhood often still display difficulties as they get older, which demonstrates a potential longitudinal effect of motor skill development (Cousins & Smyth, 2003). Cousins and Smyth (2003) investigated poor motor proficiency into adulthood. The participants consisted of 19 adults between the ages of 18 and 65 who had either received the diagnosis of having poor motor skills or who self-reported to have poor motor skills. In addition, a control group of 19 participants, without movement difficulties, was included. Motor tasks were selected based off the three-subscales of the Movement Assessment Battery for Children (M-ABC). In addition, the participants also competed a questionnaire to indicate their abilities within different areas of motor development. The results of this study showed that the experimental group was slower than the control group when performing the simple block construction tasks, and the dynamic balance tasks. In addition, the experimental group scored significantly less hits during the ball skills task, and had a worse performance for the clap-and-catch tasks. This study demonstrates that adults can demonstrate motor impairments that are also seen in children. In addition, as children age and become adults these motor impairment do not always disappear and can still be a prevalent aspect of their lives (Cousins & Smyth, 2003).

In order to further understand adults with poor motor skills, Fitzpatrick and Watkinson (2003) conducted a qualitative study to assess the lived-experiences of adults with physical awkwardness. The participants consisted of 12 adults between the ages of 30 to 70 years and all identified as having physical awkwardness. Six participants provided two full interviews; whereas, the remaining six were interviewed once, for a total of 18 interviews. Prior to the interviews taking place, the participants were then asked to complete a writing task to recall the past incidences of awkwardness during PA. The participants were then asked to retell their stories during the interviews for the researcher to prompt for further conversation. The themes that have been identified were the frequency of failing, humiliation, reflecting on physically awkward performances and the reactions from their peers, and avoiding awkwardness (Fitzpatrick & Watkinson, 2003). For individuals who experience failure during PA, they often become discouraged and later no longer attempt to complete the complex motor task (Fitzpatrick & Watkinson, 2003). Adults with physical awkwardness may often feel humiliated due to their performance, and these feelings are often reinforced by interactions with peers. Individuals would often refrain from PA to avoid the ridicule and humiliation that their peers would inflict upon them (Fitzpatrick & Watkinson, 2003). Following PA, these individuals would often reflect and worry about their performance, often in a pessimistic manner (Fitzpatrick & Watkinson, 2003). Finally, individuals with physical awkwardness often avoided PA all together in fear of awkward motor proficiency and to reduce the risk of displaying their awkwardness (Fitzpatrick & Watkinson, 2003); therefore, their PA engagement is likely low.

How adults perceive their motor proficiency can have an impact on their ability to be physically active (Fitzpatrick & Watkinson, 2003). For adults who demonstrate poor FMS, developing interventions could help to promote the FMS acquisition. In addition, if any adults, who consider themselves to physically awkward and have poor motor skills, become parents, they could be negatively influencing the PA behaviours of their children (Craig et al., 2013). Therefore, intervening on adults with poor motor skills could help promote FMS development in both them as well as their children.

Conclusion

In conclusion, there is a lack of research surrounding parent motor skill proficiency as well as how it relates to motor skill proficiency in their children. This literature review clearly outlined the association between parent and child PA; however, very little research could be found on adult motor skills and how it relates to the motor skills of children. In addition, the development of poor motor skills can lead to negative consequences such as poor PA levels (Barnett et al., 2009), and obesity (Southall, Okely, & Steele, 2004). Barriers of PA can also impact both children (O'Dea, 2003) and their parents (Mailey, Huberty, Dinkel, & McAuley, 2014). Internal barriers such as motivation or how children perceive PA (Protudjer, Marchessault, Kozyrskyj, & Becker, 2010), or external barriers such as socioeconomic status (Vermeesch et al., 2015) can influence PA engagement of children and their parents. In addition, children often cited that the lack of skill prevented them from being physically active (Vermeesch et al., 2015). Therefore, further research should be conducted on the parent-child relationship between PA and motor skill proficiency to help identify the issues that may present, as well as to design future interventions to target children and adults with poor motor skills and increase their both their overall motor skill proficiency and PA levels.

References

Aaltonen, S., Latvala, A., Rose, R. J., Pulkkinen, L. E. A., Kujala, U. M., Kaprio, J., & Silventoinen, K. (2015). Motor Development and Physical Activity: A Longitudinal Discordant Twin-Pair Study. *Medicine & Science in Sports & Exercise, 47*(10), 2111-2118. doi:10.1249/MSS.0000000000000650

Barnett, L. M., van Beurden, E., Morgan, P. J., Brooks, L. O., & Beard, J. R. (2009). Childhood Motor Skill Proficiency as a Predictor of Adolescent Physical Activity. *Journal of Adolescent Health, 44*(3), 252-259. doi:http://dx.doi.org/10.1016/j.jadohealth.2008.07.004

Biddle, S., & Goudas, M. (1996). Analysis of children's physical activity and its association with adult encouragement and social cognitive variables. *The Journal of School Health, 66*(2), 75.

Borkhoff, C. M., Heale, L. D., Anderson, L. N., Tremblay, M. S., Maguire, J. L., Parkin, P. C., & Birken, C. S. (2015). Objectively measured physical activity of young Canadian children using accelerometry. *Applied Physiology, Nutrition, and Metabolism, 40*(12), 1302-1308. doi:10.1139/apnm-2015-0164

Bouffard, M., Watkinson, E. J., Thompson, L. P., Dunn, J. L. C., & Romanow, S. K. E. (1996). A Test of the Activity Deficit Hypothesis With Children With Movement Difficulties. *Adapted Physical Activity Quarterly, 13*(1), 61-73.

Campbell, W. N., Missiuna, C., & Vaillancourt, T. (2012). Peer victimization and depression in children with and without motor coordination difficulties. *Psychology in the Schools, 49*(4), 328-341. doi:10.1002/pits.21600

Cliff, D. P., Okely, A. D., Morgan, P. J., Jones, R. A., Steele, J. R., & Baur, L. A. (2012). Proficiency Deficiency: Mastery of Fundamental Movement Skills and Skill Components in Overweight and Obese Children. *Obesity, 20*(5), 1024-1033. doi:10.1038/oby.2011.241

Colley, R. C., Garriguet, D., Janssen, I., Craig, C. L., Clarke, J., & Tremblay, M. S. (2011a). Physical activity of Canadian adults: Accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. *Health Reports, 22*(1), 7-14. doi:10.1139/h07-130

Colley, R. C., Garriguet, D., Janssen, I., Craig, C. L., Clarke, J., & Tremblay, M. S. (2011b). Physical activity of Canadian children and youth: Accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. *Health Reports, 22*(1), 15-23.

Cousins, M., & Smyth, M. M. (2003). Developmental coordination impairments in adulthood. *Human Movement Science, 22*(4–5), 433-459. doi:http://dx.doi.org/10.1016/j.humov.2003.09.003

Craig, C. L., Cameron, C., & Tudor-Locke, C. (2013). Relationship between parent and child pedometer-determined physical activity: a sub-study of the CANPLAY surveillance study. *The International Journal of Behavioral Nutrition and Physical Activity, 10*, 8.

Craig, C. L., Russell, S. J., Cameron, C., & Bauman, A. (2004). Twenty-year Trends in Physical Activity Among Canadian Adults. *Canadian Journal of Public Health, 95*(1), 59-63.

Fitzpatrick, D. A., & Watkinson, E. J. (2003). The Lived Experience of Physical Awkwardness: Adult's Retrospective Views. *Adapted Physical Activity Quarterly, 20*(3), 279.

Fuemmeler, B. F., Anderson, C. B., & Masse, L. C. (2011). Parent-child relationship of directly measured physical activity. *The International Journal of Behavioral Nutrition and Physical Activity, 8*, 17.

Hammami, R., Chaouachi, A., Makhlouf, I., Granacher, U., & Behm, D. G. (2016). Associations Between Balance and Muscle Strength, Power Performance in Male Youth Athletes of Different Maturity Status. *Pediatric Exercise Science, 28*(4), 521-534.

Hay, J., & Missiuna, C. (1998). Motor proficiency in children reporting low levels of participation in physical activity. *Canadian Journal of Occupational Therapy, 65*, 64+.

Henderson, S. E., & Hall, D. (1982). Concomitants of clumsiness in young schoolchildren. *Developmental Medicine & Child Neurology, 24*(5), 448-460. doi:10.1111/j.1469-8749.1982.tb13649.x

Jago, R., Fox, K. R., Page, A. S., Brockman, R., & Thompson, J. L. (2010). Parent and child physical activity and sedentary time: Do active parents foster active children? *BMC Public Health, 10*, 194. doi:10.1186/1471-2458-10-194

Jago, R., Sebire, S. J., Wood, L., Pool, L., Zahra, J., Thompson, J. L., & Lawlor, D. A. (2014). Associations between objectively assessed child and parental physical activity: a cross-sectional study of families with 5-6 year old children. *BMC Public Health, 14*, 655. doi:10.1186/1471-2458-14-655

Kambas, A., Michalopoulou, M., Fatouros, I. G., Christoforidis, C., Manthou, E., Giannakidou, D., . . . Zimmer, R. (2012). The relationship between motor proficiency and pedometer-determined physical activity in young children. *Pediatric Exercise Science, 24*(1), 34-44.

Ling, J., Robbins, L., & Hines-Martin, V. (2016). Perceived parental barriers to and strategies for supporting physical activity and healthy eating among Head Start children. *Journal of Community Health, 41*(3), 593-602. doi:10.1007/s10900-015-0134-x

Lloyd, M., Saunders, T. J., Bremer, E., & Tremblay, M. S. (2014). Long-term importance of fundamental motor skills: A 20-Year follow-up study. *Adapted Physical Activity Quarterly, 31*(1), 67-78.

Lubans, D., Morgan, P., Cliff, D., Barnett, L., & Okely, A. (2010). Fundamental movement skills in children and adolescents. *Sports Medicine, 40*(12), 1019-1035. doi:10.2165/11536850-000000000-00000

Mailey, E. L., Huberty, J., Dinkel, D., & McAuley, E. (2014). Physical activity barriers and facilitators among working mothers and fathers. *BMC Public Health, 14*(1), 657-657 651p. doi:10.1186/1471-2458-14-657

Marshall, J. D., & Bouffard, M. (1997). The effects of quality daily physical education on movement competency in obese versue nonobese. *Adapted Physical Activity Quarterly, 14*(3), 222-237.

O'Dea, J. A. (2003). Why do kids eat healthful food? Perceived benefits of and barriers to healthful eating and physical activity among children and adolescents. *Journal of the American Dietetic Association, 103*(4), 497-501. doi:http://dx.doi.org/10.1016/S0002-8223(03)00013-0

Pagani, L. S., Fitzpatrick, C., Archambault, I., & Janosz, M. (2010). School readiness and later achievement: A French Canadian replication and extension. *Developmental Psychology, 46*(5), 984. doi:0.1037/a0018881

Protudjer, J. L. P., Marchessault, G., Kozyrskyj, A. L., & Becker, A. B. (2010). Children's perceptions of healthful eating and physical activity. *Canadian Journal of Dietetic Practice & Research, 71*(1), 19-23 15p. doi:10.3148/71.1.2010.19

Rhodes, R. E., & Pfaeffli, L. A. (2010). Mediators of physical activity behaviour change among adult non-clinical populations: A review update. *The International Journal of Behavioral Nutrition and Physical Activity, 7*, 37. doi:10.1186/1479-5868-7-37

Rintala, P., Välimaa, R., Tynjälä, J., Boyce, W., King, M., Villberg, J., & Kannas, L. (2011). Physical activity of children with and without long-term illness or disability. *Journal of Physical Activity & Health, 8*(8), 1066-1073.

Robinson, L. E. (2011). The relationship between perceived physical competence and fundamental motor skills in preschool children. *Child: Care, Health and Development, 37*(4), 589-596. doi:10.1111/j.1365-2214.2010.01187.x

Sigmundová, D., Sigmund, E., Vokácová, J., & Kopcáková, J. (2014). Parent-child associations in pedometer-determined physical activity and sedentary behaviour on weekdays and weekends in random samples of families in the Czech Republic. *International Journal of Environmental Research and Public Health, 11*(7), 7163-7181.

Southall, J. E., Okely, A. D., & Steele, J. R. (2004). Actual and perceived physical competence in overweight and nonoverweight children. *Pediatric Exercise Science, 16*(1), 15-24.

Summers, J., Larkin, D., & Dewey, D. (2008). Activities of daily living in children with developmental coordination disorder: Dressing, personal hygiene, and eating skills. *Human Movement Science, 27*(2), 215-229. doi:http://dx.doi.org/10.1016/j.humov.2008.02.002

Sylvestre, A., Nadeau, L., Charron, L., Larose, N., & Lepage, C. (2013). Social participation by children with developmental coordination disorder compared to their peers. *Disability & Rehabilitation, 35*(21), 1814-1820 1817p. doi:10.3109/09638288.2012.756943

Tremblay, M. S., LeBlanc, A. G., Carson, V., Choquette, L., Connor Gorber, S., Dillman, C., . . . Timmons, B. W. (2012). Canadian physical activity guidelines for the early years (aged 0–4 years). *Applied Physiology, Nutrition, and Metabolism, 37*(2), 345-356. doi:10.1139/h2012-018

Tremblay, M. S., Warburton, D. E. R., Janssen, I., Paterson, D. H., Latimer, A. E., Rhodes, R. E., . . . Duggan, M. (2011). New Canadian physical activity guidelines. *Applied Physiology, Nutrition & Metabolism, 36*(1), 36-46. doi:10.1139/H11-009

Van der Linde, B. W., van Netten, J. J., Otten, B., Postema, K., Geuze, R. H., & Schoemaker, M. M. (2015). Activities of daily living in children with developmental coordination disorder: Performance, learning, and participation. *Physical Therapy, 95*(11), 1496-1506 1411p. doi:10.2522/ptj.20140211

Vander Ploeg, K. A., Biao, W., McGavock, J., & Veugelers, P. J. (2012). Physical activity among Canadian children on school days and nonschool days. *Journal of Physical Activity & Health, 9*(8), 1138-1145.

Vander Ploeg, K. A., Kuhle, S., Maximova, K., McGavock, J., Wu, B., & Veugelers, P. J. (2013). The importance of parental beliefs and support for pedometer-measured physical activity on school days and weekend days among Canadian children. *BMC Public Health, 13*, 1132. doi:10.1186/1471-2458-13-1132

Vermeesch, A. L., Jiying, L., Voskuil, V. R., Bakhoya, M., Wesolek, S. M., Bourne, K. A., . . . Robbins, L. B. (2015). Biological and sociocultural differences in perceived barriers to physical activity among fifth- to seventh-grade urban girls. *Nursing Research, 64*(5), 342-350 349p. doi:10.1097/NNR.0000000000000113

Warburton, D. E. R., Charlesworth, S., Ivey, A., Nettlefold, L., & Bredin, S. S. D. (2010). A systematic review of the evidence for Canada's Physical Activity Guidelines for Adults. *The International Journal of Behavioral Nutrition and Physical Activity, 7*, 39. doi:10.1186/1479-5868-7-39

CHAPTER 3: MANUSCRIPT 1

Abstract

Fundamental motor skills (FMS) are the rudimentary skills that lead into more complex skills in children. The purpose of this study was to examine the mother-child relationship between motor skills. Furthermore, secondary research questions investigated if perceived motor competence is related to actual motor competence in children and mothers. Motor skills in children were assessed using the Test of Gross Motor Development – 2 (TGMD-2) and the Developmental Coordination Disorder Questionnaire (DCDQ). Both the mothers and the children had their dynamic balance assessed using the Y-Balance Test Lower Quadrant (YBT). To assess perceived motor competence the Pictorial Scale of Perceived Movement Skill Competence (PSPM) was used for the children, whereas, the mothers used the Adult Developmental Coordination Disorder Questionnaire/Dyspraxia Checklist (ADC) and the Developmental Coordination Disorder Questionnaire for Adults (DCDQ-A). The results of this study showed that mother YBT reach percentages were related to the TGMD-2 scores of the children when boys and girls were analyzed separately. In addition, PSPM scores were not related to TGMD-2 scores for the children, and neither the ADC nor the DCDQ-A were related to the mother's YBT reach percentages. In conclusion, the result of this study indicate that although mothers may or may not have proficient motor skills, they could still provide opportunity and access to their children in order for them to practice and master their FMS.

Introduction

Fundamental motor skills in childhood

Fundamental motor skills (FMS) are the basic movements that lead to more complex skills required for both structured and unstructured physical activities (Barnett et al., 2009; Lloyd et al., 2014; Lubans et al., 2010). Motor skills are usually refined through practice in childhood (Barnett et al., 2009); moreover, the level of motor proficiency demonstrated in childhood often continues into adulthood (Lloyd et al., 2014). Fundamental motor skills consist of the locomotor, body management and object control domains (Barnett et al., 2009). Locomotor skills include movements such as running, and hopping whereas, body management skills includes movements like balancing, and object control skills focus on the manipulation of an object, including movements such as throwing and kicking (Lubans et al., 2010).

Research suggests that children who practice their FMS are able to become more proficient at these skills (Lubans et al., 2010), and that boys often have more proficient FMS compared to girls (Kokštejn, Psotta, & Musálek, 2015). Children with proficient motor skills may demonstrate success in other areas of development, such as academic performance (Jaakkola, Hillman, Kalaja, & Liukkonen, 2015), activities of daily living (Summers et al., 2008), and lowering the risk of becoming overweight or obese (Cairney, Hay, Faught, & Hawes, 2005). Therefore, it is important to provide time for children to master their FMS. Children can be encouraged to practice their FMS by various mediators such as parental encouragement, opportunity to practice, and access to the appropriate facilities. Furthermore, the development of FMS is not promoted solely from a biological standpoint; FMS need to be nurtured through practice (Hardy, Reinten-Reynolds, Espinel, Zask, & Okely, 2012). Research suggests that parents can promote participation in many areas of their children's development such as their participation in sport (Sukys, Majauskienė, Cesnaitiene, & Karanauskiene, 2014), PA and sedentary behaviours (Hamilton, Hatzis, Kavanagh, & White, 2014), and musical talent (Pitt & Hargreaves, 2016). This suggests that parents can have an influence over their child's behaviours in multiple domains. For this reason, parents could also influence their child's motor proficiency; however, this relationship has not yet been established. Moreover, due to the differences in motor proficiency between boys and girls, parental influence can impact the motor competence of boys and girls to various degrees; therefore, research should also focus on the parent-child relationship for motor proficiency between boys and girls.

Motor skills have been known to track into adulthood; hence, understanding the factors that promote and inhibit motor skill development throughout the lifespan is essential to understand the motor patterns of children as they age. Research by Lloyd et al. (2014) examined the long-term pattern of motor skill proficiency and self-reported PA and found that the motor skills of six year old children were significantly correlated with their perceived motor skill proficiency as a teenager. In addition, the perceived motor skills of teenagers was positively associated with their perceived motor skill proficiency at age 26. The results suggest that motor skill proficiency in childhood is an important factor that predicts perceived motor skill proficiency in adolescence as well as in adulthood, and that children with high motor skill proficiency at age six had a positive association with self-reported PA at age 26 (Lloyd et al., 2014). Adults with lower motor proficiency may avoid situations where they are able to practice their FMS, and as a result, potentially limit the opportunity for themselves and even their future children to engage in activities that promote FMS. Motor skill proficiency could predict PA patterns later on in life, and as a result motor skill development should be promoted in children.

Fundamental Motor Skills in Adulthood

Changes in motor proficiency stretch beyond childhood and adolescence, reaching well into adulthood; with the focus of research shifting to decreases or declines in motor proficiency in adulthood (Gallahue, Ozmun, & Goodway, 2012). Research often focuses on the motor proficiency of children and older adults, and often neglects the healthy adult population. The literature suggests that motor skill patterns that are demonstrated in childhood can also be seen into adulthood (i.e., if you had proficient motor skills as a child you are likely to have proficient motor skills as an adult) (Lloyd et al., 2014). In older adults, the focus is often on balance, postural sway, gait patterns, driving and activities of daily living as these skills can often can impact quality of life in the older population (Gallahue et al., 2012). However, having lower motor proficiency for these skills may not impact younger adults to such a great extent and other skills may be more relevant to PA and physical fitness in younger adults (Gallahue et al., 2012). Therefore, it is important to understand the factors that influence motor proficiency in healthy adults, including parents, because it could have further implications on the health outcomes of their children, including their FMS proficiency.

FMS proficiency is important for the participation in many activities across all age spans, and these activities (e.g., sports) often require high levels of muscular and cardiorespiratory endurance (Stodden, Langendorfer, & Roberton, 2009). Stodden et al. (2009) evaluated three FMS and their relationship with physical fitness in 188 individuals between the ages of 18 and 25 years. They measured motor skills by evaluating the maximum throw and kicking speed, and maximum jumping distance. The results indicated that motor skill product scores were related to five of the six fitness measures. This suggests that adults who are more proficient have higher levels of physical fitness. Physical fitness is related to overall health, therefore FMS may be an important mediator and should be studied further in the adult population. In addition, the amount of regular exercise parents participate in has been associated with the exercise participation of their children (Sukys et al., 2014); therefore, due to the relationship between parent FMS and physical fitness, parent FMS may also be a predictor of child FMS.

Adults can also experience low motor proficiency, with these patterns originating in childhood and continuing into adulthood (Lloyd et al., 2014). Cousins and Smyth (2003) examined the motor skills of 38 adults between the ages of 18 and 65 years. From the total sample, 19 participants were identified as having low motor proficiency and placed into the experimental group; whereas, 19 age-matched participants with typical development were placed into the control group. The results showed that participants with low motor proficiency took longer to perform the balance task compared to the control group and had significantly lower ball skills. This study demonstrates the poor motor skills experienced by some children can track into adulthood. Furthermore, if these adults are unable to become proficient at the motor skills as they age through practice, this could negatively impact the motor proficiency of their children.

Perceived and Actual Motor Competence in Children

Perceived motor competence is defined as the feelings that one has about his or her success at completing a movement (Gallahue et al., 2012). It has been suggested that perceived motor competence can impact motor skill proficiency in children where children who believe they are proficient at a certain skill may feel more competent as they perform that particular skill (Robinson, 2011); therefore, they may be more inclined to participate in that skill or activity. Robinson (2011) investigated the relationship between perceived motor competence and fundamental motor skills in preschool-age children. A total of 119 children with a mean age of four years, including 54 girls and 65 boys, were recruited for the study. Motor skills were measured using the Test of Gross Motor Development – 2 (TGMD-2); perceived motor competence was measured using the Pictorial Scale of Perceived Competence and Social Acceptance. The results of this study found a moderate, significant correlation between perceived motor competence and motor skill proficiency, demonstrating that motor competence was related to motor skill proficiency in pre-school age children. If children perceive themselves as having proficient motor skills, they may be more internally motivated, to participate in activities that promote these skills.

Crane, Naylor, Cook, and Temple (2015) assessed the relationship between motor competence and motor skill proficiency in kindergarten-age children. The participants consisted of 116 children with a mean age of five years. Fundamental motor skills were assessed using the TGMD-2; perceived motor competence was measured using the Pictorial Scale of Perceived Competence and Social Acceptance for Young Children, and only the physical competence subtest was used for the analysis. The results from this study suggested perceived motor competence was a significant mediating variable that could predict object control skills (Crane et al., 2015); this highlights how children feel about their motor ability and how it relates their motor skills. Due to their higher levels of perceived motor competence, the children in this study had better object control skills.

Previous literature suggests that perceived motor competence is related to actual motor competence in children (Crane et al., 2015; Hay & Missiuna, 1998; Robinson, 2011); however, gaps in the literature still prevail. Some studies often use tools, that assess perceived motor competence, that include general coordination skills, or fine motor skills, that are in addition to gross motor skills. Tools that focus on all aspects of motor proficiency (e.g., general motor coordination, fine motor skills, and gross motor skills) may not be able to look at specific FMS; therefore, it is important to utilize a perceived motor competence tool that consists of the same tools as the TGMD-2. Having knowledge of how well children perceive their motor skills can help researchers understand that children with higher perceived motor competence could be encouraged to participate more in activities that promote FMS.

Perceived Motor Competence of Adults and Fundamental Motor Skills

Research suggests that perceived motor competence influences motor proficiency in children (Crane et al., 2015; Robinson, 2011), and that levels of motor proficiency that are seen in childhood are often displayed in adulthood (Lloyd et al., 2014). Due to the impact that perceived motor competence has on motor proficiency in children, perceived motor competence could be an important factor that predicts motor proficiency in adulthood. Fitzpatrick and Watkinson (2003) examined the lived experiences of 12 adults who identify with physical awkwardness by conducting 18 semi-structured interviews. The results identified several themes such as failing and falling, hurt and embarrassment, worry and wondering, and avoiding awkwardness. Participants perceived themselves to have a lack of confidence about their motor abilities. Due to this lack of confidence, participants often felt embarrassed when performing physical activities; therefore, they would become uncomfortable and regret participating in that activity. Lastly, due to their clumsy behaviours, the participants often avoided activities that highlighted their physical awkwardness. If these adults have children of their own, their own avoidance of PA may result in their children not having the opportunity to participate in PA (Craig et al., 2013); hence, children may not have the opportunity to practice their FMS. This demonstrates that how well adults perceived their motor skills can affect their participation in certain activities and if these individuals continue to avoid opportunities to practice their FMS, their ability to master these skills will be limited. Therefore, how well adults perceive their ability to move is an important aspect to consider when measuring their motor ability.

Summary

A considerable amount of literature has been published on their importance FMS in children (Bouffard et al., 1996; Lloyd et al., 2014; Lubans et al., 2010); suggesting that children who have lower motor proficiency in childhood may display these characteristics in adulthood (Lloyd et al., 2014). In addition, studies suggest that physical activity of mothers is related to their children's PA (Craig et al., 2013); however, it is not yet known if mother motor proficiency is related to their children's motor proficiency. People that display low motor proficiency into adulthood could consequently impact their own child's motor competence or vice versa. There are currently no known studies that measure the parent-child relationship on motor skills. Studies on the relationship between mother and child motor skill proficiency could address a considerable gap in the literature to design future family-based interventions.

Purpose

The purpose of this study was to investigate the relationship between mother and child motor skill proficiency. In addition, the relationship between children and mothers' perceived motor competence and their actual motor skill proficiency was measured, separately. The following questions were examined during this study:

1. Are the fundamental motor skills of mothers related to fundamental motor skills of children?
2. Is perceived motor competence related to actual motor competence in children?
3. Is perceived motor competence related to actual motor competence in the mothers?

Methods

Study Design

Ethical approval was received from the University of Ontario Institute of Technology Research Ethics Board (UOIT REB #14097; Appendix 1) on October 16th, 2016. Following approval from the UOIT REB, the recruitment process began and all mothers and children who agreed to participate in the study provided informed consent and child assent prior to any data collection taking place (Appendices 2 to 4). This study consisted of a exploratory, cross-sectional design in order to assess the motor skills and perceived motor competence of both mothers and their children at one point in time. The data collection sessions included one mother, and typically one child between the ages of 8 to 10 years. However, if there was more than one sibling within the age range, he or she was also able to participate and also had his or her data included in the analysis.

Recruitment

Participants were recruited by placing recruitment flyers (Appendix 5) around local recreational facilities, and churches. In addition, word-of-mouth and social media were also used to help recruit participants for the study.

Participants

The participants for this study consisted of 19 children (5 boys, and 14 girls) and 15 mothers, and one father. The father participated in the study with his two children, as well as their mother; however, the father's data was not included in the analysis because he was the only father who agreed to take part in the study. In total, four sibling pairing groups were included, with one being a brother-sister pairing and the remaining three pairings being sister-sister. Participants were excluded from the study if they were non-ambulatory, have neurodegenerative conditions (i.e., Multiple sclerosis, Parkinson's disease, amyotrophic lateral sclerosis), or any injuries that impact the ability to walk. The total sample included 19 children, as well as 15 mothers.

Measurements

All measurements were conducted at the Motor Behaviour and Physical Activity Lab at the University of Ontario Institute of Technology, with the mother and child(ren) present for the session. Each mother-child dyad was required to come for one session. In addition, the mother also completed a supplemental information form to provide demographic information (Appendix 6; Table 1 lists the measures conducted in this session).

Table 1. Motor skill measures

	Mother Measures	Child Measures
Motor skill assessments	• Developmental Coordination Disorder Questionnaire for Adults (DCDQ-A) • Adult Developmental Coordination Disorder/Dyspraxia Checklist (ADC) • Y-Balance Test Lower Quadrant	• Test of Gross Motor Development-2 (TGMD-2) • Developmental Coordination Disorder Questionnaire (DCDQ) • Pictorial Scale for Perceived Movement Skill Competence for Young Children (PSPM) • Y-Balance Test Lower Quadrant
	Supplemental Information Form	

Child Motor Skill Measures

Test of Gross Motor Development-2

The children had their motor skills directly assessed using the TGMD-2 (Ulrich, 2000). The TGMD-2 is a common test for children that is validated, assessment to evaluate the quality of motor skill performance for children between that ages of three and ten years of age (Ulrich, 2000). The TGMD-2 assesses 12 fundamental motor skills that require the use of locomotor and object control skills (Ulrich, 2000). Object control skills include movements such as throwing, catching, striking, kicking, dribbling, and underhand rolling (Ulrich, 2000). In contrast, locomotor skills include running, sliding, galloping, jumping, hopping and leaping (Ulrich, 2000). When coding the results, inter-rater reliability was conducted on 20 percent of the participants to ensure that there was 80 percent agreement between the two, independent scorers.

Development Coordination Disorder Questionnaire

In addition to direct assessment tools to measure motor skill proficiency, the Developmental Coordination Disorder Questionnaire (DCDQ) was completed by the mothers for their child(ren) (Appendix 7) (Wilson et al., 2009). The DCDQ is a parent report measure to help identify children between the ages of 5 and 15 with movement difficulties and was selected to provide information on how the mothers perceive their own child's motor skills. Parent-report questionnaires were used in addition to objective motor skill assessments in order to triangulate the data.

The Pictorial Scale for Perceived Movement Skill Competence

The Pictorial Scale for Perceived Movement Skill Competence (PSPM) is a self-report tool that is based off of the six locomotor and six object control skills demonstrated in the TGMD-2 (Appendix 8) (Barnett, Robinson, Webster, & Ridgers, 2015). This tool allowed for children to indicate their perceived competence by identifying if their skill level was similar to one of two pictures (Barnett et al., 2015). The first picture consists of an image portraying a child who is competent at that particular skills; whereas, the second image portrays a child who is not competent at that skill. Children were then asked to determine which child in the picture is the most like them. In addition, the PSPM was found to be a reliable measure in this population (Barnett et al., 2015).

Parent Motor Skill Measures

Developmental Coordination Disorder Questionnaire for Adults

The mothers completed the Developmental Coordination Disorder for Adults (DCDQ-A) where the mothers compared their motor skills to those of other adults using a five point Likert scale (Appendix 9) (Cantell, Crawford, & Doyle-Baker, 2008; Lloyd et al., 2014). Previous literature had used this tool to identify adults with movement impairments (Cantell et al., 2008; Lloyd et al., 2014) and this tool is similar to the DCDQ which measures motor proficiency of the children; however, one question on driving ability has been included.

Adult Developmental Coordination Disorders/Dyspraxia Checklist

The Adult Developmental Coordination Disorders/Dyspraxia Checklist (ADC) is a self-report, 40-item questionnaire used by the mothers to assess their motor ability within various environments (Appendix 10) (Kirby, Edwards, Sugden, & Rosenblum, 2010). The two subscales involved are the difficulties experienced in childhood, and current difficulties that affect their motor performances (Kirby et al., 2010). Lastly, the ADC has been found to have high levels of internal validity for both the whole questionnaire, as well as the two subscales (Kirby et al., 2010).

Mother and child motor skill measures

The Y-Balance Test – Lower Quadrant

The Y Balance Test (YBT) was conducted in order to directly measure one motor ability the same way for both the mothers and their children (Fullam, Caulfield, Coughlan, & Delahunt, 2014) (Appendix 11). The test consists of the participants maintaining single-leg balance on one leg while reaching as far as possible with the contralateral leg in three different directions. The three directions are anterior, posteromedial, and posterolateral. Prior to the test taking place, the primary investigator measured the limb length from the anterosuperior iliac spine to the ipsilateral medial malleolus (Hip to the inside of the ankle) in order to normalize to the reach distance. The YBT is conducted barefoot with the toes placed behind the reach-direction line. The test was demonstrated by the primary investigator. After an opportunity to practice, both the mothers and the children completed three test trials in each direction, for each leg. Both mothers and their children completed the same protocol, and no modifications were made. All measurements were taken to the nearest 0.5 cm, with the maximum distance reached being the measurement used for the analyses. The reach distances was calculated in proportion to the length of the limb using the formula: (Reach distance/limb length) x 100 = Maximum reach distance. The YBT is a non-invasive, standard measure of dynamic balance commonly used in the kinesiology field (Butler, Southers, Gorman, Kiesel, & Plisky, 2012).

Statistical Analyses

Descriptive statistics were conducted for all variables by calculating the means and standard deviations for total scores of both the mother and child motor skill assessments. An independent samples t-test was calculated for differences in TGMD-2 GMQ between boys and girls. In addition, Pearson product correlation analyses were conducted to determine the relationship between the mother and child variables. When mothers participated with multiple children, only the older child was included in the analysis in order to have an equal number of mothers and children for the analysis; the younger child was not included as a part of the correlation analyses. For each specific research question, the following Pearson correlations were conducted:

Are the fundamental motor skills of mothers related to fundamental motor skills of children?

- Relationship between mother and child YBT reach percentages.
- Relationship between mother YBT reach percentages and child TGMD-2 Gross Motor Quotient, locomotor and object control raw scores.

Is perceived motor competence related to actual motor competence in children?

- The relationship between the PSPM and the TGMD-2 GMQ, locomotor and object control raw scores.
- The relationship between the DCDQ and the TGMD-2 variables.

Is perceived motor competence related to actual motor competence in the mothers?

- The relationship between the ADC and DCDQ-A.
- The relationship between mothers' YBT reach percentages and DCDQ-A total score, as well as the ADC total score.

A power calculation was performed between the mother YBT reach percentage for the anterior direction, and the child YBT reach percentage in the posteromedial direction (r=0.489), and found that a minimum of 30 participants was needed. Due to time constraints, recruiting 30 participants was not feasible. However, this is an exploratory study and warrants investigation in order to examine the relationship between mother and child motor proficiency.

In order to measure the strength of the analyses conducted, effect sizes were determined using the correlation coefficients. The correlation coefficients were classified as effect sizes by using the following guidelines:

- Small: r = 0.10
- Medium: r = 0.30
- Large: r = 0.50

Results

Both the mother and child participant characteristics are presented in Table 2. Descriptive statistics of all the motor measures completed by the child participants are presented in Table 3, and the descriptive statistics for the mothers performance results are presented in Table 4. There was a total of 16 parents; however, since only one of these parent participants was male (n=1), his data was excluded from the study. This left a total of 15 mothers in the analyses.

Table 2. Participant characteristics for both the mothers and children

Characteristics	**Participants** Mean(SD)
Children	
N	N=19
Age (years)	8.90(±0.94)
Ethnicity	Caucasian (n=13) Non-Caucasian (n=6)
Mothers	
N	N=15
Age (years)	42.25(±3.62)
Socioeconomic status	>$100,000/year (n=12) $60,000 – 99, 000 (n=3)

There was a total of 19 children who participated in the study, including five boys and 14 girls, as well as 15 mothers. The average age for the boys and girls was 8.80±1.09 years and 8.93±0.917 years, respectively. The sample consisted primarily of Caucasian children, who were also the first born in their families. In addition, the participants were predominately from high socioeconomic income brackets.

Table 3. Descriptive results for motor proficiency, and perceived motor competence of the children

Child Measures	**Participants** Mean(SD)		
	Group Average	Male (n=5)	Female (n=14)
TGMD-2 Locomotor Raw Score	42.42(±4.83)	42.60(±4.51)	42.36(±5.12)
TGMD-2 Locomotor Standard Score	10.05(±2.74)	10.00(±2.45)	10.07(±2.92)
TGMD-2 Object Control Raw Score	37.32(±7.10)	44.00(±2.30)	34.79(±6.48)
TGMD-2 Object Control Standard Score	8.42(±2.89)	10.40(±1.34)	7.71(±2.99)
TGMD-2 Gross Motor Quotient	95.42(±11.29)	101.20(±9.63)	93.36(±11.42)
DCDQ Control during Movement Score	26.58(±10.92)	18.40(±5.18)	26.89(12.62)
DCDQ Fine Motor/Handwriting Score	17.37(±2.77)	14.00(±2.45)	18.57(±1.70)
DCDQ General Coordination Score	20.05(±4.52)	26.00(±4.30)	20.64(±4.31)
DCDQ Total Score	61.74(±9.50)	58.4(±9.92)	62.93(±9.43)
PSPM Total Score	56.5(±5.98)	60.6(±5.23)	54.21(±5.44)
Right Leg YBT Anterior *	79.33(±8.84)	81.40(±7.65)	78.60(±9.38)
Right Leg YBT Posterolateral	119.09(±15.98)	123.82(±28.47)	117.40(±9.62)
Right Leg YBT Posteromedial	114.76(±13.57)	114.65(±11.50)	114.79(±14.64)
Left Leg YBT Anterior	81.05(±10.04)	88.52(±12.03)	78.38(±8.12)
Left Leg YBT Posterolateral	119.24(±12.55)	125.58(±15.14)	116.97(±11.26)
Left Leg YBT Posteromedial	118.29(±12.87)	123.72(±11.22)	116.35(±13.23)

*Reach percentage = [distance(cm)/limb length] x 100

The boys and girls TGMD-2 locomotor raw scores were relatively similar; however, boys had higher object control raw and standard scores, as well as overall gross motor quotient (GMQ) scores compared to girls. In addition, boys also had higher levels of perceived competence and YBT scores compared to girls. In contrast, girls had higher DCDQ scores compared to the boys. An independent t-test was conducted to determine if there was a difference that existed between the means of the TGMD-2 locomotor raw scores, object control raw scores, and GMQ, between the boys and girls. The results indicate that there are no significant differences between the boys and girls concerning their TGMD-2 locomotor and GMQ. However, significant differences were found between boys and girls in terms of their object control skills ($p=0.005$). The mothers perceive themselves to have proficient motor skills based on the scores from the DCDQ-A and the ADC (Table 4). Furthermore, the mothers had lower YBT scores in comparison to their children; however, there were no significant differences.

Table 4. Descriptive statistics for motor proficiency and perceived motor competence of the mothers.

Mother Motor Skill Measure	**Participants** Mean(SD)
DCDQ-A Total Score	68.4(±5.19)
ADC Total Score	18.27(±10.52)
Right Leg YBT Anterior Direction*	67.83(±6.99)
Right Leg YBT Posterolateral Direction	107.87(±11.30)
Right Leg YBT Posteromedial Direction	106.27(±11.04)
Left Leg YBT Anterior Direction	68.49(±7.67)
Left Leg YBT Posterolateral Direction	108.27(±11.52)
Left Leg YBT Posteromedial Direction	105.86(±11.98

*Reach percentage = [distance(cm)/limb length] x 100

Mother and child motor skills

The results for the Pearson product correlations between the mother and child motor skills are listed in Appendices 13 – 15. When examining the relationship between the TGMD-2 GMQ, locomotor and object control raw scores of the children with the mothers' YBT scores, the results show that there was only one significant correlation (Table 5). This significant result was between the TGMD-2 GMQ and the mothers' YBT score for the anterior direction of the left leg (r=0.541, p-value=0.037), indicating a moderate correlation. When correlating the mothers and daughters (n=14) results separately, significant, positive correlations were found between the mothers' YBT scores for the left leg in the posterolateral direction and the TGMD-2 GMQ (r=0.610, p-value=0.046), as well as the object control raw scores (r=0.685, p-value=0.020) of their daughters, and between the mothers' YBT scores for the left leg in the posteromedial direction and the object control raw scores of their daughters (r=0.712, p-value=0.014) (Tables 6 and 7). All three correlation coefficients indicate that each has a moderate to strong correlation with each variable. Concerning boys (n=5), significant, positive correlations were found between the mothers' YBT scores for the left leg in the anterior direction and the locomotor raw scores of their sons (r= 0.890, p-value=0.043), indicating a strong correlation between these two variables (Table 8). Due to the number of analyses perform, a Bonferroni correction was applied to ensure that the results did not reach significance due to a Type II alpha error. Once the correction was applied, the alpha level was 0.008; therefore, all results were found to be insignificant.

Concerning the effect sizes of the correlations between mother YBT reach percentages and child TGMD-2 variables, all but two variables had at least moderate effect sizes (r = 0.30). In addition, the effect sizes between mother and child YBT reach percentages were low (r = 0.10) to moderate (r = 0.3) in strength.

Table 5. Pearson correlation results between mothers' YBT reach percentages and child TGMD-2 GMQ scores

Variable One	Variable Two	R	p-value	Effect Size
YBT Max. Reach % Right Leg Anterior Direction	TGMD-2 Gross Motor Quotient	0.467	0.079	Moderate
YBT Max. Reach % Right Leg Posterolateral Direction	TGMD-2 Gross Motor Quotient	0.371	0.173	Moderate
YBT Max. Reach % Right Leg Posteromedial Direction	TGMD-2 Gross Motor Quotient	0.254	0.362	Small
YBT Max. Reach % Left Leg Anterior Direction	TGMD-2 Gross Motor Quotient	0.541	0.037*	Large
YBT Max. Reach % Left Leg Posterolateral Direction	TGMD-2 Gross Motor Quotient	0.290	0.295	Small
YBT Max. Reach % Left Leg Posteromedial Direction	TGMD-2 Gross Motor Quotient	0.340	0.215	Moderate

*Significant at the 0.05 level

Table 6. Pearson correlations between mothers' YBT reach percentages and females TGMD-2 GMQ scores

Variable One	Variable Two	R	p-value	Effect Size
YBT Max. Reach % Right Leg Anterior Direction	TGMD-2 Gross Motor Quotient	0.444	0.171	Moderate
YBT Max. Reach % Right Leg Posterolateral Direction	TGMD-2 Gross Motor Quotient	0.560	0.073	Large
YBT Max. Reach % Right Leg Posteromedial Direction	TGMD-2 Gross Motor Quotient	0.391	0.235	Moderate
YBT Max. Reach % Left Leg Anterior Direction	TGMD-2 Gross Motor Quotient	0.569	0.068	Large
YBT Max. Reach % Left Leg Posterolateral Direction	TGMD-2 Gross Motor Quotient	0.610	0.046*	Large
YBT Max. Reach % Left Leg Posteromedial Direction	TGMD-2 Gross Motor Quotient	0.563	0.071	Large

*Significant at the 0.05 level

Table 7. Pearson correlations between mothers' YBT reach percentages and female TGMD-2 object control raw scores

Variable One	Variable Two	R	p-value	Effect Size
YBT Max. Reach % Right Leg Anterior Direction	TGMD-2 Object Control Raw Score	0.353	0.287	Moderate
YBT Max. Reach % Right Leg Posterolateral Direction	TGMD-2 Object Control Raw Score	0.537	0.089	Large
YBT Max. Reach % Right Leg Posteromedial Direction	TGMD-2 Object Control Raw Score	0.481	0.134	Moderate
YBT Max. Reach % Left Leg Anterior Direction	TGMD-2 Object Control Raw Score	0.380	0.249	Moderate
YBT Max. Reach % Left Leg Posterolateral Direction	TGMD-2 Object Control Raw Score	0.685	0.020*	Large
YBT Max. Reach % Left Leg Posteromedial Direction	TGMD-2 Object Control Raw Score	0.712	0.014*	Large

*Significant at the 0.05 level

Table 8. Pearson correlations between mothers' YBT reach percentages and male TGMD-2 locomotor raw scores

Variable One	Variable Two	R	p-value	Effect Size
YBT Max. Reach % Right Leg Anterior Direction	TGMD-2 Locomotor Raw Score	0.572	0.313	Large
YBT Max. Reach % Right Leg Posterolateral Direction	TGMD-2 Locomotor Raw Score	0.463	0.432	Moderate
YBT Max. Reach % Right Leg Posteromedial Direction	TGMD-2 Locomotor Raw Score	0.731	0.160	Large
YBT Max. Reach % Left Leg Anterior Direction	TGMD-2 Locomotor Raw Score	0.890	0.043*	Large
YBT Max. Reach % Left Leg Posterolateral Direction	TGMD-2 Locomotor Raw Score	0.324	0.594	Moderate
YBT Max. Reach % Left Leg Posteromedial Direction	TGMD-2 Locomotor Raw Score	0.552	0.335	Large

*Significant at the 0.05 level

Perceived and actual motor competence in children

When determining the relationship between perceived and actual motor competence in children, the results of this analysis indicate that there are no significant relationships between the TGMD-2 and the PSPM. In addition, the mothers were able to perceive their child's motor proficiency, using the DCDQ, to determine if the DCDQ was related to the TGMD-2 variables. These results are listed in Appendices 16 and 17. The effect sizes showed that there are small effect sizes between the DCDQ and the TGMD-2 variables; however, when separating by sex, moderate to large effect sizes were shown between these two variables. There was an exception for the GMQ and DCDQ total score for both boys and girls, where small effect sizes were noted. Concerning the PSPM and the TGMD-2 variables, only small effect sizes were noticed.

Perceived and actual motor competence in mothers

When examining the relationship between perceived and actual motor proficiency in mothers, correlations were performed between the DCDQ-A and YBT and the ADC and YBT reach percentages. The results of these analyses indicated no significant relationships, suggesting that the mothers may have been unable to accurately perceive their motor competence. Furthermore, the results indicated that there was no significant relationship between the ADC and the DCDQ-A. The results are listed in Appendices 18 and 19. When considering the effect sizes, each correlation indicated a small effect size.

Discussion

The purpose of this study was to investigate the relationship between motor skills in adulthood and childhood by specifically examining the relationship between mother and child motor skill proficiency. A secondary research question was to see if a relationship exists between perceived motor competence and actual motor competence in both mothers and children. Motor skills can be important factors that influence many aspects of child development such as PA, activities of daily living, participation in sport (Barnett et al., 2009), as well as motor skill proficiency in adulthood (Lloyd et al., 2014).

Results indicated that there were no significant differences between boys and girls with the TGMD-2 which suggests that the boys and girls had similar overall FMS proficiency. However, there were statistically significant differences for object control skills between boys and girls. The difference in object control skills between boys and girls is consistent with the literature that indicates that girls have lower object control skills compared to boys (Barnett et al., 2009). Therefore, in order for girls to be able to practice their object control skills, interventions could be created or have community programs implemented that could encourage object control skill development in girls. By having adequate practice for their object control skills this could help close the disparity seen with object control skills between boys and girls. In our study, the motor skills of the boys were found to be in the 50^{th} percentile and the girls scored within the 35^{th} percentile, which is consistent with the current literature in that boys are often found to have more proficient motor skills compared to girls (Barnett et al., 2009; Burns, Brusseau, You, & Hannon, 2015; Lubans et al., 2010). The average percentile score for the girls suggests that they may demonstrate motor delays because they scored below the 50^{th} percentile. The implications from these findings suggest that motor skill interventions should be developed and tailored to improve the motor skills of girls. The use of interventions is supported by Ericsson (2011) who found after the conclusion of an extended motor skill and PA program, that both the boys and the girls had better motor skills after the conclusion of the intervention. Moreover, the disparities in motor proficiency between boys and girls had decreased compared to the control group (Ericsson, 2011). Interventions should consist of a motivational climate where children have the choice to learn the skills at their own pace while in a supervised setting (Martin, Rudisill, & Hastie, 2009), activity-based settings by developing specific skills (Apache, 2005), family-based or community-based programs (Cliff, Wilson, Okely, Mickle, & Steele, 2007).

The group average of the DCDQ total scores indicated that the child participants did not demonstrate any movement difficulties as perceived by their mothers. When separated by sex, the girls had higher DCDQ total scores compared to the boys, indicating that mothers perceived the girls to have more proficient motor skills compared to the boys. Silva, Flôres, Corrêa, Cordovil, and Copetti (2017) reported evidence that is contradictory to our results, stating that the mothers perceived that their sons had more proficient motor skills compared to their daughters. The differences in the findings may be due to the differences in the measures used. Our study used the DCDQ and was comprised of questions that examined fine motor skills, and general motor coordination, whereas Silva et al. (2017) had the mothers analyze their own child's FMS by recalling their children's motor proficiency by completing the Peabody Developmental Motor Scales – 2 (PDMS-2). The mothers did not watch their children complete the required skills for the PDMS-2, and were required to estimate their children's proficiency. The PDMS-2 is a direct assessment FMS of children from birth to five years of age (Folio & Fewell, 2000). Girls are often found to have more proficient fine motor skills (Pahlevanian & Ahmadizadeh, 2014); therefore, by using the DCDQ which includes components on fine motor skills may explain why our results showed that mothers perceived their daughters to have more proficient motor skills compared to their sons. However, the fact that the DCDQ and the TGMD-2 results may not be measuring similar motor domains could indicate that more assessments are needed before concluding that the girls had motor delays.

Lastly, concerning the YBT scores for the children, boys and girls had similar reach percentages for the posteromedial direction for the right leg; however, the boys typically had higher reach percentages for the remaining directions which suggests that boys may have more proficient dynamic balance compared to girls. This finding is inconsistent with other literature because typically, girls have more proficient balance compared to boys (Valtr, Psotta, & Abdollahipour, 2016). Valtr et al. (2016) found that girls had more proficient static balance; however, there were no differences in dynamic balance between boys and girls. In addition, Butz, Sweeney, Roberts, and Rauh (2015) also found no significant differences in gender between boys and girls between the ages of 5 and 12 on the Timed Up and Go test. The results from both of these studies differ from our results, likely due to our small sample size, especially for the boys and girls, because only having five boys in the sample is not representative of the entire population. The YBT is often used with athletic populations; therefore, this the first known study to use the YBT on a sample of children who are not athletes and more research is needed to understand the results on the YBT with this population.

The mothers also completed the YBT to measure dynamic balance, and the results were used as a motor skill measure that could be compared between the mothers and the children. The results showed that the mothers typically had lower levels of dynamic balance compared to their children; yet, there were no significant relationships between mother and child YBT reach percentages. Cuozzo Lemos, de David, and Bolli Mota (2016) found that there were no significant differences in balance between children and adults; however, the adults in this study had a mean age of 22.36 years which was much younger compared to the adults in our study, who had a mean age of 42.25 years. Balance declines in middle age adults have not been well documented and warrants more study. In addition, to our knowledge, there have been no studies that compared dynamic balance of mothers to their children. The relationship between mother and child balance could be an important factor that influences FMS in children. Although our exploratory study could not uncover this relationship, future studies with larger samples are need to further understand the implications of this relationship.

In order to assess the mother-child relationship between motor skill proficiency, the dynamic balance of the mothers was compared to the FMS proficiency of the children, with the results showing that dynamic balance in mothers was related to overall FMS proficiency in their children, as measured by the TGMD-2. Furthermore, when separating by sex, significant relationships were found between dynamic balance in mothers and the overall FMS proficiency as well as the object control skills of their daughters. A significant relationship was also found between dynamic balance in mothers and the locomotor scores of their sons. These results suggest that the dynamic balance of the mothers may influence, or be related, to their children's FMS differently between boys and girls. However, this needs to be studied further with a much bigger sample size. Mothers have been shown to positively influence different aspects of their children's lives, including, PA (Craig et al., 2013), emotional well-being (Kerns, Abraham, Schlegelmilch, & Morgan, 2007), academic achievement (Davis-Kean, 2005) and musical ability (Pitt & Hargreaves, 2016). Mothers who were more physically active generally had children who were also more physically active (Craig et al., 2013). Although the mother-child relationship between PA engagement has been established, there is no known established relationship between mother and child motor skill proficiency. Motor skills in childhood are often the precursor for a physically active lifestyle (Lubans et al., 2010); therefore, understanding the potential factors that could promote child development, such as maternal influence, is important to encourage FMS development in children.

When conducting the various correlations between the mothers' YBT reach percentages, and the child TGMD-2 scores, a Bonferroni correction was applied. The results of this correction showed that there are no significant relationships between mother and child motor proficiency. Although these results may no longer be significant, our study was able to identify trends that could suggest that dynamic balance in mothers is related to their children's FMS proficiency. Future research should use larger sample sizes in order to have greater statistical power in detecting these relationships. Our study is considered exploratory because the relationship between mother and child motor proficiency has not yet been established; therefore, the trends that are demonstrated in our study are important to guide future research.

How well children perceive their ability to move may impact their FMS proficiency (Liong, Ridgers, & Barnett, 2015; Robinson, 2011). Our results found the boys had higher PSPM scores compared to the girls which suggests that boys perceived themselves to have better motor skills compared to the girls; however, no significant relationships between the PSPM and any of the TGMD-2 scores were found for the total sample or when boys and girls were separated. This demonstrates that the children who participated in our study may not be able to perceive the proficiency of their FMS accurately. In contrast, Liong et al. (2015) found that boys and girls had similar PSPM scores and that there was a significant relationship between perceived and actual motor competence for the boys. Moreover, a significant relationship was present between perceived and actual motor competence for the entire sample, indicating the perceived motor competence is related to actual motor competence (Liong et al., 2015). Both our study and Liong et al. (2015) were able to use a questionnaire that aligned with the six object control and six locomotor skills that were used in the TGMD-2 to measure perceived motor competence; however, we were unable to find any significant relationships. This may be due to the differences in sample size, with our study only having 19 children, and only five boys, resulting in lower statistical power.

In addition, the fact that the children in the current study were less able to accurately predict their motor skill proficiency is an interesting finding. This might suggest that children between the ages of eight and ten may have an inaccurate perception of their actual motor proficiency. Children who are unable to accurately predict their motor proficiency may not participate in certain activities, because they may believe that they not are proficient at that skill (Barnett, Hinkley, Okely, & Salmon, 2013; Robinson, 2011). As a result, children might avoid opportunities to practice their FMS. More research is needed on the relationship between perceived motor competence and actual motor competence for children between the ages of eight and ten years, as well as research involving the PSPM in relation to the TGMD-2 because this tool is relatively new and may require further study.

How the mothers perceived their children's motor proficiency compared to their actual motor competence was investigated, and the results showed that there were no significant relationships. This suggests that the mothers may not have been able to accurately perceive their child's actual motor competence. This may reduce the motor skill development of their children because the mothers may feel that if their children are proficient in their FMS, their children might not be given the opportunity to practice their skills (Liong et al., 2015). If the children have delayed FMS, the mothers may not be aware to provide opportunity for their children to practice and master their FMS (Liong et al., 2015). Our results differs from those reported by Liong et al. (2015) who found that parents perceptions of their child's motor proficiency was significantly and moderately associated with their child's motor proficiency. After adjusting for sex, parents were able to accurately perceive their daughters' locomotor scores, as well as their sons' object control skills. Why their results may differ from our study may be due to the method of measuring the parents' perceptions of their child's motor proficiency. We used the DCDQ, whereas Liong et al. (2015) used a written version of the PSPM for the parents to complete. These questionnaires differ because the DCDQ encompasses multiple motor constructs such as fine motor coordination and general motor coordination; whereas, the PSPM strictly viewed the 12 skills that are a part of the TGMD-2. Variations may have also occurred due to the differences in sample size because Liong et al. (2015) had recruited 136 children between the ages five and eight years, with a proportionate amount of boys to girls; however, our study had only 19 children, with only five of these children being boys. Therefore, future studies should examine the impacts of how parents perceive their children's motor proficiency and their actual level of motor proficiency using larger sample sizes, as well as having questionnaires properly mirror the child objective motor skill assessment tool.

This study had the opportunity to compare dynamic balance to overall FMS proficiency, and found that there were no significant relationships. It is possible that these two tools may not be measuring the same motor constructs. The TGMD-2 is a process oriented tool that is comprised of the locomotor and object control subtests, which observes locomotor and object control skills (Logan, Robinson, Rudisill, Wadsworth, & Morera, 2014); however, the TGMD-2 does not include a subtest that focuses on body management, or postural control skills. In contrast, the YBT is a product oriented tool that measures dynamic balance and a result, takes into account the body management construct and does not measure locomotor or object control skills. The differences between the TGMD-2 and the YBT motor skill constructs, could contribute to the lack of a relationship found in this study. The lack of a relationship detected between these two variables may also be due to the proportion of males to females that volunteered to participate in our study. Due to only five boys participating, their YBT reach percentages may be skewed as a result of the small sample. If there was an equal amount of boys compared to girls and larger overall numbers, there would have been more of a representative sample.

The influence that mothers have on their child’s development has been documented in other areas of development, including PA (Craig et al., 2013; Fuemmeler et al., 2011; Jago et al., 2014), cognitive development (Miller, Manhal, & Mee, 1991) and interests in music (Pitt & Hargreaves, 2016). With respect to our study, there is no known published research that examines the mother-child relationship between motor skill proficiency. To assess this question, we examined the dynamic balance of both the mothers and their children; however, no statistically significant relationships were found regardless if the mothers were compared to all the children, or when separated by sex. Furthermore, to the best of our knowledge, this is the first study that compared the YBT between mothers and their biological children. The lack of a statistically significant relationship between the mother-child YBT results suggests indicate that motor skill proficiency in their children may not be biologically driven, and that the environment could play an important role in shaping the FMS proficiency of children.

The environment is likely an important contributor to the development of FMS in children. A positive environment can be mediated through encouragement from mothers and fathers. Maternal influences are particularly an important catalyst to the behaviours of their children (Vander Ploeg et al., 2013) and as a result, can have a major influence over their child’s overall health and development (Hamilton et al., 2014). Parents, especially mothers, can help to create an environment that provides opportunity and access to nurture their children’s FMS development; for example, this can be achieved by mothers enrolling their children in programs that promote FMS development, such as sports. Hamilton et al. (2014) reported that parents understood the importance of children engaging in activities that support FMS mastery, and that these interactions were beneficial to personal and family interactions. However, parents often face barriers that could prevent their children from being in an environment that promotes their FMS. Hamilton et al. (2014) stated that parents who did not engage in motor skill-promoting activities often reported that financial constraints prevented their children from having access to skill-based programs (e.g., swimming and dancing), and that these activities conflicted with other commitments. In addition, parents found that having appropriate access to local parks, organized sports, appropriate weather and living in a suitable home for PA could promote FMS in their children (Hamilton et al., 2014). Therefore, it is essential for children to have equal opportunity to participate in activities that promote their skill development. Future considerations should include measures that include the environment in order to understand how the environment impacts motor skill development.

Situations where a child is faced with stimulation or lack of opportunity, can have an impact on the development of their motor skills (Gallahue et al., 2012). Previous studies involving identical twins allowed for the environment to be manipulated for one twin, and have the environment remain the same for the other twin (Gallahue et al., 2012). When the environment can be manipulated, this can strengthen FMS development in children. The environment can be manipulated by using interventions to provide children with stimulation and the opportunity to practice their skills; as a result they will be able to learn how to properly perform their skills and be able to better participate in PA. In contrast, children who do not have access to these opportunities to practice their motor skills, may not be as proficient in their skills and as a result, be less likely to participate in PA (Gallahue et al., 2012). Therefore, the opportunities that children have to practice their motor skills are influenced by a stimulating environment.

The environment can also be influenced by cultural norms that are seen between boys and girls in terms of their PA (Gallahue et al., 2012). Elements of culture can shape what activities children choose to participate in (Gallahue et al., 2012). For example, girls may be more likely to participate in activities like dance, whereas, boys are more likely to take part in activities like throwing and catching a ball (Liong et al., 2015). These cultural influences may play a role in between boys and girls. Research suggests that boys have more proficient motor skills compared to girls (Lubans et al., 2010); it is possible that our cultural practices may be encouraging children to participate in certain activities based on their gender. Children may be encouraged to develop certain skills because it may be acceptable for a child of one gender to participate in an activity that is normally reserved for another gender (Silva et al., 2017). Comparing to our results, the girls had significantly lower object control skills compared to the boys. This may suggest that boys may be influenced to participate in activities that promote object control skills, whereas, girls are participating in more activities that promote locomotor skills (Silva et al., 2017). Therefore, it is important to understand how the environment influences different constructs for both children and their parents. The results from this study indicate that an environmental influence may have a stronger influence over motor skill proficiency, rather than a biological influence. This indicates that if parents do not have proficient motor skills, their children could still be proficient in their FMS because by creating a nurturing environment this could allow for their children to receive the proper opportunities and access to practice their FMS.

Although these results were found to be statistically non-significant, there were several correlations that were shown to demonstrate moderate to large effect sizes between mother and child motor proficiency. These effect sizes were seen specifically between mother and child dynamic balance, as well as between mother dynamic balance and child FMS proficiency. Furthermore, small effect sizes were seen between actual and perceived motor proficiency in both mothers and their children. Due to these moderate to large effect sizes, future research should aim to further study the relationship between mother and child motor proficiency.

Strengths and Limitations

Like all studies, there are limitations to our findings. The first limitation is due to the small sample size that was recruited for this study, resulting in lowered statistical power. When power calculations were conducted between the different variables, a sample size of at least 102 participants would have been necessary, however, this was not feasible for our study; therefore, this can be considered an exploratory study. Another limitation due to the sample was because the majority of the families recruited for this study were Caucasian and from a high socioeconomic status that could have resulted in a biased sample. Furthermore, the adult participants consisted only of mothers. In order to achieve a complete understanding of how the motor skills of parents impacts their children, both mothers and fathers should be recruited for future study.

An additional limitation may have been due to the use of motor skill assessments that observed different motor constructs, and were then used to determine if a relationship existed between mothers and their children. Currently, there is no known tool that can be used to measure the FMS of both children and adults. As a result, utilizing a motor skill that measures the locomotor and object control skills of children, and the dynamic balance of the mothers may not yield statistically significant results because these two tests involve different motor constructs. The questionnaires that were used also focused on overall motor proficiency, rather than FMS, and included constructs such as fine motor skill and general motor coordination. However, it was still beneficial to include the YBT and the motor skill questionnaires because we were able to better triangulate the data and assess motor proficiency with different methods. Regardless of the limitations of this study, the results were able to begin to link the FMS proficiency of parents to their children.

To the best of our knowledge, this is one of the first studies that examines the relationship between mother and child motor skill proficiency. As a result, this study contributes to a current gap in the literature concerning the maternal impact on child motor proficiency. A strength of this study was that we were able to compare the child participants directly to their biological mothers, and the YBT was able to be used as a direct measure of motor proficiency, that was used for both the mothers and their children. The same YBT protocol was used for both the mothers and their children; therefore, this maintained consistency between all mother and child participants. The use of one objective assessment that could be used for both the children and the mothers was a strength for this study.

Future Research

Future studies should examine the relationship between mother and child FMS proficiency and how environmental factors could influence this relationship. This could determine how “nurture” impacts FMS proficiency through opportunity and accessibility for children to have the ability to practice these skills. In contrast, future studies should also consider the biological component of FMS proficiency by understanding how genetics could potentially play a role in FMS development for children. The environmental aspect can be encouraged through family-based motor skill interventions, where both the parents and their children are able to participate to encourage FMS development in both populations. Moreover, physical education programs can be designed to further promote FMS development in children. Concerning the family dynamic and the environment, future studies should also look into adopted families, and how the motor skills of the parents impact the motor proficiency of their adopted children.

Conclusion

The objective of this study was to determine if there was a relationship between mother and child FMS, and if perceived motor competence was related to actual motor competence in both the children and the mothers. The results indicate that there are relationships between mother dynamic balance and total FMS proficiency for the total sample of children. Furthermore, significant relationships were found when the mothers were compared separately to their sons and daughters. There were no significant relationships found between perceived and actual motor competence for both the mothers and their children. These results suggest that FMS proficiency in mothers could be related to their children's motor skill competence; however, children and adults are unable to accurate perceive their actual motor competence. However, the environment can play an important role by influencing the mother-child relationship between motor competence; which could suggest that = biology might not be the only factor to encourage FMS development in children. Future research should to examine how the environment can influence the mother-child relationship between motor proficiency in order to support our findings.

References

Apache, R. R. G. (2005). Activity-Based Intervention in Motor Skill Development. *Perceptual and Motor Skills, 100*(3_suppl), 1011-1020. doi:doi:10.2466/pms.100.3c.1011-1020

Barnett, L. M., Hinkley, T., Okely, A. D., & Salmon, J. (2013). Child, family and environmental correlates of children's motor skill proficiency. *Journal of Science and Medicine in Sport, 16*(4), 332-336. doi:10.1016/j.jsams.2012.08.011

Barnett, L. M., Robinson, L. E., Webster, E. K., & Ridgers, N. D. (2015). Reliability of the Pictorial Scale of Perceived Movement Skill Competence in 2 Diverse Samples of Young Children. *Journal of Physical Activity & Health, 12*(8), 1045-1051.

Barnett, L. M., van Beurden, E., Morgan, P. J., Brooks, L. O., & Beard, J. R. (2009). Childhood Motor Skill Proficiency as a Predictor of Adolescent Physical Activity. *Journal of Adolescent Health, 44*(3), 252-259. doi:http://dx.doi.org/10.1016/j.jadohealth.2008.07.004

Bouffard, M., Watkinson, E. J., Thompson, L. P., Dunn, J. L. C., & Romanow, S. K. E. (1996). A Test of the Activity Deficit Hypothesis With Children With Movement Difficulties. *Adapted Physical Activity Quarterly, 13*(1), 61-73.

Burns, R. D., Brusseau, T. A., You, F. U., & Hannon, J. C. (2015). Predictors and trends of gross motor skill performance in at-risk elementary school-aged children. *Perceptual & Motor Skills, 121*(1), 284-299.

Butler, R. J., Southers, C., Gorman, P. P., Kiesel, K. B., & Plisky, P. J. (2012). Differences in Soccer Players' Dynamic Balance Across Levels of Competition. *Journal of Athletic Training (Allen Press), 47*(6), 616-620.

Butz, S. M., Sweeney, J. K., Roberts, P. L., & Rauh, M. J. (2015). Relationships among age, gender, anthropometric characteristics, and dynamic balance in children 5 to 12 years old. *Pediatr Phys Ther, 27*(2), 126. doi:10.1097/PEP.0000000000000128

Cairney, J., Hay, J. A., Faught, B. E., & Hawes, R. (2005). Developmental coordination disorder and overweight and obesity in children aged 9-14 y. *International Journal of Obesity, 29*, 369.

Cantell, M., Crawford, S. G., & Doyle-Baker, P. K. (2008). Physical fitness and health indices in children, adolescents and adults with high or low motor competence. *Human Movement Science, 27*(2), 344-362. doi:10.1016/j.humov.2008.02.007

Cliff, D. P., Wilson, A., Okely, A. D., Mickle, K. J., & Steele, J. R. (2007). Feasibility of SHARK: A physical activity skill-development program for overweight and obese children. *Journal of Science and Medicine in Sport, 10*(4), 263-267. doi:10.1016/j.jsams.2006.07.003

Cousins, M., & Smyth, M. M. (2003). Developmental coordination impairments in adulthood. *Human Movement Science, 22*(4–5), 433-459. doi:http://dx.doi.org/10.1016/j.humov.2003.09.003

Craig, C. L., Cameron, C., & Tudor-Locke, C. (2013). Relationship between parent and child pedometer-determined physical activity: a sub-study of the CANPLAY surveillance study. *The International Journal of Behavioral Nutrition and Physical Activity, 10*, 8.

Crane, J. R., Naylor, P. J., Cook, R., & Temple, V. A. (2015). Do Perceptions of Competence Mediate The Relationship Between Fundamental Motor Skill Proficiency and Physical Activity Levels of Children in Kindergarten? *Journal of Physical Activity & Health, 12*(7), 954-961.

Cuozzo Lemos, L. F., de David, A. C., & Bolli Mota, C. (2016). Development of postural balance in Brazilian children aged 4-10 years compared to young adults. / Desenvolvimento do equilíbrio postural em crianças brasileiras de 4 a 10 anos de idade comparadas com adultos-jovens. *Brazilian Journal of Kineanthropometry & Human Performance, 18*(4), 419-428.

Davis-Kean, P. E. (2005). The Influence of Parent Education and Family Income on Child Achievement: The Indirect Role of Parental Expectations and the Home Environment. *Journal of Family Psychology, 19*(2), 294-304. doi:http://dx.doi.org/10.1037/0893-3200.19.2.294

Ericsson, I. (2011). Effects of increased physical activity on motor skills and marks in physical education: an intervention study in school years 1 through 9 in Sweden. *Physical Education & Sport Pedagogy, 16*(3), 313-329.

Fitzpatrick, D. A., & Watkinson, E. J. (2003). The Lived Experience of Physical Awkwardness: Adult's Retrospective Views. *Adapted Physical Activity Quarterly, 20*(3), 279.

Folio, R. M., & Fewell, R. R. (2000). *Peabody Developmental Motor Scales* (2nd ed.). Austin, Texas: Pro-ed.

Fuemmeler, B. F., Anderson, C. B., & Masse, L. C. (2011). Parent-child relationship of directly measured physical activity. *The International Journal of Behavioral Nutrition and Physical Activity, 8*, 17.

Fullam, K., Caulfield, B., Coughlan, G. F., & Delahunt, E. (2014). Kinematic Analysis of Selected Reach Directions of the Star Excursion Balance Test Compared With the γ-Balance Test. *Journal of Sport Rehabilitation, 23*(1), 27-35.

Gallahue, D. L., Ozmun, J. C., & Goodway, J. D. (2012). *Understanding Motor Development: Infants, Children, Adolescents, Adults* (7th ed.). New York, NY: McGraw Hill.

Hamilton, K., Hatzis, D., Kavanagh, D. J., & White, K. M. (2014). Exploring Parents' Beliefs About Their Young Child's Physical Activity and Screen Time Behaviours. *Journal of Child and Family Studies, 24*(9), 2638-2652. doi:10.1007/s10826-014-0066-6

Hardy, L. L., Reinten-Reynolds, T., Espinel, P., Zask, A., & Okely, A. D. (2012). Prevalence and Correlates of Low Fundamental Movement Skill Competency in Children. *Pediatrics, 130*(2), e390-e398. doi:10.1542/peds.2012-0345

Hay, J., & Missiuna, C. (1998). Motor proficiency in children reporting low levels of participation in physical activity. *Canadian Journal of Occupational Therapy, 65*, 64+.

Jaakkola, T., Hillman, C., Kalaja, S., & Liukkonen, J. (2015). The associations among fundamental movement skills, self-reported physical activity and academic performance during junior high school in Finland. *Journal of Sports Sciences, 33*(16), 1719-1729. doi:10.1080/02640414.2015.1004640

Jago, R., Sebire, S. J., Wood, L., Pool, L., Zahra, J., Thompson, J. L., & Lawlor, D. A. (2014). Associations between objectively assessed child and parental physical activity: a cross-sectional study of families with 5-6 year old children. *BMC Public Health, 14*, 655. doi:10.1186/1471-2458-14-655

Kerns, K. A., Abraham, M. M., Schlegelmilch, A., & Morgan, T. A. (2007). Mother–child attachment in later middle childhood: Assessment approaches and associations with mood and emotion regulation. *Attachment & Human Development, 9*(1), 33-53.

Kirby, A., Edwards, L., Sugden, D., & Rosenblum, S. (2010). The development and standardization of the Adult Developmental Co-ordination Disorders/Dyspraxia Checklist (ADC). *Research in Developmental Disabilities, 31*(1), 131-139. doi:10.1016/j.ridd.2009.08.010

Kokštejn, J., Psotta, R., & Musálek, M. (2015). Motor competence in Czech children aged 11-15: What is the incidence of a risk of developmental coordination disorder? *Acta Gymnica, 45*(2), 61-68.

Liong, G. H. E., Ridgers, N. D., & Barnett, L. M. (2015). ASSOCIATIONS BETWEEN SKILL PERCEPTIONS AND YOUNG CHILDREN'S ACTUAL FUNDAMENTAL MOVEMENT SKILLS. *Perceptual & Motor Skills, 120*(2), 591-603.

Lloyd, M., Saunders, T. J., Bremer, E., & Tremblay, M. S. (2014). Long-term importance of fundamental motor skills: A 20-Year follow-up study. *Adapted Physical Activity Quarterly, 31*(1), 67-78.

Logan, S. W., Robinson, L. E., Rudisill, M. E., Wadsworth, D. D., & Morera, M. (2014). The comparison of school-age children's performance on two motor assessments: the Test of Gross Motor Development and the Movement Assessment Battery for Children. *Physical Education and Sport Pedagogy, 19*(1), 48-59. doi:10.1080/17408989.2012.726979

Lubans, D., Morgan, P., Cliff, D., Barnett, L., & Okely, A. (2010). Fundamental movement skills in children and adolescents. *Sports Medicine, 40*(12), 1019-1035. doi:10.2165/11536850-000000000-00000

Martin, E. H., Rudisill, M. E., & Hastie, P. A. (2009). Motivational climate and fundamental motor skill performance in a naturalistic physical education setting. *Physical Education and Sport Pedagogy, 14*(3), 227-240. doi:10.1080/17408980801974952

Miller, S. A., Manhal, M., & Mee, L. L. (1991). Parental beliefs, parental accuracy, and children's cognitive performance: A search for causal relations. *Developmental Psychology, 27*(2), 267-276. doi:http://dx.doi.org/10.1037/0012-1649.27.2.267

Pahlevanian, A. A., & Ahmadizadeh, Z. (2014). Relationship Between Gender and Motor Skills in Preschoolers. *Middle East J Rehabil Health, 1*(1), e20843. doi:10.17795/mejrh-20843

Pitt, J., & Hargreaves, D. J. (2016). Attitudes towards and perceptions of the rationale for parent–child group music making with young children. *Music Education Research*, 1-17. doi:10.1080/14613808.2016.1145644

Robinson, L. E. (2011). The relationship between perceived physical competence and fundamental motor skills in preschool children. *Child: Care, Health and Development, 37*(4), 589-596. doi:10.1111/j.1365-2214.2010.01187.x

Silva, S. D., Flôres, F. S., Corrêa, S. L., Cordovil, R., & Copetti, F. (2017). Mother's Perception of Children's Motor Development in Southern Brazil. *Perceptual & Motor Skills, 124*(1), 72-85.

Stodden, D., Langendorfer, S., & Roberton, M. A. (2009). The Association Between Motor Skill Competence and Physical Fitness in Young Adults. *Research Quarterly for Exercise and Sport, 80*(2), 223-229.

Sukys, S., Majauskienė, D., Cesnaitiene, V. J., & Karanauskiene, D. (2014). Do Parents' Exercise Habits Predict 13–18-Year-Old Adolescents' Involvement in Sport? *Journal of Sports Science & Medicine, 13*(3), 522-528.

Summers, J., Larkin, D., & Dewey, D. (2008). Activities of daily living in children with developmental coordination disorder: Dressing, personal hygiene, and eating skills. *Human Movement Science*, *27*(2), 215-229. doi:http://dx.doi.org/10.1016/j.humov.2008.02.002

Ulrich, D. A. (2000). *The test of gross motor development* (2nd ed.). Austin, Texas: Pro-Ed, Inc.

Valtr, L., Psotta, R., & Abdollahipour, R. (2016). Gender differences in performance of the Movement Assessment Battery for Children - 2nd edition test in adolescents. *Acta Gymnica*, *46*(4), 155-161.

Vander Ploeg, K. A., Kuhle, S., Maximova, K., McGavock, J., Wu, B., & Veugelers, P. J. (2013). The importance of parental beliefs and support for pedometer-measured physical activity on school days and weekend days among Canadian children. *BMC Public Health*, *13*, 1132. doi:10.1186/1471-2458-13-1132

Wilson, B. N., Crawford, S. G., Green, D., Roberts, G., Aylott, A., & Kaplan, B. J. (2009). Psychometric Properties of the Revised Developmental Coordination Disorder Questionnaire. *Physical & Occupational Therapy in Pediatrics*, *29*(2), 182-202. doi:10.1080/01942630902784761

CHAPTER 4: MANUSCRIPT 2

Abstract

Physical activity (PA) promotes health benefits across all ages; however, research suggests that Canadian children and adults are not meeting the recommended PA guidelines. As a result, it is important to understand the relationships that help promote PA in both of these populations. For children specifically, parents can serve as a positive role model to their children's PA engagement. The purpose of this study was to investigate the mother-child relationship between PA patterns. In addition, secondary research questions examined how motor proficiency influences PA in both mothers and children. The children were assessed using the Test of Gross Motor Development – 2 (TGMD-2), along with the Developmental Coordination Disorder Questionnaire (DCDQ). In contrast, the mothers had their motor skills assessed using the Adult Developmental Coordination Disorder/Dyspraxia Checklist and the Developmental Coordination Disorder Questionnaire for Adults (DCDQ-A). Both the mothers and the children performed the Y-Balance Test Lower Quadrant (YBT) in order to compare their dynamic balance. Lastly, the mothers and the children both wore a pedometer for seven days, and completed the International Physical Activity Questionnaire (IPAQ) to assess self-reported PA. The results demonstrate that in this study mother PA did not influence child PA. Furthermore, when the boys and girls were analyzed separately, their TGMD-2 variables were related to their own pedometer-measured PA. Lastly, the mothers' YBT reach percentages influenced their IPAQ continuous scores. The results of this study suggest that motor proficiency in mothers and children can influence their PA engagement.

Introduction

Physical activity (PA) has been demonstrated to improve overall health in both children and adults (Colley et al., 2011a, 2011b; Vander Ploeg et al., 2012). Children between the ages of 5 and 17 years should achieve a minimum of 60 minutes of moderate to vigorous physical activity (MVPA), or 13,500 steps, every day (Colley et al., 2011b). Evidence also suggests that children should participate in vigorous PA at least three days per week. However, despite these recommendations, approximately 7% of children in Canada (9% of boys and 4% of girls) meet the PA guidelines (Colley et al., 2011b). PA has been documented to have a relationship with other areas of development such as mental health (Paluska & Schwenk, 2000), and academic performance (Trudeau & Shephard, 2008). Therefore, it is important to understand the PA patterns of Canadian children because understanding the determinants of PA can lead to interventions that can help individuals lead a healthy lifestyle across all ages (Tremblay et al., 2011). The literature also recommends that adults between the ages of 18 and 64 should attain a minimum of 150 minutes of MVPA each week, in bouts of ten minutes or more (Colley et al., 2011a; Tremblay et al., 2011). However, only 15 % of adults in Canada are able to meet this recommended guideline, and men are more physically active compared to women (Colley et al., 2011a). Parents can influence the behaviours of their children, including their PA patterns (Craig et al., 2013; Fuemmeler et al., 2011). Due to the influential abilities that parents can have over their child’s health behaviours, examining the relationship between parent and child PA is important in order to understand the factors that can influence PA patterns across a lifespan.

Parental Influence on Children's Physical Activity

Parent role-modeling and encouragement can promote PA engagement in their children (Fuemmeler et al., 2011). Therefore, it is important to have an understanding of the parent-child relationship about PA because it can help researchers understand how the family dynamic can be impacted by PA engagement. Craig et al. (2013) assessed the pedometer-measured PA patterns of 539 children to see if their activity was related to that of their parents. Participants were asked to wear a pedometer and record the steps taken per day for seven days with the results demonstrating that when mothers increased their activity by 1000 steps per day, their sons and daughters' activity would increase by 263-439 and 195-219 steps per day, respectively. This indicates that parent PA engagement may have a positive influence on the PA of their children. Due to the health benefits that PA engagement can provide, it is important to be knowledgeable about the impact that parent PA can have on child PA because parents could be helping their children promote a healthy lifestyle.

The parent-child relationship may impact PA differently due to the differences seen between mother and father relationships with their children. Fuemmeler et al. (2011) assessed the PA of 45 parent-child triads by having each participant wear an accelerometer for four consecutive days. The results of this study revealed that children's PA was correlated with both their mothers and fathers' PA patterns; however, girls showed more significant correlations with their mothers PA compared to their fathers, and boys displayed more significant correlations with the fathers. This indicates there may be sex-based relationships that need to be further studied. It is important to understand the roles that mothers and fathers individually play in promoting their children's PA patterns because mothers and father could influence their children differently. If mothers could have specific influences on their children's PA patterns, having an understanding of these factors can help researchers further understand the parent-child link between PA.

Mothers have an important role in influencing their children's PA patterns. Olvera et al. (2011) investigated the role that Hispanic mothers play on their children's PA. The sample consisted of 102 mothers and their children, whose mean ages were 36 years and 10 years respectively, and each participant had their PA measured using an accelerometer that was worn for seven consecutive days. The results of this study found that children were more active compared to their mothers, with boys more active than girls, and there were significant differences between mothers and their children for both MVPA. Positive correlations were found between the PA patterns of mothers and their children which suggests that children's PA levels are related to their mothers' PA patterns. Mothers who are more physically active may have children who are also physically active, this relationship warrants further study.

The Impact of Fundamental Motor Skills on Physical Activity in Children

Regular participation in PA can be encouraged in several ways with evidence suggesting that motor skill proficiency can influence PA patterns in children (Lubans et al., 2010). Participating in PA gives children the opportunity to practice their motor skills and consequently children who are more proficient in their motor competence may have the tools necessary to participate in PA (Lubans et al., 2010). This is supported by research conducted by Okely, Booth, and Patterson (2001) who examined the relationship between six motor skills and self-reported PA. The results showed that motor skills significantly predicted the amount of time children spent in organized PA, and that motor skill proficiency did not significantly predict unorganized PA (Okely et al., 2001). However, the measures were self-reported and the question needs further research with the support of objective PA measures.

Iivonen et al. (2013) assessed the relationship between accelerometer-measured PA and the FMS of 37 4-year-old children. The FMS that were measured for the study consisted of dynamic balance, locomotor and object control skills and the accelerometer was worn for five consecutive days to measure PA. The results of this study demonstrated that sliding and galloping were significantly associated with MVPA, whereas dynamic balance and object control skills were not significantly associated. Furthermore, locomotor skills predicted PA in four-year-old children. In contrast, object control skills were found to not play in a role in children's PA patterns. Future research is needed to determine how different constructs of FMS are related to the PA of older children.

Larouche, Boyer, Tremblay, and Longmuir (2014) investigated the relationship between motor skill proficiency and pedometer-measured PA in 491 children in grades 4 to 6. FMS were measured using an obstacle course to assess each skill in a dynamic environment and was scored by overall time of completion; the pedometers were worn for seven consecutive days and a daily log sheet was used to record the number of steps taken per day. The results of this study indicated that having a higher score on the obstacle course had a weak, positive correlation with the average pedometer step counts. This indicates that those with more proficient motor skills also had higher levels of PA; thus, motor skill proficiency may be a factor that promotes PA.

The literature is able to demonstrate the relationship between motor skills and PA in children, where children who have more proficient motor skills are more physically active (Larouche et al., 2014; Okely et al., 2001). Despite the benefits that proficient motor skills can have with PA engagement in children, the relationship between motor proficiency and PA levels had not yet been established in adults. The relationship between balance and PA engagement has been studied in older adults (Louis et al., 2016), yet this relationship has not been studied in middle-aged adults. Due the link between motor proficiency and PA that is seen in children, this relationship could also be seen in adults; however, a gap in the literature surrounding this topic still exists and warrants further study.

Summary

The mother-child relationship is important to investigate in order to understand the behaviours in both parents and their children. A physically active lifestyle may allow for parents to be able to serve as a positive role model to their children. Motor skill proficiency has also been documented to influence PA engagement in children (Larouche et al., 2014; Lubans et al., 2010; Okely et al., 2001); however, this same relationship has not be established in adults. Understanding how motor skills can influence PA across a lifespan can provide information on what factors help to improve PA engagement in both children and adults.

Purpose

The purpose of this study was to examine how the PA patterns of mothers relates to the PA patterns of their children. In addition, this study also examined how the motor skills of mothers are related to their own PA levels. Lastly, the relationship between children's motor skills and PA levels was investigated. The following research questions were examined in this study:

1. Is there a relationship between the physical activity levels of mothers and their children?
2. Is there a relationship between motor proficiency and physical activity in mothers?
3. Is there a relationship between fundamental motor skill proficiency and physical activity in children?

Methods

Study Design

The study design consisted of a cross-sectional methodology in order to assess each participant at one point in time. Prior to study commencement, ethical approval was obtained by the University of Ontario Institute of Technology Research Ethics Board (UOIT-REB #14097; Appendix 1) on October 16th, 2016. Once approval was obtained, the study required that one mother, and one child attend a motor skill assessment session that lasted approximately 90 minutes. Upon arrival to this session, the mothers provided written informed consent for their own participation, as well as for their child's participation in the study, and children provided child assent to participate (Appendices 2 to 4).

Recruitment

Participants were recruited by placing flyers (Appendix 5) at local recreational facilities, and churches. In addition, word-of-mouth and social media were used as other forms of participant recruitment.

Participants

This study included 19 children between the ages of 8 to 10 years, as well as 15 mothers, and one father. One family who volunteered included the father and the mother along with their two daughters; however, the father was excluded from the analysis because he was the only father who volunteered. This allowed for all analysis to be on mothers and their children. The inclusion criteria consisted of children between the ages of 8 to 10 years, and all children had typical development. No age restrictions were placed on the parents. Participants were excluded if they were non-ambulatory, had any developmental disabilities (e.g., Cerebral palsy, autism spectrum disorder, etc.), neurodegenerative conditions (e.g., Multiple sclerosis, Parkinson's disease, etc.), or any injuries that impacted their ability to walk.

Measurements

All measurements were conducted at the Motor Behaviour and Physical Activity Lab and all are described below. In addition, a supplemental information form was completed by each mother (Appendix 6).

Table 9. Mother and child physical activity and motor skill measures.

	Mother Measures	**Child Measures**
Motor skill assessments	• Developmental Coordination Disorder Questionnaire for Adults (DCDQ-A) • Adult Developmental Coordination Disorder/Dyspraxia Checklist (ADC) • Y-Balance Test Lower Quadrant	• Test of Gross Motor Development-2 (TGMD-2) • Developmental Coordination Disorder Questionnaire (DCDQ) • Y-Balance Test Lower Quadrant
Physical activity assessments	• Pedometer & pedometer step log • International Physical Activity Questionnaire (IPAQ)	• Pedometer and pedometer step log • International Physical Activity Questionnaire (IPAQ)
	Supplemental Information Form	

Child Motor Skill Measures

Test of Gross Motor Development – 2

The children had their motor skills assessed using the Test of Gross Motor Development – 2 (TGMD-2) (Ulrich, 2000). The TGMD-2 is a validated, motor skill assessment for children between that ages of three and ten years of age that evaluates the quality motor skill performance (Ulrich, 2000). The TGMD-2 assesses 12 fundamental motor skills that require the use of locomotor and object control skills (Ulrich, 2000). Object control skills include movements such as throwing, catching, striking, kicking, dribbling, and underhand rolling (Ulrich, 2000). In contrast, locomotor skills include running, sliding, galloping, jumping, hopping and leaping (Ulrich, 2000). Lastly, inter-rater reliability was conducted on 20 % of the participants to confirm that there was at least 80 % agreement between the two independent scorers.

Development Coordination Disorder Questionnaire

In addition to directly assessing motor proficiency in children, the Developmental Coordination Disorder Questionnaire (DCDQ) was used as a parent-report measure of motor skill proficiency (Appendix 7) (Wilson et al., 2009). The DCDQ is designed for the parents to report on their children’s motor proficiency to determine if their children are experiencing any movement difficulties, and is used for children between the ages of 5 and 15 (Wilson et al., 2009). The DCDQ was selected in order to understand how the mothers perceive their child’s motor skills.

Parent Motor Skill Measures

Developmental Coordination Disorder Questionnaire for Adults

The mothers completed the Developmental Coordination Disorder for Adults (DCDQ-A) where the mothers compared their motor skills to those of other adults (Appendix 9) (Cantell et al., 2008). This questionnaire is similar to the DCDQ because it measures motor proficiency and it includes other adult specific skills such as driving. Self-report questionnaires were used for the mothers in addition to objective motor skill assessments in order to triangulate the data.

Adult Developmental Coordination Disorders/Dyspraxia Checklist

The Adult Developmental Coordination Disorders/Dyspraxia Checklist (ADC) is a self-report questionnaire used to assess the motor ability of adults within a variety of environmental contexts (Appendix 10) (Kirby et al., 2010). The items assessed on the ADC cover the ability to organize in space and time during daily living and self-care tasks, academic and specialized tasks, as well as tasks that relate to hobbies and social participation (Kirby et al., 2010). The two subscales include childhood history and current motor ability (Kirby et al., 2010). Lastly, the ADC was found to have high levels of internal validity for both the whole questionnaire, as well as the subscales (Kirby et al., 2010).

Mother and Child Motor Skill and Physical Activity Measures

Pedometer

The mothers and children each wore a time-stamped pedometer (Omron Pocket Pedometer Model Number HJ-729ITCCAN) for seven days to measure the number of steps taken per day. In addition to the pedometer, both mothers and their children were given a pedometer step log to record the type and duration of PA (Appendices 20 and 21). This pedometer model has time-stamp abilities that measure steps taken per day, aerobic steps, acceleration and duration.

International Physical Activity Questionnaire

The mothers and children also completed the International Physical Activity Questionnaire Short Form (IPAQ) (Appendix 22) (Craig et al., 2003). The IPAQ is a reliable and valid self-reporting questionnaire that is used for individuals aged 15 to 69 years (Craig et al., 2003); however, its use has been documented in children (dos Santos Amorim, de Faria, Byrne, & Hills, 2006). It involves the use of four questionnaires to measure the amount of MVPA that individuals participate within the last seven days. The four questionnaires consists of questions pertaining to job-related PA, transportation PA, housework, maintenance and caring for family, and recreation, sport and leisure-time PA. Within each domain, the metabolic equivalent of task (MET) values were calculated. MET values above four indicated moderate levels of PA, and scores above eight indicated vigorous PA. In addition, the total PA METs were calculated by summing the total amount of walking METs with moderate and vigorous MET values. This questionnaire was used for both the mothers and the children in order to have consistent measures of PA.

Y – Balance Test Lower Quadrant

Dynamic balance was assessed in both the mothers and the children using the Y Balance Test (YBT) (Appendix 11). Prior to the test taking place, the primary investigator measured the limb length from the anterosuperior iliac spine to the ipsilateral medial malleolus (Hip to the inside of the ankle). The YBT is conducted barefoot with the toes placed behind the reach-direction line. The test consisted of the participants maintaining single-leg balance on one leg while reaching as far as possible with the contralateral leg in three different directions. A demonstration was provided for each participant, followed by four practice trials. Three test trials were conducted in each direction, and for each leg. The three directions are anterior, posteromedial, and posterolateral. In addition, all measurements was taken to the nearest 0.5 cm, with the maximum distance reached being the measurement used for the analyses. The reach distances were calculated in proportion to the length of the limb using the formula: (Reach distance/limb length) x 100 = Maximum reach distance. The YBT is a non-invasive, standard measure of dynamic balance commonly used in the kinesiology field.

Statistical Analysis

Descriptive statistics were calculated for all motor and PA variables by calculating the means and standard deviations. Furthermore, an independent samples t-test was conducted between the mother and child average steps per day to determine if there were any differences present between mother and child PA engagement. In order to determine if there were any relationships between mother and child PA, as well as FMS and PA, Pearson product correlations were performed on the following variables to answer the research questions:

Is there an association between the physical activity levels of mothers and their children?

- Mother and child IPAQ continuous scores.
- Mother and child average steps per day over seven days, weekend, and weekdays.
- Mother IPAQ continuous scores and child pedometer steps per day.
- Mother pedometer steps per day and child IPAQ continuous scores.

Is there an association between motor proficiency and physical activity in mothers?

- YBT reach percentage and the IPAQ continuous score.

- YBT reach percentage and the pedometer average steps per day.
- DCDQ-A total score and the IPAQ continuous score.
- DCDQ-A total score and the pedometer average steps per day.

Is there an association between fundamental motor skill proficiency and physical activity in children?

- TGMG-2 GMQ, locomotor and object control raw scores and the IPAQ continuous score.
- TGMD-2 variables and the pedometer average steps per day.
- DCDQ total score and the IPAQ continuous score.
- DCDQ total score and the pedometer average steps per day.

Lastly, a power calculation was performed between the average steps per day taken by the mothers on weekends and their YBT reach percentages of the anterior direction for the left leg (r=0.504). The results from this analysis yielded the smallest predicted sample size of 29 participants. Furthermore, effect sizes were also measured by using the correlation coefficients. The following guidelines were used to classify each effect size: small (r = 0.10), moderate (r = 0.30), and large (r = 0.50).

Results

The participant characteristics and descriptive statistics for both the children and the mothers are presented in Tables 10 – 13. The boys and girls had an average age of 8.80(±1.09) and 8.93(±0.917), respectively. The child participants were predominantly Caucasian, with the majority of the children being the first born in their families and were predominately from a high socioeconomic status.

Table 10. Mother and child participant characteristics.

Characteristics	**Participants** Mean(SD)
Children	
N	n=19
Age (years)	8.90(±0.94)
Ethnicity	Caucasian (n=13)
	Non-Caucasian (n=6)
Mothers	
N	N=15
Age (years)	42.25(±3.62)
Socioeconomic status	>$100,000/year (n=12)
	$60,000 – 99, 000 (n=4)

Table 11. Child descriptive statistics for the motor skill measures.

	Participants Mean(SD)		
Motor Skill Measures	Group average	Male (n=5)	Female (n=14)
TGMD-2 Locomotor Raw Score	42.42(±4.83)	42.60(±4.51)	42.36(±5.12)
TGMD-2 Locomotor Standard Score	10.05(±2.74)	10.00(±2.45)	10.07(±2.92)
TGMD-2 Object Control Raw Score	37.32(±7.10)	44.00(±2.30)	34.79(±6.48)
TGMD-2 Object Control Standard Score	8.42(±2.89)	10.40(±1.34)	7.71(±2.99)
TGMD-2 Gross Motor Quotient	95.42(±11.29)	101.20(±9.63)	93.36(±11.42)
DCDQ Control during Movement Score	26.58(±10.92)	18.40(±5.18)	26.89(12.62)
DCDQ Fine Motor/Handwriting Score	17.37(±2.77)	14.00(2.45)	18.57(±1.70)
DCDQ General Coordination Score	20.05(±4.52)	26.00(±4.30)	20.64(±4.31)
DCDQ Total Score	61.74(±9.50)	58.4(±9.92)	62.93(±9.43)
Right Leg YBT Anterior*	79.33(±8.84)	81.40(±7.65)	78.60(±9.38)
Right Leg YBT Posterolateral	119.09(±15.98)	123.82(±28.47)	117.40(±9.62)
Right Leg YBT Posteromedial	114.76(±13.57)	114.65(±11.50)	114.79(±14.64)
Left Leg YBT Anterior	81.05(±10.04)	88.52(±12.03)	78.38(±8.12)
Left Leg YBT Posterolateral	119.24(±12.55)	125.58(±15.14)	116.97(±11.26)
Left Leg YBT Posteromedial	118.29(±12.87)	123.72(±11.22)	116.35(±13.23)

*Reach percentage = [distance(cm)/limb length] x 100

Mothers self-reported to have proficient motor skills; however, their levels of dynamic balance were lower compared to their children (Table 8). In addition, the mothers took less steps per day compared to the children, except for the average steps on the weekends when compared to the girls; the mothers took more steps during the weekends. Despite having lower steps per day, mothers self-reported to be more physically active compared to girls.

Table 12. Descriptive statistics for the child physical activity measures.

Physical Activity Measures	Total	Males (n=5)	Females (n=14)
Average steps per day over seven days	9762.12 (±3371.49)	13,442.71 (±3704.29)	8447.62 (±2108.46)
Average steps per day on weekends	6649.56 (±3012.92)	8460.8 (±3347.73)	5894.88 (±2648.77)
Average steps per day on weekdays	10,720.05 (±3617.49)	14,830.77 (±3734.03)	9251.94 (±2238.05)
IPAQ continuous score (METs/min)	3822.63 (±2720.33)	4861.20 (±1802.30)	3451.71 (±2946.85)

Table 13. Mother descriptive statistics for the ADC, DCDQ-A, YBT, pedometer average steps per day, and the IPAQ

	Participants Mean(SD)
Motor Skill Measures	
DCDQ-A Total Score	68.4(5.19)
ADC Total Score	18.27(10.52)
Right Leg YBT Anterior*	67.83(6.99)
Right Leg YBT Posterolateral	107.87(11.30)
Right Leg YBT Posteromedial	106.27(11.04)
Left Leg YBT Anterior	68.49(7.67)
Left Leg YBT Posterolateral	108.27(11.52)
Left Leg YBT Posteromedial	105.86(11.98)
Physical Activity Measures	
Average steps per day over seven days	7003.54(±1415.08)
Average steps per day on weekends	7629.75(±2294.51)
Average steps per day on weekdays	6879.32(±1753.92)
IPAQ continuous score (METs min/week)	4384.50(±4602.90)

*Reach percentage = [distance(cm)/limb length] x 100

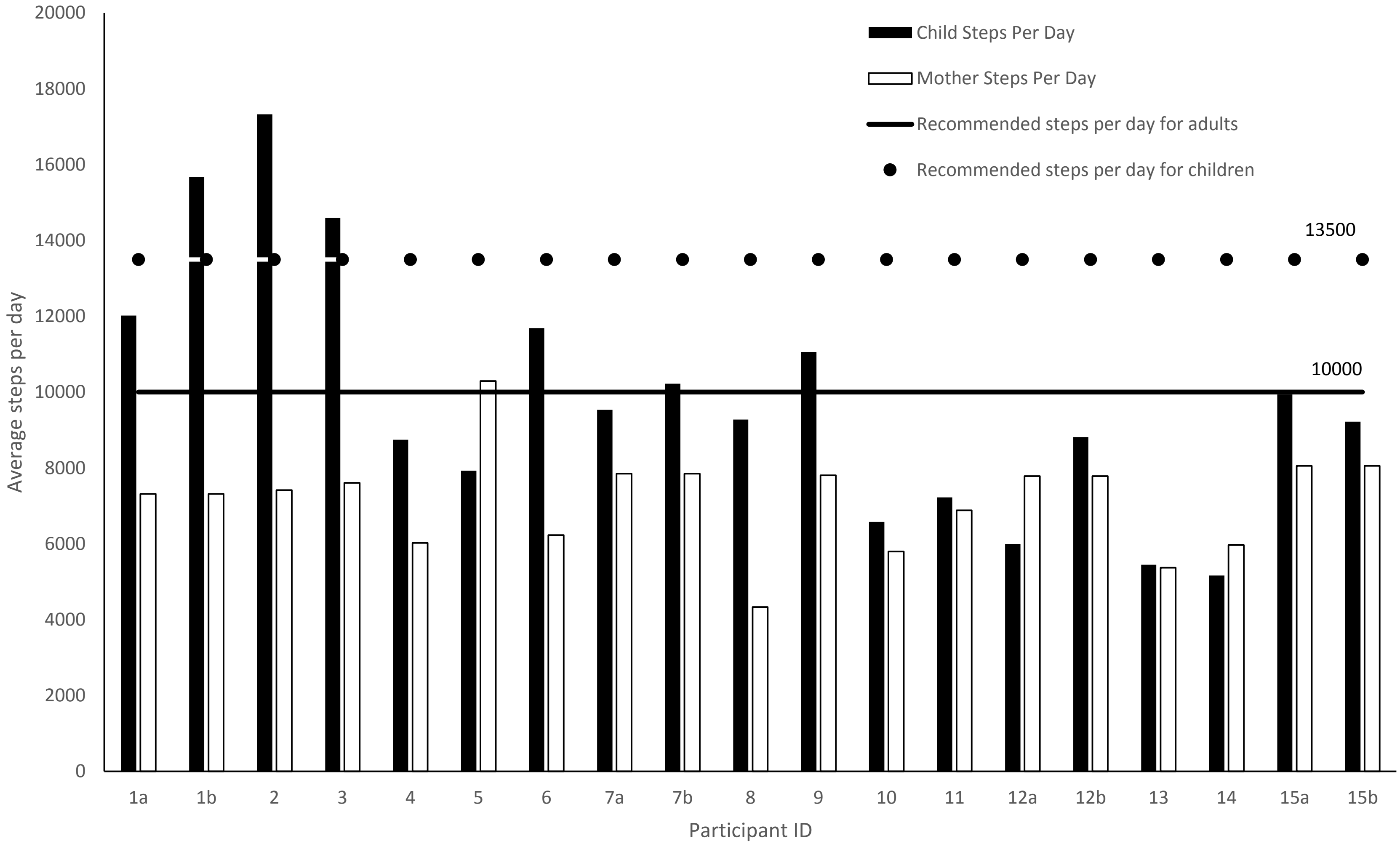


Figure 2. Average pedometer steps per day for mothers and their children

The relationship between mother physical activity and child physical activity.

An independent t-test was conducted between the mother and child steps per day over seven days, with the results showing that the mothers took 2,758.57 significantly less steps compared to the children, ($p = 0.006$). The results still showed that there were statistically significant differences between mother and child steps per day over seven days. The results shown include the outlier in the analysis. Concerning the difference in steps between mothers and children on weekdays, the mothers had less steps per day on weekdays (6879.31±1753.91) compared to their children (10, 702.05 ± 3617.49). A significant difference of 3,840.73 steps on the weekdays was seen between the mothers and the children ($p=<0.005$). Lastly, there were no statistically significant differences between the mother and child steps per day on the weekend.

The relationship between mother PA and child PA was investigated. Pearson product correlations were performed and the results are presented in Appendices 23 to 26. The results of these analyses demonstrate that there were no significant relationships present between the mother and child pedometer, or IPAQ, measures of PA. These results demonstrated small effect sizes between direct and indirect PA measures between mothers and children. Moderate effect sizes were seen between the average steps per day when separating by sex. Concerning self-reported PA, small and moderate effect sizes were noticed between mothers and their children. Lastly, self-reported PA in mothers was shown to have a moderate effect between the average steps per day of the children.

The relationship between child fundamental motor skills and physical activity

In order to assess the relationship between motor skills and PA in children, Pearson product correlations were conducted and the results are presented in Appendices 27 to 31.

The results indicate that there are no significant relationships between the IPAQ and the TGMD-2 in children. In addition, the average steps per day for the children was not related to the DCDQ, indicating that how the mothers perceived their children's motor skills is not related to their PA. Pearson product correlations were conducted between the TGMD-2 GMQ, locomotor and object control skills and the pedometer determined steps per day in children. The results demonstrated that there were no significant relationships between pedometer measured PA and FMS in children as a total sample. When separated by sex, the results indicate that there is a significant relationship between the GMQ and the steps per day on the weekends for boys (r=0.891, p=0.043), as well as, object control skills and steps per day on the weekdays (r=0.938, p=0.018) and over the entire seven days (r=0.901, p=0.037) (Table 14). Concerning girls, a significant, negative relationship was found between object control skills and the average steps taken during weekdays (r= -0.615, p=0.033) (Table 15). To reduce these relationships showing significance due to chance, a Bonferroni correction was applied to control for a type II alpha error and found that all results were not significant.

When observing the effect sizes between the IPAQ and the TGMD-2 variables, moderate effect sizes were found when separating by sex. Furthermore, only small effect sizes were noted between the IPAQ and the YBT reach percentages, the IPAQ and DCDQ scores, as well as between pedometer measured PA and the TGMD-2 variables. However, moderate effect sizes were seen between the steps per day on the weekends and the locomotor raw scores, between the steps per day on the weekdays and over seven days and object control raw scores. Moderate to large effect sizes were seen in boys between their pedometer measured PA, and the TGMD-2 variables; yet, when comparing the girls, there were only two moderate effects sizes and the remaining effect sizes were small. Lastly, there were only small effect sizes when comparing the DCDQ to the pedometer measured PA.

Table 14. Pearson product correlations between TMGD-2 GMQ, locomotor and object control raw scores and averages steps taken per day for boys.

Variable 1	Variable 2	R	p-value	Effect Size
Gross Motor Quotient	Male average steps per day over seven days	0.710	0.179	Large
	Male average steps per day on weekends	0.891	0.043*	Large
	Male average steps per day on weekdays	0.671	0.215	Large
Locomotor raw scores	Male average steps per day over seven days	0.428	0.472	Moderate
	Male average steps per day on weekends	0.828	0.083	Large
	Male average steps per day on weekdays	0.384	0.523	Moderate
Object control raw score	Male average steps per day over seven days	0.901	0.037*	Large
	Male average steps per day on weekends	0.562	0.324	Large
	Male average steps per day on weekdays	0.938	0.018*	Large

Table 15. Pearson product correlations between TMGD-2 GMQ, locomotor and object control raw scores and averages steps taken per day for girls.

Variable 1	Variable 2	R	p-value	Effect Size
Gross Motor Quotient	Female average steps per day over seven days	-0.397	0.160	Moderate
	Female average steps per day on weekends	-0.225	0.482	Small
	Female average steps per day on weekdays	-0.362	0.204	Moderate
Locomotor raw scores	Female average steps per day over seven days	-0.016	0.957	Small
	Female average steps per day on weekends	0.266	0.403	Small
	Female average steps per day on weekdays	-0.137	0.641	Small
Object control raw score	Female average steps per day over seven days	-0.423	0.131	Moderate
	Female average steps per day on weekends	-0.615	0.033*	Large
	Female average steps per day on weekdays	-0.255	0.379	Small

The relationship between mother motor proficiency and physical activity

The relationship between mother motor proficiency and PA was examined, and Pearson product correlations were performed. The results of these analyses are presented in Appendices 32 to 35. The results indicate that the neither the DCDQ-A or ADC was related to the mothers steps per day or the IPAQ. This indicates that how mothers perceive their motor proficiency was not significantly related to their self-reported or directly measured PA. Furthermore, the mothers YBT reach percentages were not related to their average steps per day indicating that their dynamic balance may not be related to their directly measured PA.

Significant, positive relationships were found between the mothers YBT maximum reach distances and the IPAQ. The results indicate that there were significant relationships between the posterolateral direction for the right (r=0.610, p=0.016) and left legs (r=0.633, p=0.011), posteromedial direction for the right (r=0.540, p=0.038) and left legs (r=0.570, p=0.026), and the anterior direction for the left leg (r=0.634, p=0.011). This indicates that there was a positive relationship found between self-reported PA and dynamic balance in mothers. Due to the number of correlations that were conducted, a Bonferroni correction was applied to control for a type II alpha error, resulting in all the results to be insignificant.

When considering the strength of these analyses, moderate to large effect sizes were found between the IPAQ and the YBT reach percentages, as well as between the steps per day on the weekends and the DCDQ-A and the YBT reach percentages for the right leg in both the anterior and posterolateral direction, as well as between the steps per day on the weekday and the YBT reach percentage for the left leg in the posterolateral direction.

Discussion

The primary purpose of this study was to determine if mothers' PA was related to their children's PA. In addition, the secondary research questions investigated how FMS impacted PA, separately, in children and mothers. Our results showed that there was no significant relationship between mother and child PA engagement. Furthermore, the results demonstrated that FMS in boys were found to be related to their steps per day on the weekends; additionally, their object control skills were related to the steps per day on both the weekends and throughout the whole seven days. For girls specifically, a negative relationship was found between their object control skills and the average steps taken during the weekdays. Lastly, significant relationships were found between the mothers' dynamic balance and their self-reported PA.

Boys had higher levels of PA, and were also more proficient in their motor proficiency. A significant relationship was found overall FMS proficiency and the average steps per day on the weekends for the boys, and between their object control skills and average steps per day on the weekdays and the average steps per day over the seven days. Our findings are consistent with other literature suggesting that relationships exist between the FMS and PA in boys (Hume et al., 2008; Lubans et al., 2010). Hume et al. (2008) found a weak significant relationship (r = 0.240) between object control scores and MVPA in 123 boys. Our results were able to uncover strong correlation (r=0.938) between object control skills, even though a small sample size was recruited. Boys may have higher object control skills because they may be participating in activities that require object control skills (Silva et al., 2017); therefore, they have the opportunity to continually practice these skills (Hume et al., 2008). The result of this study may indicate that object control skills are a critical skill for boys to lead a physically active lifestyle.

A significant relationship between FMS and PA in girls was also established; however, this was found to be a negative relationship between object control skills and the average steps taken per day during weekdays. The results indicate that girls with lower object control skills have higher PA levels. Our findings are supported by Barnett et al. (2013) who found an inverse association between participating in dance classes and object control skills in children. When girls participate in activities associated with locomotor skills (i.e., dance), this may result in fewer opportunities to develop object control skills. If girls are participating in activities that require locomotor skills, then they are able to continually practice their locomotor skills in greater detail compared to their object control skills; therefore, as a result, their object control skills may decline due to lack of practice.

Motor proficiency could also be an important factor that may influence the PA in adults. Our results indicate that a significant relationship existed between dynamic balance and self-reported PA in the mothers. Little is known about the relationship between balance and self-reported PA in middle-age adults; however, literature has been published on the impact of PA on balance in older adults. Louis et al. (2016) found that when the adults self-reported lower levels of PA, they also had lower levels of balance. However, this study recruited older adults, and our study had mothers with a mean age of 42 years. The differences in age may not allow for an adequate comparison between the participants in our study and the participants recruited by Louis et al. (2016). Therefore, more research is needed on the impact of dynamic balance and FMS, and self-reported PA in middle-aged adults.

The primary research question investigated the mother-child relationship between PA engagement. Our results demonstrated that mothers had significantly fewer steps per day on the weekdays and on average over the seven days compared to their sons and daughters. However, there were no significant relationships between mother and child PA engagement. This indicates that the PA patterns of mothers may not have an influence on their child's PA engagement; although, our results may have been influenced by our small sample size. Fuemmeler et al. (2011) found that after four days of accelerometer wear, mothers MVPA was associated with their children's PA. Furthermore, Craig et al. (2013) had their participants wear pedometers for seven days and found that an increase in steps per day for the mothers was associated with an increase in steps per day for their sons and daughters. Both Craig et al. (2013) and Fuemmeler et al. (2011) had large sample sizes which may contribute to the statistically significant findings. Therefore, future studies should focus on recruiting larger samples, as well as samples that are comprised of different ages, socioeconomic statuses, and ethnic groups. In addition, our study took place during November to the middle of December in Canada; therefore, our participants may not have been as active due to the cold weather suggesting that seasonal effects need to be considered. O'Neill, Lee, Yan, and Voorhees (2013) found a relationship between temperature and precipitation and PA in adolescents. Therefore, because the weather during the data collection period the children may have been less inclined to participate in outdoor activities and as a result, limiting the amount of PA.

The secondary research question examined the relationship between mother motor proficiency and PA, and identified that there were no significant relationships between self-reported motor proficiency and PA, or on dynamic balance and the average steps taken per day. This suggests that mothers self-reported motor proficiency is not related to their own PA engagement, and that dynamic balance is also not related to their average steps per day. Therefore, PA may not be influenced by dynamic balance in mothers because dynamic balance may not be a factor that promotes PA engagement in mothers. To the author's knowledge, there have been no known studies that examine the impact of motor proficiency on PA in middle-aged adults. Previous studies have reported that motor proficiency in childhood can predict PA in adulthood (Lloyd et al., 2014). However, the study by Lloyd et al. (2014) required the participants to recall their motor proficiency as a young adult, much may have resulted in recall-bias. Therefore, more research is needed to determine if motor proficiency in adults is related to their PA engagement.

Lastly, our results indicated that no significant relationships were identified between motor skills and self-reported PA in children. Our results differ from what was suggested by Barnett, Morgan, van Beurden, and Beard (2008) who found that children with proficient motor skills reported higher levels of self-reported PA in adolescence. Both our study, and Barnett et al. (2008), used self-reported measures to assess PA; however, we used the IPAQ short form. Although the IPAQ is validated for individuals between the ages of 15 and 69 years, other studies have used the IPAQ in children and adolescents that are younger than 15 years of age (dos Santos Amorim et al., 2006; Rääsk et al., 2017). Due to their age, the children in our study may have answered the questions based on the socially acceptable answer (Shephard, 2003). These children may understand that they need to be physically active; therefore, on the IPAQ they may have over-estimated their answers. Future studies should look to focus on validating the IPAQ for children. Lastly, how mothers perceived their child's motor proficiency was not related to their self-reported PA or average steps per day. This may be due to the mothers being unable to properly assess their child's motor proficiency. If mothers are not able to accurately assess what skills their children do not possess, they may not understand when to intervene to improve their children's motor proficiency.

Due to the exploratory nature of this study, effect sizes were calculated in order to understand the strength of the relationships that were analyzed. We found that there were moderate effect sizes between mother and child PA engagement. Despite the null result for PA engagement between mothers and their children, these moderate effect sizes can demonstrate significant strength for this relationship and statistically significant results could be seen with a larger sample. Furthermore, moderate effect sizes were seen between

FMS and PA engagement in children and between dynamic balance and self-reported PA in mothers. These effect sizes are important to note because they could indicate that a trend occurs between mother and child PA, as well as between motor proficiency and PA engagement in mothers and children; therefore, these relationships warrant future study.

Strengths and Limitations

As with any study there are several limitations to discuss. The YBT was a useful tool to help compare motor skills of mothers to their children; yet, the YBT only encompasses the body management construct and does not include any locomotor or object control measures. To our knowledge, there are no known motor skills assessments that can be used on adults 21 years and over; therefore, future research should explore creating an assessment tool that focuses on the FMS of individuals across all ages. Furthermore, our study was limited by a small sample size that included only mothers and a small amount of boys. Future studies should look to recruit fathers as well as aim to recruit an equal amount of boys to girls. These families were all from higher socioeconomic statuses, which could have also influenced our results. Lastly, the study took place during the winter months in Canada; therefore, the participants may have been less physically active due to the weather conditions.

This research is one of the first known studies that examines the relationship between FMS and PA in mothers; as a result, the strengths of this study include having the ability to objectively measure motor skills in adults by using the YBT. In addition, self-reported measures were able to be used triangulate the results with the objective PA measures. Concerning motor skill assessments, we were able to use the same direct motor assessment for both the mothers and the children. Similar to the PA measures, self-reported motor proficiency was also assessed to compliment the use of the object measures. Lastly, another strength of this study is that it adds to the current literature because there are no studies in the published literature that use the YBT as a motor skill assessment in order to compare the results between mothers and their children.

Future Research

Future research should investigate the impact of motor skills on the PA engagement in both mothers and their children. A large sample size should be recruited for these studies (Craig et al., 2013; Fuemmeler et al., 2011). The samples included for future studies should consist of children of all ages, from various socioeconomic and ethnic backgrounds in order to have a more holistic sample. This may be beneficial because researchers will be able to examine the impact that motor skills have on PA engagement across many age bands. Furthermore, future research should also demonstrate if there are links between FMS and PA, in both adults and children, by using accelerometers as a measure of PA. By understanding how FMS impacts PA engagement in both mothers and children, family-based interventions can be created to help facilitate motor skill development and PA engagement in both parents and their children. Longitudinal research may also be important to understand how the parental influence impacts motor skills and PA as their children age.

Furthermore, future studies should also look at the impact of FMS on the PA in children with disabilities, and investigate how the parent-child relationship can affect children with disabilities. Several parent-child relationships that are present for children with typical development, such as PA (Craig et al., 2013), may also be present for children with disabilities. Therefore, the parent-child relationship is an important dynamic to understand, in order to promote FMS and PA in both parents and their children.

Conclusion

In conclusion, the purpose of this study was to investigate the mother-child relationship between both pedometer-determined PA and self-reported PA. Moreover, the relationship between FMS and PA was examined for both mothers and their children. The results indicate that mother PA is not related to the PA engagement of their children. However, the children took more steps per day when compared to their mothers, and the mothers had higher self-reported PA compared to their children. When separated by sex, the TGMD-2 scores of the children was related to their average steps per day. This analysis also pointed out an interesting finding where a significant, negative relationship exists between object control skills and average steps per day over weekdays for girls. Lastly, YBT scores of the mothers was related to their self-reported PA. This results suggest that motor skills can influence PA in both mothers and their children; however, more research is needed to further investigate the mother-child relationship between FMS and PA by using validated motor skill assessments that are able to be used on individuals of all ages.

References

Barnett, L. M., Hinkley, T., Okely, A. D., & Salmon, J. (2013). Child, family and environmental correlates of children's motor skill proficiency. *Journal of Science and Medicine in Sport, 16*(4), 332-336. doi:10.1016/j.jsams.2012.08.011

Barnett, L. M., Morgan, P. J., van Beurden, E., & Beard, J. R. (2008). Perceived sports competence mediates the relationship between childhood motor skill proficiency and adolescent physical activity and fitness: a longitudinal assessment. *The International Journal of Behavioral Nutrition and Physical Activity, 5,* 40.

Biddle, S., & Goudas, M. (1996). Analysis of children's physical activity and its association with adult encouragement and social cognitive variables. *The Journal of School Health*, *66*(2), 75.

Cantell, M., Crawford, S. G., & Doyle-Baker, P. K. (2008). Physical fitness and health indices in children, adolescents and adults with high or low motor competence. *Human Movement Science, 27*(2), 344-362. doi:10.1016/j.humov.2008.02.007

Cliff, D. P., Okely, A. D., Smith, L. M., & McKeen, K. (2009). Relationships between fundamental movement skills and objectively measured physical activity in preschool children. *Pediatric Exercise Science, 21*(4), 436-449.

Colley, R. C., Garriguet, D., Janssen, I., Craig, C. L., Clarke, J., & Tremblay, M. S. (2011a). Physical activity of Canadian adults: Accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. *Health Reports*, *22*(1), 7-14. doi:10.1139/h07-130

Colley, R. C., Garriguet, D., Janssen, I., Craig, C. L., Clarke, J., & Tremblay, M. S. (2011b). Physical activity of Canadian children and youth: Accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. *Health Reports*, *22*(1), 15-23.

Craig, C. L., Cameron, C., & Tudor-Locke, C. (2013). Relationship between parent and child pedometer-determined physical activity: a sub-study of the CANPLAY surveillance study. *The International Journal of Behavioral Nutrition and Physical Activity, 10*, 8.

Craig, C. L., Marshall, A. L., Sjöström, M., Bauman, A. E., Booth, M. L., Ainsworth, B. E., . . . Oja, P. (2003). International physical activity questionnaire: 12-country reliability and validity. *Medicine and science in sports and exercise, 35*(8), 1381-1395. doi:10.1249/01.MSS.0000078924.61453.FB

dos Santos Amorim, P. R., de Faria, R. C., Byrne, N. M., & Hills, A. P. (2006). Physical activity and nutritional status of Brazilian children of low socioeconomic status: undernutrition and overweight. *Asia Pacific Journal of Clinical Nutrition, 15*(2), 217.

Fuemmeler, B. F., Anderson, C. B., & Masse, L. C. (2011). Parent-child relationship of directly measured physical activity. *The International Journal of Behavioral Nutrition and Physical Activity, 8*, 17.

Holfelder, B., & Schott, N. (2014). Relationship of fundamental movement skills and physical activity in children and adolescents: A systematic review. *Psychology of Sport and Exercise, 15*(4), 382-391. doi:http://dx.doi.org/10.1016/j.psychsport.2014.03.005

Hume, C., Okely, A., Bagley, S., Telford, A., Booth, M., Crawford, D., & Salmon, J. (2008). Does weight status influence associations between children's fundamental movement skills and physical activity? *Research Quarterly for Exercise and Sport, 79*(2), 158-165.

Iivonen, K. S., SÄÄKslahti, A. K., MehtÄLÄ, A., Villberg, J. J., Tammelin, T. H., Kulmala, J. S., & Poskiparta, M. (2013). Relationship between fundamental motor skills and physical activity in 4-year-old preschool children. *Perceptual & Motor Skills, 117*(2), 627-646. doi:10.2466/10.06.PMS.117x22z7

Kirby, A., Edwards, L., Sugden, D., & Rosenblum, S. (2010). The development and standardization of the Adult Developmental Co-ordination Disorders/Dyspraxia Checklist (ADC). *Research in Developmental Disabilities, 31*(1), 131-139. doi:10.1016/j.ridd.2009.08.010

Larouche, R., Boyer, C., Tremblay, M. S., & Longmuir, P. (2014). Physical fitness, motor skill, and physical activity relationships in grade 4 to 6 children. *Applied Physiology, Nutrition & Metabolism, 39*(5), 553-559 557p. doi:10.1139/apnm-2013-0371

Lloyd, M., Saunders, T. J., Bremer, E., & Tremblay, M. S. (2014). Long-term importance of fundamental motor skills: A 20-Year follow-up study. *Adapted Physical Activity Quarterly, 31*(1), 67-78.

Louis, E. D., Collins, K., Rohl, B., Morgan, S., Robakis, D., Huey, E. D., & Cosentino, S. (2016). Self-reported physical activity in essential tremor: Relationship with tremor, balance, and cognitive function. *Journal of the Neurological Sciences, 366*, 240-245. doi:http://dx.doi.org/10.1016/j.jns.2016.05.034

Lubans, D., Morgan, P., Cliff, D., Barnett, L., & Okely, A. (2010). Fundamental movement skills in children and adolescents. *Sports Medicine, 40*(12), 1019-1035. doi:10.2165/11536850-000000000-00000

O'Neill, A. H., Lee, S., Yan, A., & Voorhees, C. C. (2013). Association Between Weather and Physical Activity in Baltimore Teens. *Environment and Behavior, 45*(1), 138-151. doi:10.1177/0013916511415517

Okely, A. D., Booth, M. L., & Patterson, J. W. (2001). Relationship of physical activity to fundamental movement skills among adolescents. *Medicine and science in sports and exercise, 33*(11), 1899-1904. doi:10.1097/00005768-200111000-00015

Oliver, M., Schofield, G., & McEvoy, E. (2006). An integrated curriculum approach to increasing habitual physical activity in children: A feasibility study. *Journal of School Health, 76*(2), 74-79.

Olvera, N., Smith, D. W., Chanam, L., Jian, L., Jay, L., Jun-Hyun, K., & Kellam, S. F. (2011). Comparing High and Low Acculturated Mothers and Physical Activity in Hispanic Children. *Journal of Physical Activity & Health, 8*, S206-S213.

Paluska, S. A., & Schwenk, T. L. (2000). Physical Activity and Mental Health: Current Concepts. *Sports Medicine, 29*(3), 167-180.

Rääsk, T., Mäestu, J., Lätt, E., Jürimäe, J., Jürimäe, T., Vainik, U., & Konstabel, K. (2017). Comparison of IPAQ-SF and Two Other Physical Activity Questionnaires with Accelerometer in Adolescent Boys. *PLoS One, 12*(1). doi:10.1371/journal.pone.0169527

http://dx.doi.org/10.1371/journal.pone.0169527

Schofield, L., Mummery, W. K., & Schofield, G. (2005). Effects of a controlled pedometer-intervention trial for low-active adolescent girls. *Medicine and science in sports and exercise, 37*(8), 1414-1420. doi:10.1249/01.mss.0000174889.89600.e3

Shephard, R. J. (2003). Limits to the measurement of habitual physical activity by questionnaires. *British Journal of Sports Medicine, 37*(3), 197-206. doi:10.1136/bjsm.37.3.197

Tremblay, M. S., Warburton, D. E. R., Janssen, I., Paterson, D. H., Latimer, A. E., Rhodes, R. E., . . . Duggan, M. (2011). New Canadian physical activity guidelines. *Applied Physiology, Nutrition & Metabolism, 36*(1), 36-46. doi:10.1139/H11-009

Trudeau, F., & Shephard, R. J. (2008). Physical education, school physical activity, school sports and academic performance. *International Journal of Behavioral Nutrition and Physical Activity, 5*(1), 10.

Ulrich, D. A. (2000). *The test of gross motor development* (2nd ed.). Austin, Texas: Pro-Ed, Inc.

Vander Ploeg, K. A., Biao, W., McGavock, J., & Veugelers, P. J. (2012). Physical activity among Canadian children on school days and nonschool days. *Journal of Physical Activity & Health, 9*(8), 1138-1145.

Wilson, B. N., Crawford, S. G., Green, D., Roberts, G., Aylott, A., & Kaplan, B. J. (2009). Psychometric Properties of the Revised Developmental Coordination Disorder Questionnaire. *Physical & Occupational Therapy in Pediatrics*, *29*(2), 182-202. doi:10.1080/01942630902784761

CHAPTER 5: THESIS CONCLUSIONS

Thesis Conclusions

Summary

Physical activity (PA) is an important influence that promotes overall health (Colley et al., 2011a); however, despite the benefits from a physically active lifestyle, only 7% of children (Colley et al., 2011b) and 15% of adults (Colley et al., 2011a) meet the PA guidelines. To promote PA engagement in children, studies have shown that children who have more proficient fundamental motor skills (FMS) are more likely to be physically active (Barnett et al., 2009; Iivonen et al., 2013); therefore, to increase PA engagement in children, FMS may be key. The relationship between FMS and PA has been established in children (Barnett et al., 2009; Iivonen et al., 2013; Okely et al., 2001); however, the relationship between motor skills and PA has not been established in adults. Parents can also serve as a positive influence to promote PA engagement in their children (Craig et al., 2013; Fogelholm et al., 1999; Fuemmeler et al., 2011; Jago et al., 2014). Due to the link between FMS and PA in children, as well as the parent-child relationship between PA patterns, FMS in parents may play an important role to influence FMS proficiency in their children. To the best of our knowledge, a comprehensive study on the parent-child relationship between motor skill proficiency and PA has not been conducted, and warrants investigation. The purpose of this exploratory study was to investigate the relationship between mother and child motor proficiency and PA engagement.

The results indicated that motor skill proficiency of the mothers, was not related to the motor skill proficiency of their children. Due to these null results, this could be preliminary evidence to suggest that environmental factors, such as barriers to PA or parental beliefs surrounding PA and skill development, could also be factors that influence motor proficiency in children. Research suggests that children who demonstrate proficient motor skills are also more likely to have higher levels of PA engagement (Barnett et al., 2009). Therefore, if the environment is manipulated, providing increased opportunities to learn and practice skills that promote physical activity such as enrolling in dance or a sport of their choosing, this could promote the development of motor skills and PA patterns in children. In other words, for children whose parents do not engage in regular physical activity it is possible for these children to be quite skilled and active if they are exposed to an environment where their skills and activity are supported and fostered. Furthermore, if children with proficient motor skills are able to have opportunities to practice their skills, this could also strengthen their levels of perceived motor competence. Due to the benefits seen with proficient motor skills, the overall environment could be an important factor to consider when promoting physical activity in children.

Based on our results, the mother-child relationship between motor skill proficiency might be mediated by external factors, such as parental encouragement. Anderssen and Wold (1992) found that parental support for PA had a positive influence on the PA engagement of their children. PA is important for mothers and children because during these activities, they can receive the necessary opportunities to practice their motor skills. The importance of parental support for PA engagement supports our preliminary findings because the mothers in our study still likely encouraged their own children to be physically active, despite being physical inactive themselves. The mothers in this study had low physical activity levels and reported having average skill. Our findings indicate that just because a parent has low motor proficiency and PA levels, does not mean that their children will have the same behavioural patterns. The environment in which the child is raised has the potential to positively impact both the skill and the activity engagement.

When considering the nature and nurture aspects of this study, the nature side of the argument suggests that the children were inactive due to the biological influences they inherited from their mothers. In contrast, the nurture side of the argument suggests that the environment has a greater influence on motor proficiency. Biology could influence PA through genetic inheritance (Moore-Harrison & Lightfoot, 2010), however based on the results of this study it appears the environment is a greater driving force. For example, parental encouragement is known to have a positive influence on the PA engagement and motor skills of the children and likely played a factor even when the mothers themselves did not display high motor proficiency. Other environmental factors that could influence motor proficiency in children even when parent motor proficiency is not high include opportunities to participate in programs or teams that focus on motor skill development. Additionally, the built environment that allows a safe place for children to practice their motor skills, and physical education that provides a supportive environment for the acquisition and practice of skills. A structured environment can help to support the nurture aspect of the nature versus nurture relationship because children can receive the opportunity to practice their motor skills and engage in PA. Due to the ability for children to practice their motor skills, the environment can help to mediate their motor skill development. Although we found that there was no relationship between motor and child fundamental motor skills, this relationship needs to be studied further with a much larger sample size. Furthermore, the effects of the environment on the mother-child relationship between motor skill proficiency should be considered in future research.

Physical Inactivity and the WHO-ICF

The primary research questions of this study investigated the mother-child relationship between motor skills and PA. When considering the mother-child relationship between motor skills and PA, the activity and participation factors indicated by the World Health Organization International Classification of Functioning (WHO-ICF) was considered (WHO, 2001). The WHO-ICF is used to help provide a framework of health and health-related conditions, and is comprised of several components: Body Functions and Structures, and Activity and Participation (WHO, 2001). The activity component observes how well an individual is able to perform a task or movement, whereas, the participation component identifies what activities individuals choose to participate in. The activity component was important for this study because it encompassed how proficient the children and mothers were at their FMS. In contrast, the participation component includes the amount of PA the children and mothers engage in. Participation in PA is an important factor to FMS development because participation in PA provides opportunities for individuals to practice their FMS. The WHO-ICF also includes aspects that consider personal and environmental factors that influence physical inactivity. Personal factors can include aspects of individuals' lives that are not impacted by health, including age, sex, as well as racial and socioeconomic backgrounds; while environmental factors are the external surroundings where the individuals live and work. The components of the WHO-ICF help to understand the role of physical inactivity in individuals across a lifespan.

The preliminary results demonstrate that the environment could have a slightly greater influence on PA and FMS proficiency compared to personal factors and biology due to the lack of a relationship found between mothers and their children in terms of PA;

however, more research is needed with a much larger sample to replicate these preliminary findings. The lack of relationship between mother and child physical activity and motor skills, in this study, may indicate that PA and FMS proficiency can be can have an environmental influence alongside biology. Therefore, it is important that individuals have equal opportunity to environments where they are able to master their FMS, and in turn improve their PA engagement. This study can be applied to the WHO-ICF due to the relationship between the Activity and Participation components as seen with the influence of motor skills on PA between mothers and their children. However, more research is needed to determine to what extent the Environmental Factors and Body Structures and Functions could contribute to influence the Activity and Participation components.

Recommendations

The preliminary findings of this study warrant future research that should examine the mother-child relationship between motor skills and PA. Future studies should consider a longitudinal design in order to understand how this relationship changes as both children and mothers age. In addition, larger sample sizes that include a proportionate amount of girls to boys from various socioeconomic statuses and ethnic backgrounds. Furthermore, these samples should strive to include both mothers and fathers in order for researchers to be able to analyze the parent-child relationships with mothers and fathers separately.

The use of longitudinal studies can allow for researchers to understand how the parent-child relationship evolves with age. The participants in our study were children that were still in pre-pubescence, and as a result their motor skills may differ from their mothers because of the difference in body morphology. Morphology has been shown to impact motor proficiency in adolescence (Vandendriessche et al., 2012); therefore, it is important to understand how the morphology in children changes and how it affects the parent-child relationship between motor skill proficiency. Longitudinal research designs can help to create a timeline that illustrates the parent-child relationship between motor skill proficiency as children age and grow. Furthermore, by highlighting the differences the parent-child relationship as children age, interventions can be designed and tailored to the needs of each specific age band.

Recruiting larger samples may also benefit future studies because it will allow for a more heterogeneous sample. Future sample sizes should also strive for an equal number of boys to girls, as well as a greater number of individuals from various socioeconomic and ethnical backgrounds. By including a greater number of individuals from these populations, researchers could be able to understand how socioeconomic status and ethnic background influences the parent-child relationship between motor skills and PA. Moreover, by understanding how socioeconomic status and ethnical backgrounds can influence motor proficiency and PA, interventions can be created to potentially target individuals whose motor skills are influenced by these two factors. In addition, it is essential to include an equal number of boys to girls because gender has been shown to influence motor proficiency in children (Barnett et al., 2009). By including a proportionate amount of girls to boys, this could create a better understanding of how the parent-child relationship influences motor skills and PA. For example, our study had only five boys; therefore, this sample of boys may not have been representative of the whole population and could have contributed to the non-significant results.

Lastly, only one father agreed to participate in our study; however, because his data could not be compared to other fathers, his data was excluded. Other studies have documented that fathers can influence the PA of their children (Craig et al., 2013; Fuemmeler et al., 2011); therefore, future studies should try to recruit fathers as well as mothers. By recruiting fathers, researchers could be able to see the difference that mothers and fathers each have on the children's motor proficiency and PA engagement. Due to the potential differences between maternal and paternal influences, researchers should be aware of the potential implications of these differences on children.

Conclusion

In conclusion, the preliminary results from this study demonstrate that there is no relationship between mother and child motor proficiency and PA. Having an understanding of the relationship between mother and child FMS and PA can lead to future, family-based interventions to improve these skills in both mothers and their children. Furthermore, alongside biology, the environment may play an important role in FMS development in children and can be facilitated through positive parental encouragement. Our exploratory results show that the environment may provide a crucial role to influence between mother and child FMS and PA. If parents provide their children with opportunities and access to activities that promote FMS, they could be able to help ensure that their children are able to lead a physically active lifestyle.

References

Anderssen, N., & Wold, B. (1992). Parental and Peer Influences on Leisure-Time Physical Activity in Young Adolescents. *Research Quarterly for Exercise and Sport, 63*(4), 341-348.

Barnett, L. M., van Beurden, E., Morgan, P. J., Brooks, L. O., & Beard, J. R. (2009). Childhood Motor Skill Proficiency as a Predictor of Adolescent Physical Activity. *Journal of Adolescent Health, 44*(3), 252-259. doi:http://dx.doi.org/10.1016/j.jadohealth.2008.07.004

Colley, R. C., Garriguet, D., Janssen, I., Craig, C. L., Clarke, J., & Tremblay, M. S. (2011a). Physical activity of Canadian adults: Accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. *Health Reports, 22*(1), 7-14. doi:10.1139/h07-130

Colley, R. C., Garriguet, D., Janssen, I., Craig, C. L., Clarke, J., & Tremblay, M. S. (2011b). Physical activity of Canadian children and youth: Accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. *Health Reports, 22*(1), 15-23.

Craig, C. L., Cameron, C., & Tudor-Locke, C. (2013). Relationship between parent and child pedometer-determined physical activity: a sub-study of the CANPLAY surveillance study. *The International Journal of Behavioral Nutrition and Physical Activity, 10*, 8.

.

Fogelholm, M., Nuutinen, O., Pasanen, M., Myöhänen, E., & Säätelä, T. (1999). Parent–child relationship of physical activity patterns and obesity. *International Journal of Obesity & Related Metabolic Disorders, 23*(12), 1262.

Fuemmeler, B. F., Anderson, C. B., & Masse, L. C. (2011). Parent-child relationship of directly measured physical activity. *The International Journal of Behavioral Nutrition and Physical Activity, 8*, 17.

Iivonen, K. S., SÄÄKslahti, A. K., MehtÄLÄ, A., Villberg, J. J., Tammelin, T. H., Kulmala, J. S., & Poskiparta, M. (2013). Relationship between fundamental motor skills and physical activity in 4-year-old preschool children. *Perceptual & Motor Skills, 117*(2), 627-646. doi:10.2466/10.06.PMS.117x22z7

Jago, R., Sebire, S. J., Wood, L., Pool, L., Zahra, J., Thompson, J. L., & Lawlor, D. A. (2014). Associations between objectively assessed child and parental physical activity: a cross-sectional study of families with 5-6 year old children. *BMC Public Health, 14*, 655. doi:10.1186/1471-2458-14-655

Lubans, D., Morgan, P., Cliff, D., Barnett, L., & Okely, A. (2010). Fundamental movement skills in children and adolescents. *Sports Medicine*, *40*(12), 1019-1035. doi:10.2165/11536850-000000000-00000

Moore-Harrison, T., & Lightfoot, J. T. (2010). Driven to Be Inactive?—The Genetics of Physical Activity. *Progress in Molecular Biology and Translational Science*, *94*, 271–290. http://doi.org/10.1016/B978-0-12-375003-7.00010-8

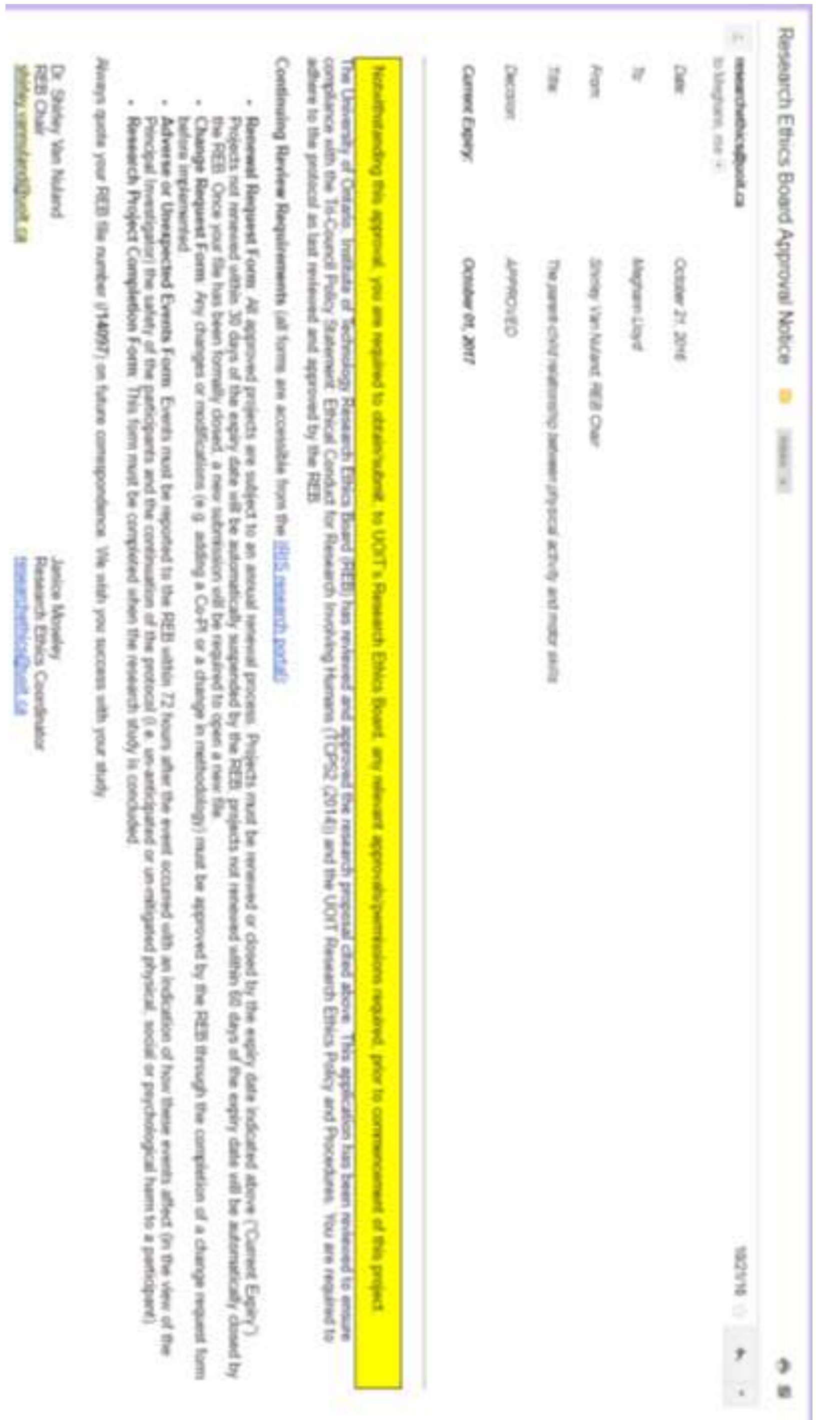
Okely, A. D., Booth, M. L., & Patterson, J. W. (2001). Relationship of physical activity to fundamental movement skills among adolescents. *Medicine and science in sports and exercise*, *33*(11), 1899-1904. doi:10.1097/00005768-200111000-00015

Vandendriessche, J. B., Vaeyens, R., Vandorpe, B., Lenoir, M., Lefevre, J., & Philippaerts, R. M. (2012). Biological maturation, morphology, fitness, and motor coordination as part of a selection strategy in the search for international youth soccer players (age 15-16 years). *Journal of Sports Sciences*, *30*(15), 1695-1703. doi:10.1080/02640414.2011.652654

WHO. (2001). *International Classification of Functioning, Disability and Health*. Geneva: World Health Organization.

Chapter 6: Appendices

Appendix 1: Certificate of Approval from the University of Ontario Institute of Technology Research Ethics Board



Research Ethics Board Approval Notice

researchethics@uoit.ca
to Megham, me

10/21/16

Date:	October 21, 2016
To:	Megham Lloyd
From:	Shirley Van Nuland, REB Chair
Title:	The parent-child relationship between physical activity and motor skills
Decision:	APPROVED
Current Expiry:	**October 01, 2017**

Notwithstanding this approval, you are required to obtain/submit, to UOIT's Research Ethics Board, any relevant approvals/permissions required, prior to commencement of this project.

The University of Ontario, Institute of Technology Research Ethics Board (REB) has reviewed and approved the research proposal cited above. This application has been reviewed to ensure compliance with the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS2 (2014)) and the UOIT Research Ethics Policy and Procedures. You are required to adhere to the protocol as last reviewed and approved by the REB.

Continuing Review Requirements (all forms are accessible from the IRIS research portal):

- **Renewal Request Form**: All approved projects are subject to an annual renewal process. Projects must be renewed or closed by the expiry date indicated above ("Current Expiry"). Projects not renewed within 30 days of the expiry date will be automatically suspended by the REB; projects not renewed within 60 days of the expiry date will be automatically closed by the REB. Once your file has been formally closed, a new submission will be required to open a new file.
- **Change Request Form**: Any changes or modifications (e.g. adding a Co-PI or a change in methodology) must be approved by the REB through the completion of a change request form before implemented.
- **Adverse or Unexpected Events Form**: Events must be reported to the REB within 72 hours after the event occurred with an indication of how these events affect (in the view of the Principal Investigator) the safety of the participants and the continuation of the protocol (i.e. un-anticipated or un-mitigated physical, social or psychological harm to a participant).
- **Research Project Completion Form**: This form must be completed when the research study is concluded.

Always quote your REB file number (**14097**) on future correspondence. We wish you success with your study.

Dr. Shirley Van Nuland
REB Chair
shirley.vannuland@uoit.ca

Janice Moseley
Research Ethics Coordinator
researchethics@uoit.ca

Appendix 2: Informed Consent for Parents

The parent-child relationship between motor skills and physical activity

Date: July 2016

Investigators:

Emma DePasquale
Principal Research Investigator
Faculty of Health Sciences
University of Ontario Institute Technology
(905) 721-8668, ext. 5988
Emma.depasquale@uoit.net

Meghann Lloyd
Faculty Supervisor
Faculty of Health Sciences
University of Ontario Institute of Technology
(905) 721-8668, ext. 5308
Meghann.lloyd@uoit.ca

Dear Parents,

I am currently a Master's student in Health Sciences at the University of Ontario Institute of Technology (UOIT), and as the Principal Research Investigator, I am inviting both you and your child(ren) to voluntarily participate in this study. The purpose of this study is to determine if parent motor skills are related to their children's motor skills. In addition, the relationship between parent physical activity levels and child physical activity levels will be observed. I am requesting your permission to participate in a 90 minute assessment session. This session will take place at the Motor Behaviour and Physical Activity Lab, and all sessions will be conducted by myself and one assistant. Within this session, you will complete two questionnaires pertaining to your motor skill proficiency, one questionnaire about your physical activity patterns, as well as a balance assessment test. Following this session, you will be given a pedometer to wear for seven days, as well as a pre-paid envelope to mail the pedometer back to the lab.

Background and Rationale:

The purpose of this study is to determine how parent and child motor skill abilities are related to each other; the secondary purpose is to investigate how parent and child physical activity are related. In addition, how children and parents perceive their motor skills, and how it affects their motor skills will also be investigated.

Why is this work important?

Physical activity engagement is an effective way to promote overall health. It is important to understand the physical patterns of both parents and their children. Fundamental motor skills are the basic skills (running, hopping, kicking, catching, and throwing) that can lead to more complex skills that are required to participate in sports and recreational activities. Children who are better at their fundamental motor skills also tend to be more physically active; however, it is not known how the motor skills of parents influence the motor skills of their children.

This relationship between fundamental motor skills and physical activity is well known for children, but we do not know how parent motor skills are related to their own physical activity. We know that physical activity for parents is important to promote their children's physical activity levels; this relationship may also exist for their fundamental motor skills. In addition, the fundamental motor skills of the parents may influence their own physical activity levels.

This study is important because both Canadian adults and children are becoming less active. The results from this study could help create future interventions and programs to help promote physical activity engagement and motor skill development.

Study Procedures:

The parents and children who are participating in the study will complete one assessment session that will last approximately 90 minutes in duration. The following measures are for the parents:

1. **Developmental Coordination Disorder Questionnaire for Adults (DCDQ-A):** The DCDQ-A is a self-reporting measure for you to compare your own motor skills to that of another adult.
2. **Adult Developmental Coordination Disorder/Dyspraxia Checklist (ADC):** The ADC is a self-reporting measure in order for you to report your motor ability within various environments.
3. **International Physical Activity Questionnaire (IPAQ) Short Form:** The IPAQ short form is a seven item questionnaire that is used to measure your physical activity within the last seven days.
4. **Y – Balance Test:** The Y – Balance Test will be used in order to evaluate dynamic postural control.
5. **Pedometer and Daily Activity Log:** A pedometer will be worn over the hip for a period of seven days following the 90-minute study sessions. This is to measure the

number of steps taken per day. The daily activity log will be used to record the type of physical activity that you participate in and for how long (ie. Biking for 30 minutes). A pre-paid self-addressed envelope will be provided for you to return the pedometer.

Risks and Benefits:
Your participation in this study does not pose any risk that differs from what would normally be encountered in daily life. All study personnel are trained in First Aid and CPR Level C with AED, and in the event of an injury, the facility's standard emergency procedures will be followed.

You will potentially benefit from this study because your PA engagement and motor skill proficiency will be identified. The results of this study could encourage you and your family to become or continue being physically active. In addition, the knowledge from this study could help to create future PA and motor skill interventions for both children and adults.

Are There Any Consequences for Not Participating?
No, this research study is completely voluntary. You may withdraw you and your child from the study at any time by telling the researchers, and you are not required to provide a reason for doing so. If after completing the assessment you do not want your data to be used, please contact me and I can delete your information.

Confidentiality:
The data collected in this study used for current research will be secured safely. All information that you and your child provide will be numbered and will not contain names. Overall results may be published for scientific purposes, but participant identity will remain confidential. Limits of this confidentiality include situations of suspected child abuse, concerns of harm to self or others, or any request for information by court order. After the study has concluded, all your data will be securely destroyed.

Right to Withdraw:
You are free to withdraw you and your child at any time without penalty. If you choose to withdraw, any data that has been collected from you or your child will be destroyed and will not be used in any analyses, publications or future research.

Dissemination:
At your request, you can receive a copy of the results from this study following its completion.

You can request a summary of your personal results once you have completed the assessment.

Questions about the study:
If you have any questions about this study or experience any discomfort related to the study, please contact the researcher Emma DePasquale at 905-721-8668, ext. 5988 or emma.depasquale@uoit.net, or Dr. Meghann Lloyd at 905-721-8668, ext. 5308. Any questions regarding your rights as a participant, complaints or adverse events may be addressed to the Research Ethics Board through the Ethics and Compliance Officer – researchethics@uoit.ca or (905) 721-8668 ext. 3693. This study has been approved by the University of Ontario Institute of Technology Research Ethics Board (REB) (REB# 14097), which is a committee of the university whose goal is to ensure the protection of the rights and welfare of people participating in research. The Board's work is not intended to replace a parent/guardian or child's judgement about what decisions and choices are best for you.

Informed Consent to Participate: The parent-child relationship between motor skills and physical activity

I, ____:
(Your Name)

- ☐ **Give consent** for my own participation in the above study.
- ☐ I wish to receive individual feedback from the results once the study has ended. If you checked this box to indicate that you would like to receive feedback from the results, please record either your email address or mailing address. Whichever method is more convenient to you to receive your Feedback Letter.

  Email Address: ____

OR

Mailing Address: ____

____

OR

- ☐ **Do not** give consent to my own participation in the above study

I have had the attached information sheet verbally explained to me, and have received a copy of this consent form. I have been fully informed of the details of the study and have had the opportunity to discuss my concerns. I understand that I am free to withdraw myself and my child at any time or bypass questions I choose not to answer.

________________________________ ________________________
Name of Participant Contact Phone Number

________________________________ ________________________
Signature of Participant Date

Principle Investigator: Emma DePasquale
Contact Information: Emma.depasquale@uoit.net or (905) 721-8668 ext.5988

____________________________________ ______________________________

Signature of Principle Investigator Date

Appendix 3: Informed Consent for Children

The parent-child relationship between motor skills and physical activity

Date: July 2016

Investigators:

Emma DePasquale
Principal Research Investigator
Faculty of Health Sciences
University of Ontario Institute Technology
(905) 721-8668, ext. 5988
Emma.depasquale@uoit.net

Meghann Lloyd
Faculty Supervisor
Faculty of Health Sciences
University of Ontario Institute of Technology
(905) 721-8668, ext. 5308
Meghann.lloyd@uoit.ca

Dear Parents,

I am currently a Master's student in Health Sciences at the University of Ontario Institute of Technology (UOIT), and as the Principal Research Investigator, I am inviting both you and your children to voluntarily participate in this study. The purpose of this study is to determine if children's motor skills are related to their parent's motor skills; and the relationship between parent physical activity levels and child physical activity levels. I am requesting your permission for your child and one of his or her parents/guardians to participate in a 90 minute assessment session (there will be a separate consent for parents). This session will take place at the Motor Behaviour and Physical Activity Lab (202 Simcoe St N), and all sessions will be conducted by myself and one assistant. Within this session, the children will complete one motor assessment tool that will focus on their motor skills, one balance test, as well as two questionnaires. Following this session, your child will be given a pedometer to wear for seven days along with a pre-paid, self-addressed envelope to send the pedometer back to us.

Background and Rationale:

The purpose of this study is to determine how parent and child motor skill abilities are related to each other; the secondary purpose is to investigate how parent and child physical activity are related. In addition, how children and parents perceive their motor skills, and how it affects their motor skills will also be investigated.

Why is this work important?

Physical activity engagement is an effective way to promote overall health. It is important to understand the physical patterns of both parents and their children. Fundamental motor skills are the basic skills (running, hopping, kicking, catching, and throwing) that can lead to more complex skills that are required to participate in sports and recreational activities. Children who are better at their fundamental motor skills also tend to be more physically active; however, it is not known how the motor skills of parents influence the motor skills of their children.

This relationship between fundamental motor skills and physical activity is well known for children, but we do not know how parent motor skills are related to their own physical activity. We know that physical activity for parents is important to promote their children's physical activity levels; this relationship may also exist for their fundamental motor skills. In addition, the fundamental motor skills of the parents may influence their own physical activity levels.

This study is important because both Canadian adults and children are becoming less active. The results from this study could help create future interventions and programs to help promote physical activity engagement and motor skill development.

Study Procedures:

The parents and children who are participating in the study will complete one assessment session that will last approximately 90 minutes in duration. During the assessment, the following measures will be used for the children:

1. **Test of Gross Motor Development – 2 (TGMD-2):** The TGMD-2 will be used to establish an objective measurement of your child's fundamental motor skill proficiency. Your child will be videotaped and their movements will be scored later.
2. **Y – Balance Test:** The Y – Balance Test will be used in order to evaluate dynamic postural control.

3. **Developmental Coordination Disorder Questionnaire (DCDQ):** The DCDQ is a parent-report measure in order for the parents to report on their children's motor abilities.
4. **Pictorial Scale for Perceived Movement Skill Competence for Young Children (PSPM):** The PSPM is a self-reporting tool that is based off of the components of the TGMD-2. For this tool, children are asked choose if their movement ability is like one of two pictures. One picture is of a child who does not appear to be skilled, and the other picture is of a child who does appear to be skilled.
5. **Pedometer and Daily Activity Log:** The pedometer is a small device that is worn on the hip and will track the number of steps taken per day to measure physical activity. The daily activity log will be used for your children to record the type of physical activity they participated in and for how long (ie. Biking for 30 minutes). A pre-paid self-addressed envelope will be provided for you to return the pedometer.
6. **International Physical Activity Questionnaire Short Form:** The IPAQ short form is a seven item questionnaire that is used to measure physical activity within the last seven days.
7. **Supplemental Information Form:** The supplemental information form will be used in order to understand the demographic and developmental information of each family.

Risks and Benefits:

Your child's participation in this study does not pose any risk that differs from what they would normally encounter in daily life (e.g. playground play, physical education class). During the TGMD-2 there is a risk of tripping or falling; however, the children will be instructed to complete each component of this task to their fullest ability while keeping their safety in mind. All study personnel are trained in First Aid and CPR Level C with AED, and in the event of an injury, the facility's standard emergency procedures will be followed.

Your children will potentially benefit from this study because physical activity engagement and motor skill proficiency will be identified. The results of this study could encourage you and your family to become or continue being physically active.

Are There Any Consequences for Not Participating?

No, this research study is completely voluntary. You may withdraw your child from the study at any time by telling the researchers, and you are not required to provide a reason for doing so. If after completing the assessment you do not want your data to be used, please contact us and we can delete your information.

Confidentiality:
The data collected in this study used for current research will be secured safely. All information that you and your child provide will be de-identified and will not contain names. Overall results may be published for scientific purposes, but participant identity will remain confidential. Limits of this confidentiality include situations of suspected child abuse, concerns of harm to self or others, or any request for information by court order. After the study has concluded, your data will be destroyed.

Right to Withdraw:
You are free to withdraw you and your child at any time without penalty. If you choose to withdraw, any data that has been collected from you or your child will be destroyed and will not be used in any analyses, publications or future research.

Dissemination:
At your request, you can receive a copy of the results from this study following its completion.
You can request a summary of your child's personal results once he or she has completed the assessment session.

Questions about the study:
If you have any questions about this study, please contact Emma DePasquale at 905-721-8668, ext. 5988, or Dr. Meghann Lloyd at 905-721-8668, ext. 5308. This study has been reviewed by the University of Ontario Institute of Technology Research Ethics Board (REB# 14097), which is a committee of the university whose goal is to ensure the protection of the rights and welfare of people participating in research. The Board's work is not intended to replace a parent/guardian or child's judgement about what decisions and choices are best for you. If you have any questions about you or your child's rights as a research participant you may contact the University of Ontario Institute of Technology Research Ethics Board at 2000 Simcoe St. N., Oshawa, ON, L1H 7K4, 905-721-8668, ext. 3693 or compliance@uoit.ca.

Informed Consent to Participate: The parent-child relationship between motor skills and physical activity

I, ____,
(Your Name)

the parent/guardian of ____:
(Your Child's Name)

- ☐ **Give consent** to my child's participation in the above study.
- ☐ **Give consent** for my child to be video recorded during the motor skill testing.
- ☐ I wish to receive my child's results once the study has ended. If you checked this box to indicate that you would like to receive feedback from the results, please record either your email address or mailing address. Whichever method is more convenient to you to receive your Feedback Letter.

  Email Address: ____

  OR

  Mailing Address: ____

  ____

OR

- ☐ **Do not** give consent to my child's participation in the above study

I have had the attached information sheet verbally explained to me, and have received a copy of this consent form. I have been fully informed of the details of the study and have had the opportunity to discuss my concerns. I understand that I am free to withdraw myself and my child at any time or not answer questions.

____
Name of Child

______________________________ ______________________
Name of Parent/Guardian Contact Phone Number

______________________________ ______________________

Signature of Parent/Guardian Date

Principle Investigator: Emma DePasquale
Contact Information: Emma.depasquale@uoit.net or (905) 721-8668 ext.5988

Signature of Principle Investigator Date

Appendix 4: Child Assent

Child Assent Form

Hi ________________, your mom/dad/guardian has said that it is okay for you to be part of my research project; but first I want to ask you if it is okay with you. The reason we are doing this project is to help us understand how your running, throwing, and kicking are related to your mom and dad's activities. Also, we would like to see how your parents' physical activity levels related to your physical activity levels.

We will ask you to show us how you run, throw, jump, kick, and all other sorts of skills, as well as answer a few questions about your physical activity levels. When you are all finished with the assessment, you get to wear a pedometer on your hip for seven days which counts how many steps you take in a day.

You do not have to participate if you do not want to, and the information you tell us will not be shared with anyone except you and your parents. You can decide to stop the study at any time.

Do you want to participate in this project? ____________ yes ____________ no

Is it okay if we video-tape you when you show us your motor skills? ____ yes _____ no

Appendix 5: Recruitment Flyer

This study has been approved by the UOIT Research Ethics Board (REB) (REB# 14097) on October 16th, 2016.

UNIVERSITY OF ONTARIO INSTITUTE OF TECHNOLOGY

How are your PHYSICAL ACTIVITY levels and MOTOR SKILLS related??

One 90-minute session and that's it!

Children ages 8 to 10 and one parent/guardian

Study for Children & their Parents

For more information about this, please contact

Emma DePasquale:
(905) 721-8668 ext: 5988
Emma.depasquale@uoit.ca
Dr. Meghann Lloyd
(905) 721-8668 ext: 5308
Meghann.lloyd@uoit.ca

A series of fun assessments for you & your kids!

Appendix 6: Supplemental Information Form

Supplemental Information Form

This form includes questions about your child that will help to describe the information learned through this study and identify factors that may relate to children's rate of progress and development. Please feel free to ask questions if you would like further clarification. In addition, the primary investigator of this research project commits to the highest level of privacy and confidentiality.

1. Participant ID#: ____

2. Birth date: ______________________________ (day, month, year)

3. Does your child have any medical diagnoses?

____

4. At what age did your child receive their diagnosis? ______________________________

5. Please indicate the number of siblings your child has and his or her birth order:

#siblings: _________ birth order: ______________

6. Has a doctor/physician or other health care provider told you that there are specific types of physical activity your child should not participate in? If yes, please specify.

____

7. Has your child also been diagnosed with any of the following?

□ Anxiety
□ Attention Deficit Disorder
□ Attention Deficit Hyperactivity Disorder
□ Development Delay
□ Epilepsy
□ Intellectual Disability
□ Learning Disability
□ Operational Defiant Disorder
□ Seizures
□ Sensory Integration Disorder
□ Visual Problems

□ Other:___________________

8. Is your child receiving any motor interventions, or has he or she received any motor interventions in the last six months? If yes, please specify from what age and the duration.

____

____

____

9. Please list any medications your child is currently taking:

____

____

10. Please self-declare your child's ethnicity using the options below:

□ Aboriginal
□ Arab/West Asian
□ Black
□ Chinese
□ Filipino
□ Japanese
□ Korean
□ Latin American
□ South Asian
□ Southeast Asian
□ White
□ Undeclared
□ Other:

11. Please indicate the approximate time (in hours) per day on average your child is sedentary for a typical weekday and weekend (ie. The time your child is not active, sitting time, TV time, etc).

Weekday: ________________ Weekend: ______________

12. Please indicate the approximate time (in hours) per day on average your child is involved in screen time:

TV: _____________________ Computer: _______________

Video games: _______________ Other: _____________________

13. Please estimate the annual household income (optional):

□ Under $20,000

□ $20,000 - $39,000

□ $40,000 - $59,000

□ $60,000 - $79,000

□ $80,000 - $99,000

□ Over $100,000

14. Please indicate any sport or recreational programs your child participate in on a regular basis, as well as the duration and frequency of the program (how many days per week, and for how long each session):

____

____

____

Appendix 7: Developmental Coordination Disorder Questionnaire

COORDINATION QUESTIONNAIRE (REVISED 2007)

			Year	Mon	Day
Participant ID#:	______________	Today's Date:			
Person completing Questionnaire	______________	Child's Birth:			
Relationship to child:	______________	Child's Age:			

Most of the motor skills that this questionnaire asks about are things that your child does with his or her hands, or when moving.
A child's coordination may improve each year as they grow and develop. For this reason, it will be easier for you to answer the questions if you think about other children that you know who *are the same age as your child*.
Please compare the degree of coordination your child has with other children of the same age when answering the questions.
Circle the one number that best describes your child. If you change your answer and want to circle another number, please circle the correct response twice.
If you are unclear about the meaning of a question, or about how you would answer a question to best describe your child, please call__________________________ at __________________ for assistance.

Not at all like your child	A bit like your child	Moderately like your child	Quite a bit like your child	Extremely like your child
1	2	3	4	5

1. Your child *throws a ball* in a controlled and accurate fashion.

   1 2 3 4 5

2. Your child *catches* a small *ball* (e.g., tennis ball size) thrown from a distance of 6 to 8 feet (1.8 to 2.4 meters).

   1 2 3 4 5

3. Your child *hits* an approaching *ball* or *birdie* with a bat or racquet accurately.

   1 2 3 4 5

4. Your child *jumps* easily *over* obstacles found in garden or play environment.

   1 2 3 4 5

5. Your child *runs* as fast and in a *similar* way to other children of the same gender and age.

   1 2 3 4 5

6. If your child has a *plan* to do a motor *activity*, he/she can organize his/her body to follow the plan and effectively complete the task (e.g., building a cardboard or cushion "fort," moving on playground equipment, building a house or a structure with blocks, or using craft materials).

   1 2 3 4 5 **(OVER)**

 www.dcdq.ca

	Not at all like your child 1	A bit like your child 2	Moderately like your child 3	Quite a bit like your child 4	Extremely like your child 5

7. Your child's printing or *writing* or drawing in class is *fast* enough to keep up with the rest of the children in the class.

1 2 3 4 5

8. Your child's printing or *writing* letters, numbers and words is *legible*, precise and accurate or, if your child is not yet printing, he or she *colors and draws* in a coordinated way and makes pictures that you can recognize.

1 2 3 4 5

9. Your child uses appropriate *effort* or tension when printing or writing or drawing (no excessive *pressure* or tightness of grasp on the pencil, writing is not too heavy or dark, or too light).

1 2 3 4 5

10. Your child *cuts* out pictures and *shapes* accurately and easily.

1 2 3 4 5

11. Your child is interested in and *likes* participating in *sports or active* games requiring good motor skills.

1 2 3 4 5

12. Your child learns *new motor tasks* (e.g., swimming, rollerblading) easily and does not require more practice or time than other children to achieve the same level of skill.

1 2 3 4 5

13. Your child is *quick and competent* in tidying up, putting on shoes, tying shoes, dressing, etc.

1 2 3 4 5

14. Your child would *never* be described as a *"bull in a china shop"* (that is, appears so clumsy that he or she might break fragile things in a small room).

1 2 3 4 5

15. Your child does *not fatigue easily* or appear to slouch and "fall out" of the chair if required to sit for long periods.

1 2 3 4 5

Thank you.

COORDINATION QUESTIONNAIRE (DCDQ'07): SCORE SHEET

Name: ______________________ **Date:** ____________

Birth Date: ______________________ **Age:** ____________

	Control During Movement	Fine Motor/ Handwriting	General Coordination
1. Throws ball			
2. Catches ball			
3. Hits ball/birdie			
4. Jumps over			
5. Runs			
6. Plans activity			
7. Writing fast			
8. Writing legibly			
9. Effort and pressure			
10. Cuts			
11. Likes sports			
12. Learning new skills			
13. Quick and competent			
14. "Bull in shop"			
15. Does not fatigue			

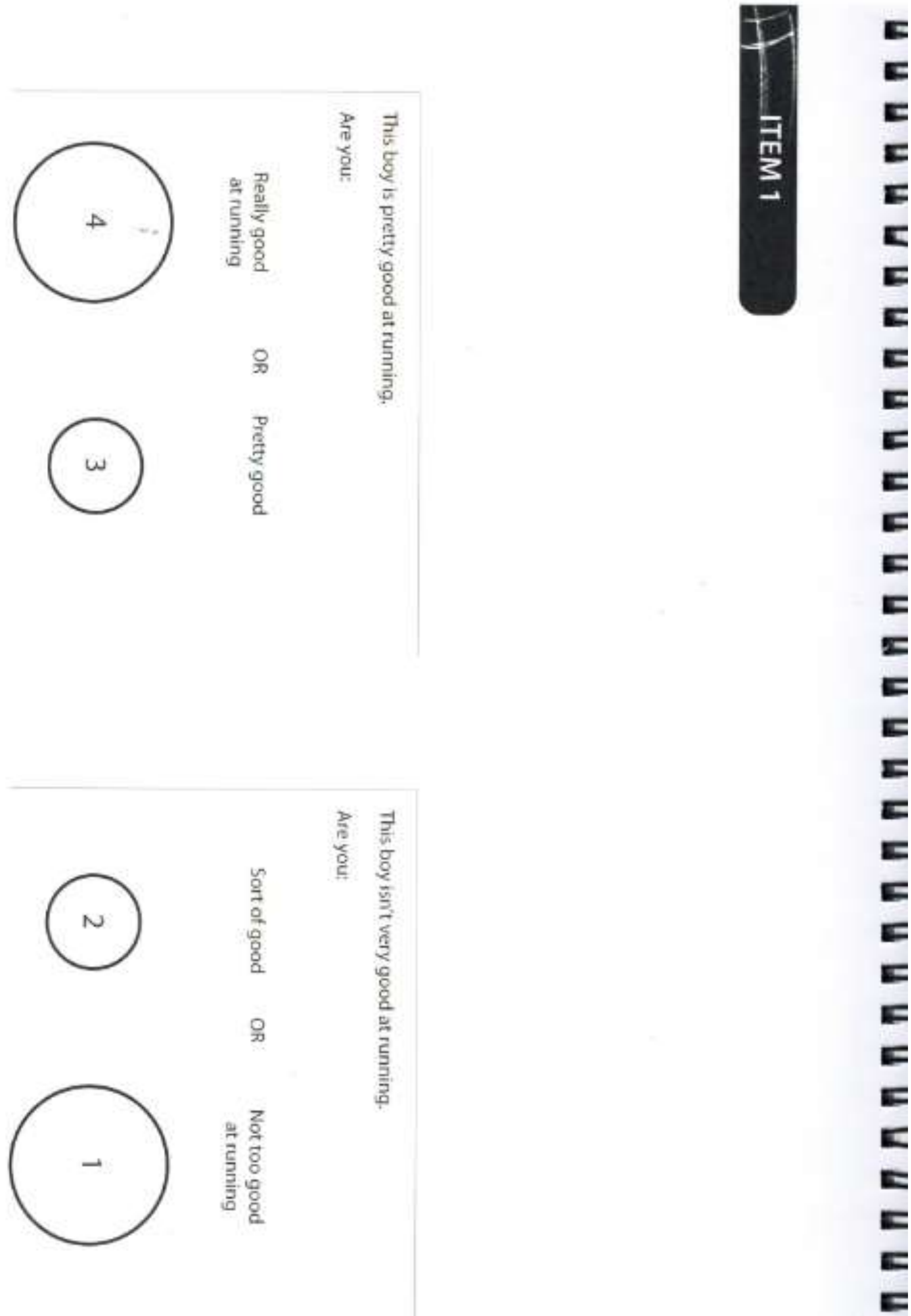
TOTAL ____ / 30 Control during Movement + ____ / 20 Fine Motor/ Handwriting + ____ / 25 General Coordination = ____ / 75 **TOTAL**

For Children Ages 5 years 0 months to 7 years 11 months
15-46 indication of DCD or suspect DCD
47-75 probably not DCD

For Children Ages 8 years 0 months to 9 years 11 months
15-55 indication of DCD or suspect DCD
56-75 probably not DCD

For Children Ages 10 years 0 months to 15 years
15-57 indication of DCD or suspect DCD
58-75 probably not DCD

Appendix 8: The Pictorial Scale for Perceived Movement Skill Competence



ITEM 1

This boy is pretty good at running.

Are you:

Really good at running OR Pretty good

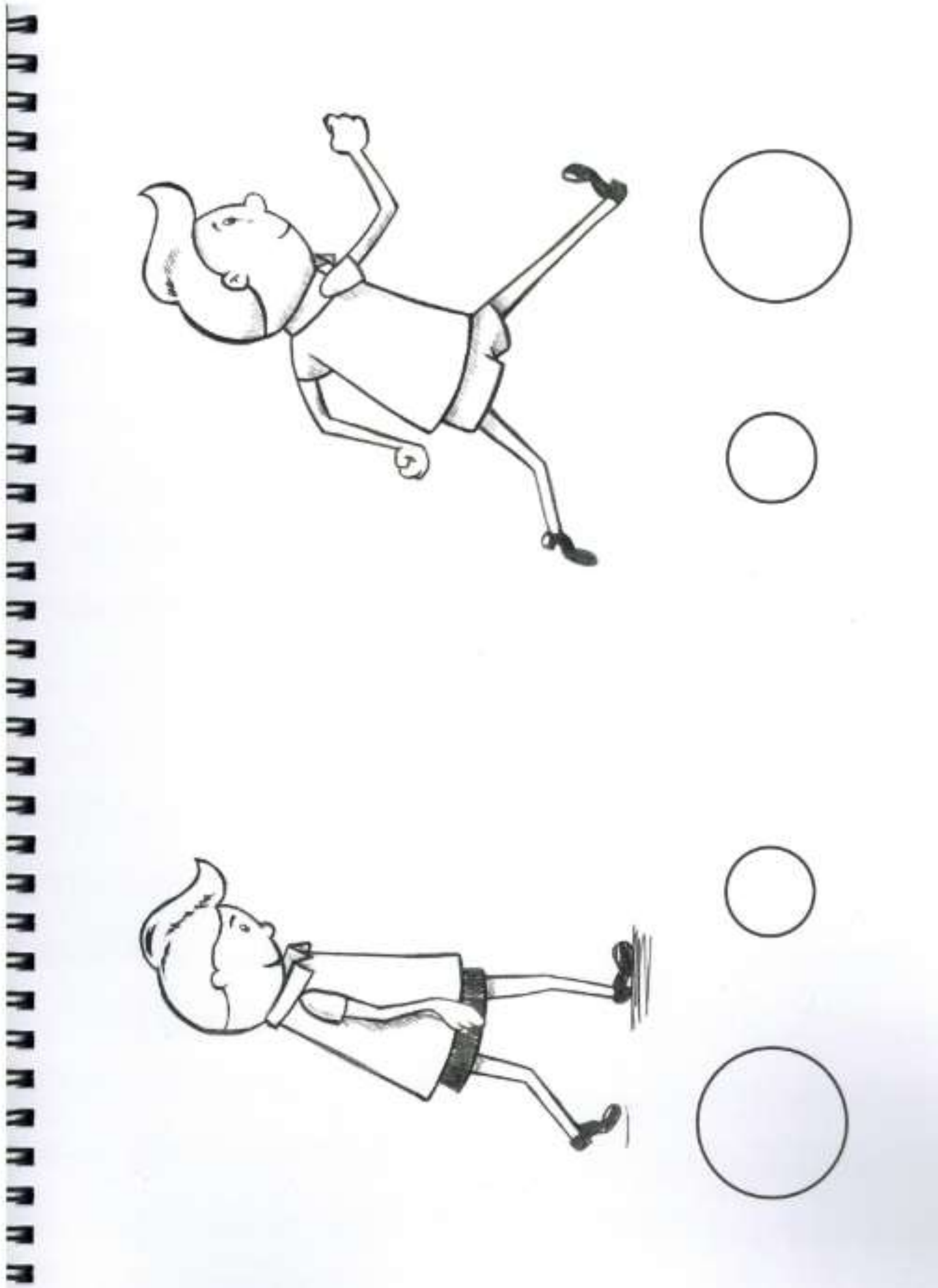
4 3

This boy isn't very good at running.

Are you:

Sort of good OR Not too good at running

2 1



PICTORIAL SCALE OF PERCEIVED MOVEMENT COMPETENCE

ALL 18 SKILLS

Individual Recording and Scoring Sheet.

SCHOOL: ______________________________

Participant ID#: ____

Grade:__________________________ Age: _______

Gender (*circle*): Male Female Date: ________________________

Comments:

(*Please put any comment you feel is relevant to results interpretation: i.e. child found it hard to choose between a certain skill picture, child completed quickly and easily, child was distracted, child didn't understand a certain skill and I needed to demonstrate, child seemed confused by reverse pictures etc.):*

____

____

____

____

____

____

____

Emma L. M. DePasquale (2017)

Not Very Good =1, Sort of Good = 2,

Pretty Good = 3, Really Good = 4

Item Order and Descriptions	**Have you tried?**	**Circle the score for that item.** *Note: reverse order items.*			
1. RUNNING	Y / N	4	3	2	1
2. THROWING	Y / N	4	3	2	1
3. GALLOPING (Reverse Order)	Y / N	1	2	3	4
4. CATCHING (Reverse Order)	Y / N	1	2	3	4
5. HOPPING	Y / N	4	3	2	1
6. ROLLING	Y / N	4	3	2	1
7. LEAPING (Reverse Order)	Y / N	1	2	3	4
8. KICKING (Reverse Order)	Y / N	1	2	3	4
9. JUMPING	Y / N	4	3	2	1
10. HITTING	Y / N	4	3	2	1
11. STEPPING AND SLIDING (Reverse Order)	Y / N	1	2	3	4
12. BOUNCING (Reverse Order)	Y / N	1	2	3	4
13. BIKE RIDING	Y / N	4	3	2	1

14.SCOOTERING (Reverse Order)	Y / N	1	2	3	4
15.BOOGIE BOARDING	Y / N	4	3	2	1
16.SKATING (Reverse Order)	Y / N	1	2	3	4
17.SWIMMING	Y / N	4	3	2	1
18.ROPE CLIMBING (Reverse Order)	Y / N	1	2	3	4

Appendix 9: Developmental Coordination Disorder Questionnaire for Adults

COORDINATION QUESTIONNAIRE FOR ADULTS

(DCDQ-A)

Participant ID#:_________________________________Today's date:___________________

It may make it easier for you to answer these questions if you think about other adults who are about the same age as you. Please compare the degree of coordination you have with other people and circle the number that best describes yourself.

	Not at all like you	A bit like you	Moderately like you	Quite a bit like you	Extremely like you
	1	**2**	**3**	**4**	**5**

1. I *throw a ball* in a controlled and accurate fashion, compared to other adults.

   1 2 3 4 5

2. I *catch* a small *ball* (e.g., tennis ball size) thrown from a distance of 8 to 12 feet, as well as other adults.

   1 2 3 4 5

3. I *hit* an approaching *ball* or *birdie* with a bat or racquet as accurately as other adults.

   1 2 3 4 5

4. I *run* easily *and* smoothly, and can *stop* with control.

   1 2 3 4 5

5. If I have a *plan to do an activity*, like building a simple object, assembling furniture from instructions, or making a craft, I can organise myself to follow the plan and effectively complete the task.

1 2 3 4 5

6. My w*riting* is *fast* enough to make notes in a meeting or lecture, and to be useful at home (if you use a keyboard rather than write, please circle #1 or #2 – depending on how much you write).

1 2 3 4 5

7. *Writing* letters, numbers and words is *legible*, precise, and accurate, compared to other adults.

1 2 3 4 5

8. I can *cut* out things and can use simple household tools accurately and easily, compared to other adults.

1 2 3 4 5

9. My performance in individual sports (such as swimming, running, skiing, skating) is better than in *team sports* (such as soccer, hockey, baseball).

1 2 3 4 5

10. I dislike participating in *sports* requiring good motor skills and avoid it whenever I can.

1 2 3 4 5

	Not at all like you	A bit like you	Moderately like you	Quite a bit like you	Extremely like you
	1	**2**	**3**	**4**	**5**

11. I sometimes have difficulty *learning* new motor *skills*, but can perform them better once I have learned them (e.g., skating, skiing, swimming).

    1 2 3 4 5

12. I have been described as a "*bull in a china shop*."

    1 2 3 4 5

13. I can easily avoid bumping into obstacles in a crowded garden or store, or bumping into people in a crowded area.

    1 2 3 4 5

14. I have good enough balance to be able to walk on a wobbly boat dock, to ride a bike, to skate well or to ski easily.

    1 2 3 4 5

15. I was able to obtain a driver's licence easily, I can parallel park, and I am considered a safe driver.

    1 2 3 4 5

16. I feel awkward and clumsy around other adults

    1 2 3 4 5

17. If I have to participate in team sports, I feel embarrassed and conceal my awkwardness by using humour, or by taking a certain role (e.g., coach, scorekeeper) that hides my lack of skill in sports.

1 2 3 4 5

18. I have been hurt (scraped, scarred, sprains, broken bones) due to my clumsiness.

1 2 3 4 5

19. I rely on friends or family to help me with things that require a lot of co-ordination (e.g., icing a cake, fixing a small appliance).

1 2 3 4 5

20. I have been teased about my awkwardness and/or have felt embarrassed or humiliated at times because of it.

1 2 3 4 5

21. I can easily follow directions to a new location without getting lost.

1 2 3 4 5

Appendix 10: Adult Developmental Coordination Disorder/Dyspraxia Checklist

Participant ID#: ______________________

Section 1: As a child, did you:				
	Never	Sometimes	Frequently	Always
1. Have difficulties with self-care tasks, such as tying shoelaces, fastening buttons and zips?	☐	☐	☐	☐
2. Have difficulty eating without getting dirty?	☐	☐	☐	☐
3. Have difficulty learning to ride a bike compared to your peers?	☐	☐	☐	☐
4. Have difficulties with playing team games, such as football, volleyball, catching or throwing balls accurately?	☐	☐	☐	☐
5. Have difficulty writing neatly (so others could read it)?	☐	☐	☐	☐
6. Have difficulty writing as fast as your peers?	☐	☐	☐	☐
7. Bump into objects or people, trip over things more than others?	☐	☐	☐	☐
8. Have difficulty playing a musical instrument (e.g. violin, recorder)?	☐	☐	☐	☐
9. Have difficulties with organising/finding things in your room?	☐	☐	☐	☐
10. Have others comment about your lack of coordination or call you clumsy?	☐	☐	☐	☐
Total				

Section 2: Do you currently have difficulties with the following items:				
	Never	Sometimes	Frequently	Always
1. Self-care tasks such as shaving or make up?	☐	☐	☐	☐
2. Eating with a knife and fork/spoon?	☐	☐	☐	☐
3. Hobbies that require good coordination?	☐	☐	☐	☐
4. Writing neatly when having to write fast?	☐	☐	☐	☐
5. Writing as fast as your peers?	☐	☐	☐	☐
6. Reading your own writing?	☐	☐	☐	☐
7. Copying things down without making mistakes?	☐	☐	☐	☐
8. Organising/finding things in your room?	☐	☐	☐	☐
9. Finding your way around new buildings or places?	☐	☐	☐	☐
10. Have others called you disorganised?	☐	☐	☐	☐
11. Do you have difficulties sitting still or appearing fidgety?	☐	☐	☐	☐
12. Do you lose or leave behind possessions?	☐	☐	☐	☐
13. Would you say that you bump into things, spill or break things?	☐	☐	☐	☐
14. Are you slower than others getting up on the morning and getting to work or college?	☐	☐	☐	☐
15. Did it take you longer than others to learn to drive? (if you do not drive, please indicate on the paper and describe why you chose not to drive)	☐	☐	☐	☐
16. Do others find it difficult to read your writing?	☐	☐	☐	☐
17. Do you avoid hobbies that require good coordination?	☐	☐	☐	☐
18. Do you choose to spend your leisure time more on your own than with others?	☐	☐	☐	☐
19. Do you avoid team games/sports?	☐	☐	☐	☐
20. If you do a sport, is it more likely to be on your own, e.g. going to the gym, than with others?	☐	☐	☐	☐

	Never	Sometimes	Frequently	Always
21. Do you/did you in your teens/twenties avoid going to clubs/dancing?	☐	☐	☐	☐
22. If you are a driver, do you have difficulty parking a car?	☐	☐	☐	☐
23. Do you have difficulty preparing a meal from scratch?	☐	☐	☐	☐
24. Do you have difficulty packing a suitcase to go away?	☐	☐	☐	☐
25. Do you have difficulty folding clothes to put them away neatly?	☐	☐	☐	☐
26. Do you have difficulty managing money?	☐	☐	☐	☐
27. Do you have difficulties with performing two things at the same time (e.g. driving and listening or taking a telephone message)?	☐	☐	☐	☐
28. Do you have difficulties with distance estimation (e.g. with regard to parking, passing through objects)?	☐	☐	☐	☐
29. Do you have difficulty planning ahead?	☐	☐	☐	☐
30. Do you feel you are losing attention in certain situations?	☐	☐	☐	☐
Section two total				
Section one total				
Questionnaire total [section one + section two]				

Can you describe any compensatory strategies or approaches that you have developed over the years in order to deal with coordination difficulties in your everyday life?

____

____

____

____

The Dyscovery Centre often conducts research with adults.
Please let us know if you would like to take part in future projects.

Prof Amanda Kirby
The Dyscovery Centre
University of Wales, Newport
Allt-yr-yn Campus
Newport
NP20 5DA
01633 432330 / dyscoverycentre@newport.ac.uk

Appendix 11: The Y-Balance Test

Figure of the Y-Balance Test

Landmarks for Leg Length Measurements

Data Table for the YBT

Participant ID#		
Maximum Leg Length (cm)		
Directions	**Right Leg Measurements (cm)**	**Left Leg Measurements (cm)**
Anterior	Trial 1	Trial 1
	Trial 2	Trial 3
	Trial 3	Trial 3
Posterolateral	Trial 1	Trial 1
	Trial 2	Trial 2
	Trial 3	Trial 3
Posteromedial	Trial 1	Trial 1
	Trial 2	Trial 2
	Trial 3	Trial 3
Directions	**Right Leg Maximum Reach (%)**	**Left Leg Maximum Reach (%)**

Anterior		
Posterolateral		
Posteromedial		

Appendix 12: Pearson product correlations between mother and child YBT scores

Variable One	Variable Two	R	p-value	Effect Size
Mother YBT Max. Reach % Right Leg Anterior Direction	Child YBT Max. Reach % Right Leg Anterior Direction	0.271	0.328	Small
Mother YBT Max. Reach % Right Leg Posterolateral Direction	Child YBT Max. Reach % Right Leg Anterior Direction	0.259	0.351	Small
Mother YBT Max. Reach % Right Leg Posteromedial Direction	Child YBT Max. Reach % Right Leg Anterior Direction	0.205	0.463	Small
Mother YBT Max. Reach % Left Leg Anterior Direction	Child YBT Max. Reach % Right Leg Anterior Direction	0.101	0.719	Small
Mother YBT Max. Reach % Left Leg Posterolateral Direction	Child YBT Max. Reach % Right Leg Anterior Direction	0.055	0.847	Small
Mother YBT Max. Reach % Left Leg Posteromedial Direction	Child YBT Max. Reach % Right Leg Anterior Direction	0.037	0.896	Small

Variable One	Variable Two	R	p-value	Effect Size
Mother YBT Max. Reach % Right Leg Anterior Direction	Child YBT Max. Reach % Right Leg Posterolateral Direction	-0.176	0.531	Small
Mother YBT Max. Reach % Right Leg Posterolateral Direction	Child YBT Max. Reach % Right Leg Posterolateral Direction	0.046	0.871	Small
Mother YBT Max. Reach % Right Leg Posteromedial Direction	Child YBT Max. Reach % Right Leg Posterolateral Direction	0.257	0.355	Small
Mother YBT Max. Reach % Left Leg Anterior Direction	Child YBT Max. Reach % Right Leg Posterolateral Direction	0.173	0.537	Small
Mother YBT Max. Reach % Left Leg Posterolateral Direction	Child YBT Max. Reach % Right Leg Posterolateral Direction	0.037	0.895	Small
Mother YBT Max. Reach % Left Leg Posteromedial Direction	Child YBT Max. Reach % Right Leg Posterolateral Direction	-0.036	0.898	Small

Variable One	Variable Two	R	p-value	Cohen's D
Mother YBT Max. Reach % Right Leg Anterior Direction	Child YBT Max. Reach % Right Leg Posteromedial Direction	0.489	0.065	Moderate
Mother YBT Max. Reach % Right Leg Posterolateral Direction	Child YBT Max. Reach % Right Leg Posteromedial Direction	0.339	0.217	Moderate
Mother YBT Max. Reach % Right Leg Posteromedial Direction	Child YBT Max. Reach % Right Leg Posteromedial Direction	0.345	0.207	Moderate
Mother YBT Max. Reach % Left Leg Anterior Direction	Child YBT Max. Reach % Right Leg Posteromedial Direction	0.225	0.419	Small
Mother YBT Max. Reach % Left Leg Posterolateral Direction	Child YBT Max. Reach % Right Leg Posteromedial Direction	0.049	0.862	Small
Mother YBT Max. Reach % Left Leg Posteromedial Direction	Child YBT Max. Reach % Right Leg Posteromedial Direction	0.035	0.900	Small

Variable One	Variable Two	R	p-value	Cohen's D
Mother YBT Max. Reach % Right Leg Anterior Direction	Child YBT Max. Reach % Left Leg Anterior Direction	0.183	0.514	Small
Mother YBT Max. Reach % Right Leg Posterolateral Direction	Child YBT Max. Reach % Left Leg Anterior Direction	-0.003	0.992	Small
Mother YBT Max. Reach % Right Leg Posteromedial Direction	Child YBT Max. Reach % Left Leg Anterior Direction	0.045	0.872	Small
Mother YBT Max. Reach % Left Leg Anterior Direction	Child YBT Max. Reach % Left Leg Anterior Direction	0.093	0.742	Small
Mother YBT Max. Reach % Left Leg Posterolateral Direction	Child YBT Max. Reach % Left Leg Anterior Direction	-0.059	0.835	Small
Mother YBT Max. Reach % Left Leg Posteromedial Direction	Child YBT Max. Reach % Left Leg Anterior Direction	-0.220	0.430	Small

Variable One	Variable Two	R	p-value	Effect Size
Mother YBT Max. Reach % Right Leg Anterior Direction	Child YBT Max. Reach % Left Leg Posterolateral Direction	0.190	0.497	Small
Mother YBT Max. Reach % Right Leg Posterolateral Direction	Child YBT Max. Reach % Left Leg Posterolateral Direction	0.282	0.308	Small
Mother YBT Max. Reach % Right Leg Posteromedial Direction	Child YBT Max. Reach % Left Leg Posterolateral Direction	0.444	0.097	Moderate
Mother YBT Max. Reach % Left Leg Anterior Direction	Child YBT Max. Reach % Left Leg Posterolateral Direction	0.259	0.351	Small
Mother YBT Max. Reach % Left Leg Posterolateral Direction	Child YBT Max. Reach % Left Leg Posterolateral Direction	0.148	0.598	Small
Mother YBT Max. Reach % Left Leg Posteromedial Direction	Child YBT Max. Reach % Left Leg Posterolateral Direction	0.098	0.728	Small

Variable One	Variable Two	R	p-value	Effect Size
Mother YBT Max. Reach % Right Leg Anterior Direction	Child YBT Max. Reach % Left Leg Posteromedial Direction	0.186	0.507	Small
Mother YBT Max. Reach % Right Leg Posterolateral Direction	Child YBT Max. Reach % Left Leg Posteromedial Direction	0.214	0.444	Small
Mother YBT Max. Reach % Right Leg Posteromedial Direction	Child YBT Max. Reach % Left Leg Posteromedial Direction	0.248	0.373	Small
Mother YBT Max. Reach % Left Leg Anterior Direction	Child YBT Max. Reach % Left Leg Posteromedial Direction	0.157	0.577	Small
Mother YBT Max. Reach % Left Leg Posterolateral Direction	Child YBT Max. Reach % Left Leg Posteromedial Direction	0.005	0.985	Small
Mother YBT Max. Reach % Left Leg Posteromedial Direction	Child YBT Max. Reach % Left Leg Posteromedial Direction	-0.095	0.736	Small

Appendix 13: Pearson product correlation tables between mothers' YBT scores and child TGMD-2 scores.

Variable One	Variable Two	R	p-value	Effect Size
YBT Max. Reach % Right Leg Anterior Direction	TGMD-2 Gross Motor Quotient	0.467	0.079	Moderate
YBT Max. Reach % Right Leg Posterolateral Direction	TGMD-2 Gross Motor Quotient	0.371	0.173	Moderate
YBT Max. Reach % Right Leg Posteromedial Direction	TGMD-2 Gross Motor Quotient	0.254	0.362	Small
YBT Max. Reach % Left Leg Anterior Direction	TGMD-2 Gross Motor Quotient	0.541	0.037*	Large
YBT Max. Reach % Left Leg Posterolateral Direction	TGMD-2 Gross Motor Quotient	0.290	0.295	Small
YBT Max. Reach % Left Leg Posteromedial Direction	TGMD-2 Gross Motor Quotient	0.340	0.215	Moderate

Variable One	Variable Two	R	p-value	Effect Size
YBT Max. Reach % Right Leg Anterior Direction	TGMD-2 Locomotor Raw Score	0.280	0.312	Small
YBT Max. Reach % Right Leg Posterolateral Direction	TGMD-2 Locomotor Raw Score	0.031	0.913	Small
YBT Max. Reach % Right Leg Posteromedial Direction	TGMD-2 Locomotor Raw Score	-0.078	0.783	Small
YBT Max. Reach % Left Leg Anterior Direction	TGMD-2 Locomotor Raw Score	0.356	0.193	Moderate
YBT Max. Reach % Left Leg Posterolateral Direction	TGMD-2 Locomotor Raw Score	-0.046	0.872	Small
YBT Max. Reach % Left Leg Posteromedial Direction	TGMD-2 Locomotor Raw Score	-0.072	0.799	Small

Variable One	Variable Two	R	p-value	Effect Size
YBT Max. Reach % Right Leg Anterior Direction	TGMD-2 Object Control Raw Score	0.311	0.259	Moderate
YBT Max. Reach % Right Leg Posterolateral Direction	TGMD-2 Object Control Raw Score	0.236	0.398	Small
YBT Max. Reach % Right Leg Posteromedial Direction	TGMD-2 Object Control Raw Score	0.225	0.421	Small
YBT Max. Reach % Left Leg Anterior Direction	TGMD-2 Object Control Raw Score	0.326	0.235	Moderate
YBT Max. Reach % Left Leg Posterolateral Direction	TGMD-2 Object Control Raw Score	0.202	0.471	Small
YBT Max. Reach % Left Leg Posteromedial Direction	TGMD-2 Object Control Raw Score	0.344	0.209	Moderate

Appendix 14: Pearson product correlation tables between the mothers' YBT scores and the TGMD-2 scores of all female children.

Variable One	Variable Two	R	p-value	Effect Size
YBT Max. Reach % Right Leg Anterior Direction	TGMD-2 Gross Motor Quotient	0.444	0.171	Moderate
YBT Max. Reach % Right Leg Posterolateral Direction	TGMD-2 Gross Motor Quotient	0.560	0.073	Large
YBT Max. Reach % Right Leg Posteromedial Direction	TGMD-2 Gross Motor Quotient	0.391	0.235	Moderate
YBT Max. Reach % Left Leg Anterior Direction	TGMD-2 Gross Motor Quotient	0.569	0.068	Large
YBT Max. Reach % Left Leg Posterolateral Direction	TGMD-2 Gross Motor Quotient	0.610	0.046*	Large
YBT Max. Reach % Left Leg Posteromedial Direction	TGMD-2 Gross Motor Quotient	0.563	0.071	Large

Variable One	Variable Two	R	p-value	Effect Size
YBT Max. Reach % Right Leg Anterior Direction	TGMD-2 Locomotor Raw Score	0.161	0.637	Small
YBT Max. Reach % Right Leg Posterolateral Direction	TGMD-2 Locomotor Raw Score	0.032	0.925	Small
YBT Max. Reach % Right Leg Posteromedial Direction	TGMD-2 Locomotor Raw Score	-0.083	0.808	Small
YBT Max. Reach % Left Leg Anterior Direction	TGMD-2 Locomotor Raw Score	0.317	0.341	Moderate
YBT Max. Reach % Left Leg Posterolateral Direction	TGMD-2 Locomotor Raw Score	0.004	0.990	Small
YBT Max. Reach % Left Leg Posteromedial Direction	TGMD-2 Locomotor Raw Score	-0.059	0.864	Small

Variable One	Variable Two	R	p-value	Effect Size
YBT Max. Reach % Right Leg Anterior Direction	TGMD-2 Object Control Raw Score	0.353	0.287	Moderate
YBT Max. Reach % Right Leg Posterolateral Direction	TGMD-2 Object Control Raw Score	0.537	0.089	Large
YBT Max. Reach % Right Leg Posteromedial Direction	TGMD-2 Object Control Raw Score	0.481	0.134	Moderate
YBT Max. Reach % Left Leg Anterior Direction	TGMD-2 Object Control Raw Score	0.380	0.249	Moderate
YBT Max. Reach % Left Leg Posterolateral Direction	TGMD-2 Object Control Raw Score	0.685	0.020*	Large
YBT Max. Reach % Left Leg Posteromedial Direction	TGMD-2 Object Control Raw Score	0.712	0.014*	Large

Appendix 15: Pearson product correlations between the mothers' YBT scores and the TGMD-2 scores of the male children

Variable One	Variable Two	R	p-value	Effect Size
YBT Max. Reach % Right Leg Anterior Direction	TGMD-2 Gross Motor Quotient	0.657	0.229	Large
YBT Max. Reach % Right Leg Posterolateral Direction	TGMD-2 Gross Motor Quotient	0.399	0.506	Moderate
YBT Max. Reach % Right Leg Posteromedial Direction	TGMD-2 Gross Motor Quotient	0.481	0.412	Moderate
YBT Max. Reach % Leftt Leg Anterior Direction	TGMD-2 Gross Motor Quotient	0.704	0.185	Large
YBT Max. Reach % Leftt Leg Posterolateral Direction	TGMD-2 Gross Motor Quotient	0.088	0.888	Small
YBT Max. Reach % Left Leg Posteromedial Direction	TGMD-2 Gross Motor Quotient	0.350	0.564	Moderate

Variable One	Variable Two	R	p-value	Effect Size
YBT Max. Reach % Right Leg Anterior Direction	TGMD-2 Locomotor Raw Score	0.572	0.313	Large
YBT Max. Reach % Right Leg Posterolateral Direction	TGMD-2 Locomotor Raw Score	0.463	0.432	Moderate
YBT Max. Reach % Right Leg Posteromedial Direction	TGMD-2 Locomotor Raw Score	0.731	0.160	Large
YBT Max. Reach % Left Leg Anterior Direction	TGMD-2 Locomotor Raw Score	0.890	0.043*	Large
YBT Max. Reach % Left Leg Posterolateral Direction	TGMD-2 Locomotor Raw Score	0.324	0.594	Moderate
YBT Max. Reach % Left Leg Posteromedial Direction	TGMD-2 Locomotor Raw Score	0.552	0.335	Large

Variable One	Variable Two	R	p-value	Effect Size
YBT Max. Reach % Right Leg Anterior Direction	TGMD-2 Object Control Raw Score	0.723	0.167	Large
YBT Max. Reach % Right Leg Posterolateral Direction	TGMD-2 Object Control Raw Score	0.358	0.555	Moderate
YBT Max. Reach % Right Leg Posteromedial Direction	TGMD-2 Object Control Raw Score	-0.002	0.997	Small
YBT Max. Reach % Left Leg Anterior Direction	TGMD-2 Object Control Raw Score	0.169	0.786	Small
YBT Max. Reach % Left Leg Posterolateral Direction	TGMD-2 Object Control Raw Score	-0.226	0.715	Small
YBT Max. Reach % Left Leg Posteromedial Direction	TGMD-2 Object Control Raw Score	0.078	0.901	Small

Appendix 16: Pearson product correlations between the TGMD-2 and DCDQ

Variable One	Variable Two	R	p-value	Effect Size
TGMD-2 Gross Motor Quotient	DCDQ Total Score	0.215	0.376	Small
TGMD-2 Locomotor Raw Scores	DCDQ Total Score	0.050	0.840	Small
TGMD-2 Object Control Raw Scores	DCDQ Total Score	0.133	0.587	Small
Female TGMD-2 Gross Motor Quotient	DCDQ Total Score	0.092	0.755	Small
Female TGMD-2 Locomotor Raw Scores	DCDQ Total Score	0.343	0.229	Moderate
Female TGMD-2 Object Control Raw Scores	DCDQ Total Score	0.334	0.243	Moderate
Male TGMD-2 Gross Motor Quotient	DCDQ Total Score	-0.068	0.913	Small
Male TGMD-2 Locomotor Raw Scores	DCDQ Total Score	0.539	0.349	Large
Male TGMD-2 Object Control Raw Scores	DCDQ Total Score	0.206	0.740	Small

Appendix 17: Pearson product correlations between the TGMD-2 and the PSPM

Variable One	Variable Two	R	p-value	Effect Size
TGMD-2 Gross Motor Quotient	PSPM Total Score	0.244	0.313	Small
TGMD-2 Locomotor Raw Scores	PSPM Total Score	0.063	0.797	Small
TGMD-2 Object Control Raw Scores	PSPM Total Score	0.273	0.258	Small
Female TGMD-2 Gross Motor Quotient	PSPM Total Score	0.192	0.511	Small
Female TGMD-2 Locomotor Raw Scores	PSPM Total Score	0.066	0.822	Small
Female TGMD-2 Object Control Raw Scores	PSPM Total Score	0.039	0.896	Small
Male TGMD-2 Gross Motor Quotient	PSPM Total Score	-0.212	0.732	Small
Male TGMD-2 Locomotor Raw Scores	PSPM Total Score	0.034	0.957	Small
Male TGMD-2 Object Control Raw Scores	PSPM Total Score	-0.732	0.160	Small

Appendix 18: Correlations between mother YBT scores and the ADC.

Variable 1	Variable 2	R	p-value	Effect Size
ADC Total Score	YBT Right Leg Anterior	-0.156	0.579	Small
	YBT Right Leg Posterolateral	-0.213	0.445	Small
	YBT Right Leg Posteromedial	-0.038	0.892	Small
	YBT Left Leg Anterior	-0.080	0.778	Small
	YBT Left Leg Posterolateral	-0.154	0.584	Small
	YBT Left Leg Posteromedial	-0.035	0.902	Small

Appendix 19: Correlations between the mother YBT scores and the DCDQ-A

Variable 1	Variable 2	R	p-value	Effect Size
DCDQ-A Total Score	YBT Right Leg Anterior	0.311	0.259	Moderate
	YBT Right Leg Posterolateral	0.128	0.648	Small
	YBT Right Leg Posteromedial	0.148	0.598	Small
	YBT Left Leg Anterior	0.080	0.776	Small
	YBT Left Leg Posterolateral	0.130	0.645	Small
	YBT Left Leg Posteromedial	0.022	0.939	Small

Appendix 20: Pedometer step log for the parents

University of Ontario Institute of Technology

PEDOMETER STEP LOG

ID #

Name:	Pedometer #:	Date of birth: ____ day ____ month ____ year
Start Date:	End Date:	Gender: ☐ **Male** ☐ **Female**

Day	Date	Time On (am/pm)	Time Off (am/pm)	# of steps taken	If you took it off for something other than going to bed, tell us what & why.	How long was it off for?	What kinds of activities did you do today?
* Practice day! *							
1							
2							
3							
4							
5							
6							
7							

Appendix 21: Pedometer step log for the children

University of Ontario Institute of Technology

PEDOMETER STEP LOG

ID #

Name:	Pedometer #:	My birthday is: ___ day ___ month ___ year
Start Date:	End Date:	I am a: ☐ **Boy** ☐ **Girl**

Day	Date	Time On (am/pm)	Time Off (am/pm)	# of steps taken	If you took it off for something other than going to bed, tell us what & why:	How long was it off for?	What kinds of activities did you do today?
* Practice day! *							
1							
2							
3							
4							
5							
6							
7							

Appendix 22: IPAQ questionnaire

Participant ID#:___________________________

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

1. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

   _____ **days per week**

   ☐ No vigorous physical activities → ***Skip to question 3***

2. How much time did you usually spend doing **vigorous** physical activities on one of those days?

   _____ **hours per day**

   _____ **minutes per day**

   ☐ Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

   _____ **days per week**

   ☐ No moderate physical activities → ***Skip to question 5***

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

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise, or leisure.

5. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?

_____ **days per week**

☐ No walking → ***Skip to question 7***

6. How much time did you usually spend **walking** on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

7. During the **last 7 days**, how much time did you spend **sitting** on a **week day**?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

This is the end of the questionnaire, thank you for participating.

SHORT LAST 7 DAYS SELF-ADMINISTERED version of the IPAQ. Revised August 2002.

Appendix 23: Pearson product correlations between mother and child average steps per day.

Variable 1	Variable 2	R	p-value	Effect Size
Child average steps per day over seven days	Mother average steps per day over seven days	0.275	0.320	Small
Child average steps per day on weekends	Mother average steps per day on weekends	0.222	0.467	Small
Child average steps per day on weekdays	Mother average steps per day on weekdays	0.105	0.710	Small
Boy average steps per day over seven days	Mother average steps per day over seven days	-0.674	0.212	Large
Boy average steps per day on weekends	Mother average steps per day on weekends	0.061	0.923	Small
Boy average steps per day on weekdays	Mother average steps per day on weekdays	-0.741	0.152	Large
Girl average steps per day over seven days	Mother average steps per day over seven days	0.479	0.136	Moderate
Girl average steps per day on weekends	Mother average steps per day on weekends	0.106	0.787	Small
Girl average steps per day on weekdays	Mother average steps per day on weekdays	0.482	0.133	Moderate

Appendix 24: Pearson product correlations between mother and child IPAQ continuous scores.

Variable 1	Variable 2	R	p-value	Effect Size
Mother IPAQ Continuous Score	Child IPAQ Continuous Score	0.094	0.739	Small
	Boy IPAQ Continuous Score	-0.368	0.542	Moderate
	Girl IPAQ Continuous Score	0.066	0.848	Small

Appendix 25: Pearson product correlations between the average steps per day for the mothers and IPAQ continuous scores for the children

Variable 1	Variable 2	R	p-value	Effect Size
Child IPAQ continuous score	Mother average steps per day over seven days	-0.447	0.095	Moderate
Child IPAQ continuous score	Mother average steps per day on weekends	0.025	0.932	Small
Child IPAQ continuous score	Mother average steps per day on weekdays	-0.374	0.170	Moderate
Boy IPAQ continuous score	Mother average steps per day over seven days	-0.425	0.476	Moderate
Boy IPAQ continuous score	Mother average steps per day on weekends	-0.358	0.554	Moderate
Boy IPAQ continuous score	Mother average steps per day on weekdays	-0.239	0.699	Small
Girl IPAQ continuous score	Mother average steps per day over seven days	-0.576	0.064	Large
Girl IPAQ continuous score	Mother average steps per day on weekends	0.061	0.867	Small
Girl IPAQ continuous score	Mother average steps per day on weekdays	-0.530	0.093	Large

Appendix 26: Pearson product correlations between the average steps per day of the children and the IPAQ continuous scores for the mothers

Variable 1	Variable 2	R	p-value	Effect Size
Mother IPAQ continuous score	Child average steps per day over seven days	-0.235	0.398	Small
Mother IPAQ continuous score	Child average steps per day on weekends	-0.250	0.388	Small
Mother IPAQ continuous score	Child average steps per day on weekdays	-0.186	0.508	Small
Mother IPAQ continuous score	Boy average steps per day over seven days	-0.535	0.352	Moderate
Mother IPAQ continuous score	Boy average steps per day on weekends	0.023	0.971	Small
Mother IPAQ continuous score	Boy average steps per day on weekdays	-0.538	0.349	Moderate
Mother IPAQ continuous score	Girl average steps per day over seven days	-0.372	0.260	Moderate
Mother IPAQ continuous score	Girl average steps per day on weekends	-0.314	0.376	Moderate
Mother IPAQ continuous score	Girl average steps per day on weekdays	-0.297	0.375	Small

Appendix 27: Pearson product correlations between child IPAQ and TGMD-2 variables.

Variable 1	Variable 2	R	p-value	Effect Size
Child IPAQ continuous score	TGMD-2 Gross Motor Quotient	0.261	0.280	Small
	TGMD-2 Locomotor Raw Score	0.172	0.480	Small
	TGMD-2 Object Control Raw Score	0.181	0.459	Small
Boy IPAQ continuous score	TGMD-2 Gross Motor Quotient	-0.470	0.425	Moderate
	TGMD-2 Locomotor Raw Score	-0.117	0.852	Small
	TGMD-2 Object Control Raw Score	-0.638	0.246	Large
Girl IPAQ continuous score	TGMD-2 Gross Motor Quotient	0.311	0.279	Moderate
	TGMD-2 Locomotor Raw Score	0.308	0.284	Moderate
	TGMD-2 Object Control Raw Score	0.060	0.840	Small

Appendix 28: Pearson product correlations between child IPAQ and YBT

Variable 1	Variable 2	R	p-value	Effect Size
Child IPAQ continuous score	Child YBT Max. Reach % for Right Leg in Anterior Direction	-0.188	0.440	Small
	Child YBT Max. Reach % for Right Leg in Posterolateral Direction	-0.094	0.702	Small
	Child YBT Max. Reach % for Right Leg in Posteromedial Direction	-0.132	0.590	Small
	Child YBT Max. Reach % for Left Leg in Anterior Direction	-0.004	0.987	Small
	Child YBT Max. Reach % for Left Leg in Posterolateral Direction	0.041	0.868	Small
	Child YBT Max. Reach % for Left Leg in Posteromedial Direction	0.145	0.555	Small
Male IPAQ continuous score	Male YBT Max. Reach % for Right Leg in Anterior Direction	-0.274	0.656	Small
	Male YBT Max. Reach % for Right Leg in Posterolateral Direction	-0.180	0.772	Small
	Male YBT Max. Reach % for Right Leg in Posteromedial Direction	-0.144	0.817	Small
	Male YBT Max. Reach % for Left Leg in Anterior Direction	0.341	0.575	Moderate
	Male YBT Max. Reach % for Left Leg in Posterolateral Direction	0.641	0.244	Large
	Male YBT Max. Reach % for Left Leg in Posteromedial Direction	0.084	0.894	Small

Female IPAQ continuous score	Female YBT Max. Reach % for Right Leg in Anterior Direction	-0.225	0.439	Small
	Female YBT Max. Reach % for Right Leg in Posterolateral Direction	-0.190	0.516	Small
	Female YBT Max. Reach % for Right Leg in Posteromedial Direction	-0.134	0.649	Small
	Female YBT Max. Reach % for Left Leg in Anterior Direction	-0.270	0.350	Small
	Female YBT Max. Reach % for Left Leg in Posterolateral Direction	-0.208	0.476	Small
	Female YBT Max. Reach % for Left Leg in Posteromedial Direction	0.091	0.758	Small

Appendix 29: Pearson product correlations between the IPAQ and the DCDQ

Variable 1	Variable 2	R	p-value	Effect Size
Child IPAQ continuous score	DCDQ total score	0.223	0.359	Small
Male IPAQ continuous score	DCDQ total score for boys	-0.042	0.946	Small
Female IPAQ continuous score	DCDQ total score for girls	0.361	0.205	Moderate

Appendix 30: Pearson product correlations between the TGMD-2 and the child average steps per day.

Variable 1	Variable 2	R	p-value	Effect Size
Gross Motor Quotient	Child average steps per day over seven days	0.177	0.468	Small
	Child average steps per day on weekends	0.206	0.427	Small
	Child average steps per day on weekdays	0.187	0.443	Small
Locomotor raw scores	Child average steps per day over seven days	0.105	0.669	Small
	Child average steps per day on weekends	0.410	0.102	Moderate
	Child average steps per day on weekdays	0.033	0.892	Small
Object control raw score	Child average steps per day over seven days	0.307	0.201	Moderate
	Child average steps per day on weekends	-0.032	0.903	Small
	Child average steps per day on weekdays	0.393	0.096	Moderate

Variable 1	Variable 2	R	p-value	Effect Size
Gross Motor Quotient	Boy average steps per day over seven days	0.710	0.179	Large
	Boy average steps per day on weekends	0.891	0.043*	Large
	Boy average steps per day on weekdays	0.671	0.215	Large
Locomotor raw scores	Boy average steps per day over seven days	0.428	0.472	Moderate
	Boy average steps per day on weekends	0.828	0.083	Large
	Boy average steps per day on weekdays	0.384	0.523	Moderate
Object control raw score	Boy average steps per day over seven days	0.901	0.037*	Large
	Boy average steps per day on weekends	0.562	0.324	Large
	Boy average steps per day on weekdays	0.938	0.018*	Large

Variable 1	Variable 2	R	p-value	Effect Size
Gross Motor Quotient	Female average steps per day over seven days	-0.397	0.160	Moderate
	Female average steps per day on weekends	-0.225	0.482	Small
	Female average steps per day on weekdays	-0.362	0.204	Moderate
Locomotor raw scores	Female average steps per day over seven days	-0.016	0.957	Small
	Female average steps per day on weekends	0.266	0.403	Small
	Female average steps per day on weekdays	-0.137	0.641	Small
Object control raw score	Female average steps per day over seven days	-0.423	0.131	Moderate
	Female average steps per day on weekends	-0.615	0.033*	Large
	Female average steps per day on weekdays	-0.255	0.379	Small

Appendix 31: Pearson product correlations between the DCDQ and the average steps taken per day by the children.

Variable 1	Variable 2	R	p-value	Effect Size
DCDQ Total Score	Child average steps per day over seven days	-0.052	0.832	Small
	Child average steps per day on weekends	-0.058	0.825	Small
	Child average steps per day on weekdays	-0.115	0.639	Small
DCDQ Total Score	Male average steps per day over seven days	0.405	0.499	Moderate
	Male average steps per day on weekends	0.106	0.865	Small
	Male average steps per day on weekdays	0.369	0.541	Moderate
DCDQ Total Score	Female average steps per day over seven days	-0.024	0.936	Small
	Female average steps per day on weekends	-0.033	0.920	Small
	Female average steps per day on weekdays	-0.119	0.685	Small

Appendix 32: Pearson product correlations between the ADC and the mothers' average steps per day, and the IPAQ continuous score.

Variable 1	Variable 2	R	p-value	Effect Size
ADC Total Score	Mother average steps per day over seven days	0.047	0.867	Small
	Mother average steps per day on weekends	-0.078	0.790	Small
	Mother average steps per day on weekdays	0.050	0.859	Small
ADC Total Score	Mother IPAQ continuous score	0.201	0.473	Small

Appendix 33: Pearson product correlations between the DCDQ-A and the mothers' pedometer steps, and the mothers' IPAQ continuous score.

Variable 1	Variable 2	R	p-value	Effect Size
DCDQ-A Total Score	Mother average steps per day over seven days	-0.015	0.956	Small
	Mother average steps per day on weekends	0.331	0.248	Moderate
	Mother average steps per day on weekdays	-0.201	0.471	Small
DCDQ-A Total Score	Mother IPAQ continuous score	-0.179	0.522	Small

Appendix 34: Pearson product correlations between the mothers' IPAQ and YBT scores.

Variable 1	Variable 2	R	p-value	Effect Size
Mother IPAQ continuous score	Mother YBT Max. Reach % for Right Leg in Anterior Direction	0.411	0.128	Moderate
	Mother YBT Max. Reach % for Right Leg in Posterolateral Direction	0.610	0.016*	Large
	Mother YBT Max. Reach % for Right Leg in Posteromedial Direction	0.540	0.038*	Large
	Mother YBT Max. Reach % for Left Leg in Anterior Direction	0.634	0.011*	Large
	Mother YBT Max. Reach % for Left Leg in Posterolateral Direction	0.633	0.011*	Large
	Mother YBT Max. Reach % for Left Leg in Posteromedial Direction	0.570	0.026*	Large

Appendix 35: Correlations between the mothers' pedometer steps and YBT scores

Variable 1	Variable 2	R	p-value	Effect Size
Mother average steps per day over seven days	Mother YBT Max. Reach % for Right Leg in Anterior Direction	-0.025	0.930	Small
	Mother YBT Max. Reach % for Right Leg in Posterolateral Direction	-0.174	0.536	Small
	Mother YBT Max. Reach % for Right Leg in Posteromedial Direction	-0.131	0.641	Small
	Mother YBT Max. Reach % for Left Leg in Anterior Direction	0.047	0.867	Small
	Mother YBT Max. Reach % for Left Leg in Posterolateral Direction	-0.117	0.677	Small
	Mother YBT Max. Reach % for Left Leg in Posteromedial Direction	-0.148	0.600	Small
Mother average steps per day on weekends	Mother YBT Max. Reach % for Right Leg in Anterior Direction	0.504	0.066	Moderate
	Mother YBT Max. Reach % for Right Leg in Posterolateral Direction	0.317	0.270	Moderate
	Mother YBT Max. Reach % for Right Leg in Posteromedial Direction	0.174	0.552	Small
	Mother YBT Max. Reach % for Left Leg in Anterior Direction	0.140	0.633	Small
	Mother YBT Max. Reach % for Left Leg in Posterolateral Direction	-0.013	0.965	Small
	Mother YBT Max. Reach % for Left Leg in Posteromedial Direction	0.232	0.425	Small
Mother average steps per day on weekdays	Mother YBT Max. Reach % for Right Leg in Anterior Direction	-0.264	0.342	Small
	Mother YBT Max. Reach % for Right Leg in Posterolateral Direction	-0.334	0.223	Moderate

Mother YBT Max. Reach % for Right Leg in Posteromedial Direction	-0.256	0.356	Small
Mother YBT Max. Reach % for Left Leg in Anterior Direction	-0.015	0.956	Small
Mother YBT Max. Reach % for Left Leg in Posterolateral Direction	-0.155	0.582	Small
Mother YBT Max. Reach % for Left Leg in Posteromedial Direction	-0.256	0.357	Small