An Investigation on the Influence of Parental Physical Activity on Physical Activity Behaviours of Children with and without Developmental Coordination Disorder

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Abstract

As children grow and develop there are many factors that play a role in influencing a child. Physical activity (PA) is important for children and youth development. Parents are widely acknowledged as significant influences in various aspects of their children's lives, particularly serving as role models for PA. In the literature pertaining to this topic, multiple findings support the notion of a positive influence of parental PA on their child's PA (Barkin et al., 2017; 2017; Song et al., 2017; Xu et al., 2018). The aim of this thesis was to investigate the relationship between parent and child PA over time through device-assessed measures. Additionally, this thesis will examine whether a distinction exists in the relationship between parent PA and PA of typically developing (TD) children and children with developmental coordination disorder (DCD). The current study will utilize data from the Coordination and Activity Tracking in children study. This study will look at 330 child-parent dyads (TD=204; DCD=126) by utilizing the actor-partner interdependence model (APIM) through path analysis. For this study the APIM looks at the relationship between parent and child PA. The actor effects represent the effect of the participants own PA on their future PA. The partner influences represent the impact of the participants PA on their partners PA. Three models were utilized, the first examining the full sample and then subsequently stratifying the children into TD and DCD groups. For the APIM it was found that there were significant actor effects for both parent and child meaning that their PA was predictive of their future PA, which was consistence across all three models. There were no significant partner influences in each of the APIM models indicating that parent and child PA were not predictive of each other at any timepoint. Overall, the results of this study reveal that there is no evident relationship between parent and child PA over time, regardless of whether they belong to the TD or DCD group. These findings emphasize the need for standardized accelerometer processes to enhance result consistency and reliability when investigating the relationship between parent and child PA.

Key words: physical activity, parental influence, child-parent dyad, developmental coordination disorder, actor-partner interdependence model

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Table of Contents

Abstract………………………………………………………………………………………….

Acknowledgements…………………………………………………….………………….…......

List of Tables……………………………………………………………………..……........

List of Figures……………………………………………………………………...……….

List of Abbreviations…………………………………………………………..…………..

Chapter 1: Introduction…………………………………………………………………………1

1.1 Physical Activity in Children and Youth………………………………………...…2

1.2 Physical Activity in Children and Youth with DCD…………………..……………...4

1.3 Parental Influences of Children Physical Activity Behaviours……………………....6

1.4 Research Questions……………………..…………………………………….……...11

1.5 Study Hypotheses………………………..……………………………………...12

Chapter 2: Methods…………………………..………………………………………..13

2.1 Study Participants…………………………………………………………………....14

2.2 Study Recruitment……………………...………………………………………….…...15

2.3 Study Procedures……………………...………………………………………….…....18

2.4 Study Measures……………………...……………………………….………….…...19

2.4.1 Demographics……………………...……………………………….………...19

2.4.2 Parent Interview……………………...……………………………….......19

2.4.3 Movement Assessment Battery for Children (MABC-2)……………….…...20

2.4.4 Additional Diagnostic Criteria……………………...…………….….……20

2.4.5 Physical Activity……………………...……………………….............20

2.5 Data Processing……………………...……………………….............................22

2.6 Assessment of DCD……………………..……………………...………………...24

2.7 Statistical Analysis……………………...……………………………….…………..25

Chapter 3: Results……………………...……………………...……………………........28

3.1 Descriptive Statistics…………….…...……………………….............................29

3.2 Test of Differences……………………...……………………….........................29

3.3 Moderate-to-Vigorous Physical Activity……………………………...………...32

3.4 Determinants of Inclusions for Covariates……………...…………………………...32

3.5 Full Sample Actor-Partner Interdependence Model……………….…………...35

3.6 TD Actor-Partner Interdependence Model……………………………………..39

3.7 DCD Actor-Partner Interdependence Model……………………………..……....43

Chapter 4: Discussion……………………...……………………...………………………..47

4.1 General Discussion………………...……………………...…………….……..48

4.2 Actor Effects………………...……………………...…………………………......48

4.3 Partner Effects………………...……………………...………………………...50

4.5 Strengths and Limitations………………...………………………......................53

4.6 Conclusions…………………...……………………...……………….……...54

References……………………...……………………...……………………...…………56

List of Tables

Table 1. Group Differences in Demographic Characteristics for Children

Table 2. Group Differences in Demographic Characteristics for Parents

Table 3. Descriptive Statistics on Child and Parent MVPA

Table 4. Correlation Table

Table 5. Fit Statistics for Full Sample APIM

Table 6. Regression Weights of APIM Pathways for Full Sample

Table 7. Fit Statistics for TD APIM

Table 8. Regression Weights of APIM Pathway for TD

Table 9. Fit Statistics for DCD APIM

Table 10. Regression Weights of APIM Pathways for DCD

List of Figures

Figure 1. Diagram of CATCH numbers for children and parents

Figure 2. Full Sample Actor-Partner Interdependence Model

Figure 3. Typically Developing Actor-Partner Interdependence Model

Figure 4. Developmental Coordination Disorder Actor-Partner Interdependence Model

List of Abbreviations

PA	Physical Activity
MVPA	Moderate-to-Vigorous Physical Activity
TD	Typically Developing
DCD	Developmental Coordination Disorder
CATCH	Coordination and Activity Tracking in Children
rDCD	At-risk Developmental Coordination Disorder
MABC-2	Movement Assessment Battery for Children Second Edition
DCDQ	Developmental Coordination Disorder Questionnaire
INCH	Infant and Child Health Lab
KBIT-2	Kaufman Intelligence Test Second Edition
DSM-V	Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition
APIM	Actor-Partner Interdependence Model

Chapter One. Introduction

1.1 Physical Activity in Children and Youth

Physical activity (PA) is an important part of healthy child development (Pujadas Botey et al., 2016). In particular, the early years are a crucial time in a child's life, as they often establish daily active living habits, and it is known that this period of life is critical in the development of behaviours such as PA (Colley et al., 2013; Hinkley et al., 2012). The Canadian 24-hour movement guideline include PA guidelines for children and youth in Canada. Specific guidelines for preschoolers aged 3-4 years recommend at least 180 minutes of PA each day, and that 60 of these minutes should be energetic play (Tremblay et al., 2011). Guidelines for children aged 5 to 17 years recommends engagement in 60 minutes of moderate-to-vigorous physical activity (MVPA) and several additional hours of light PA (Tremblay et al., 2016).

PA has a range of physical, mental, and social health benefits for children (Malm, Jakobsson & Isaksson, 2019). There are numerous physiological and psychological benefits for children who participate in PA that lead to better life trajectories for adulthood. In a study examining the psychological and social advantages of sport PA involvement in children and youth, researchers discovered that engaging in PA resulted in increased self-esteem, improved social skills, reduced depressive symptoms, and greater confidence and competence in PA (Eime et al., 2013). Another study examined the effect of implementation of physical and recreation activities on preschool aged children, and the results showed that when children engaged in these activities over a 12-month period, it had a positive impact on their social and emotional conduct (Morales et al., 2016). An investigation into the potential impact of PA to alleviate depression revealed that PA seems to serve as an effective intervention for mitigating depression or depressive symptoms in children and youth (Dale et al., 2019). Janssen & Leblanc (2010) reviewed the health benefits of PA on children. The study discovered that when children engaged in a minimum of 2-3 hours of MVPA each week, there are numerous health advantages. Participating in PA leads to decreased blood pressure and levels of cholesterol in children, aids in managing metabolic syndrome, reduces the risk of obesity, promotes stronger bones, decreases the likelihood of injuries, and lower rates of depression. Warburton and colleagues (2006), also conducted a study in which they reviewed the health benefits of PA. They found that incorporating regular PA into one's daily life can be effective in preventing various chronic diseases, including cardiovascular disease, diabetes, cancer, hypertension, osteoporosis, obesity, and depression. Overall, it has become clear that participating in PA on a daily basis brings numerous advantages for overall health and well-being (Carter et al., 2021; Guimarães et al., 2021; Mitra, Waygood, & Fullan, 2021; Parent et al., 2020).

Research has indicated that temporally, children's MVPA levels are declining, and their sedentary behaviours are increasing and becoming more prevalent as they age (Aubert et al., 2022; Mitchell, 2019; Pujadas Botey et al, 2016). Multiple studies have found that many children are not meeting the PA guidelines (Bang et al., 2020; Carson et al., 2013; Colley et al., 2017; Fitzpatrick et al., 2019; McGowan et al., 2022; Pujadas Botey et al., 2016; Tapia-Serrano et al., 2022). Further, the 2022 Raising Canada report also identifies physical inactivity and limited play as one of the top 10 threats to childhood in Canada, reinforcing the notion that children and youth are not engaging in enough PA to the extent they should be. In 2020, Canada received a D+ for overall PA and sedentary behaviours of children and youth (ParticipACTION, 2020), which was downgraded to a D in the 2022 report – citing that only 28% of children and youth had met the Canadian 24-Hour movement guidelines (ParticipACTION, 2022).

In summary, despite the many benefits associated with regular engagement in PA, most of the general population of children and youth are not engaging in enough activity (Aubert et al., 2022; Bang et al., 2020; Carson et al., 2013; Colley et al., 2013; Colley et al., 2017; Fitzpatrick et al., 2019; Hinkley et al., 2012; McGowan et al., 2022; Pujadas Botey et al., 2016; Tapia-Serrano et al., 2022; Tucker, 2008). This is even more troubling for a variety of special populations that have been shown to be an even greater risk for physical inactivity. One specific population that has been shown to be at even greater risk of physical inactivity are children with Developmental Coordination Disorder (DCD) (Cairney & Veldhuizen, 2013; Li et al., 2018).

1.2 Physical Activity in Children and Youth with DCD

DCD is a pervasive neurodevelopmental disorder affecting approximately 5-6% of children (American Psychiatric Association [APA], 2013). This disorder affects fine and/or gross motor skills that often impedes day-to-day functioning. Oftentimes, children are described as clumsy by their parents and teachers when they cannot execute skills needed for everyday functioning. Children's symptoms of DCD vary, but functioning of daily life skills and participation in school and PA are related to coordination difficulties. Importantly, there has been consistent evidence that has found school-age children with DCD engage in less PA and active play (Batey et al., 2014; Barnett et al., 2012; King-Dowling et al., 2019; O'Dea & Connell, 2016). Consequently, children with DCD have been found to be at greater risk of a number of physical and mental health problems as they age into adolescence and adulthood (Caçola, 2016).

It has been found that when young children have PA deficits and are less active at a young age it can lead to a risk of hypoactivity and obesity in adolescence (Mahumud et al., 2021; Zhu et al., 2019). One implication of children with DCD being less active throughout childhood is it leads to higher rates of obesity (Cairney et al., 2010a; Wagner et al., 2011). It has been posited that children with DCD usually have greater difficulties in performing PA tasks, which can in turn lead to multiple physical health problems including increased cardiovascular disease risk factors, cardiorespiratory disease and coronary vascular disease (Caçola, 2016; Cairney et al., 2010b). In addition, PA has been known to help with mental health, and adolescents with DCD have an increased risk of mental health issues such as psychological distress, anxiety, and depression (Biddle et al., 2019; Missiuna et al., 2014; Pratt & Hill, 2011). In a recent study, when compared to typically-developing (TD) children, children with DCD reported more internalizing problems, including anxiety and depression symptoms (Li et al., 2021). Despite what has been consistent evidence that has shown children with DCD being less physically active when compared to TD children, comparatively little research has investigated the specific determinants of PA among children with DCD.

Albeit scarce, there has been research investigating the psychosocial factors potentially related to PA behaviours among children with DCD. The psychosocial influences that play a role include individuals' thoughts and social factors. Studies indicate that children with DCD report lower perceived competence and self-efficacy towards PA (Batey et al., 2014; Noordstar et al., 2014). These studies imply that children with DCD believe that they are unable to effectively engage in and perform certain skills in PA. If an adolescent with DCD grows up observing a TD individual successfully performing tasks related to PA, but they themselves do not believe that are capable of doing the same, it can result in their unwillingness to participate, ultimately leading to lower levels of PA. However, it is also important to note that the majority of this research has been focused on mid-to-late childhood, when activity deficits are already known, with little research examining the early childhood period (Batey et al., 2014; Barnett et al., 2012; O'Dea & Connell, 2016; Payne & Ward, 2019). Examination of the early childhood period is critical given some recent research that suggest that PA deficits have yet to emerge during the preschool to kindergarten years. Specifically, a recent study by King-Dowling and colleagues

(2019) did not find any significant differences in accelerometer-assessed PA between DCD and TD children in their sample at 4 and 5 years of age.

1.3 Parental Influences of Children's Physical Activity Behaviours

Parents have a significant impact on their child's life. Parents are an important determinant of their child's development and should be considered an important agent to help support PA for their children in the early life stages (Carson et al., 2013; Colley et al., 2013). As children grow up, parents play a fundamental role in teaching them during their early life and in their key developmental years. Through social learning and genetics, a parent can, directly and indirectly, influence PA, which is crucial for health and well-being (Wilk et al., 2018). Many parents understand how critical PA (specifically moderate-to-vigorous PA) is to a healthy lifestyle (LeBlanc & Janssen, 2010). Various factors that influence PA have been identified in a systematic review focusing on determinant of PA in children (Craggs et al., 2011). This systematic review revealed that the significance of various factors varied based on the age group of the children. Specifically, among children under 13 years old, factors such as parent participation in PA, parental monitoring, physical education attitude, self-efficacy, perceived behavioural control, intention, sibling PA, rules for PA, and engagement in sedentary activities were associated with influencing children's levels of PA (Craggs et al., 2011). Together, it is evident that parental factors were found to play an important role in determining children's PA.

Throughout the literature, it has been examined how different kinds of parental influences can impact their child's PA. The scope of analysis in this thesis study will focus solely on parental PA behaviours. However, it is still essential to briefly review other parental influences, such as parental support and cognitions. It's clear that parents hold a significant role in their children's life, often exerting influence on their child's PA through various means, including support and cognitions. Research has provided evidence for the idea that parental influences such as support, cognitions and behaviours play a role in a child's life (Beets, Cardinal, & Alderman, 2010; Davison et al., 2013; Gustafson & Rhodes, 2006; Hnatiuk et al., 2013; Määttä, Ray, & Roos, 2013). Parental support has been identified as a critical factor for the development of healthy PA behaviours in children and youth and can be expressed in various ways. Multiple studies have shown a positive relationship between a child's PA level and the support they received from their parents (Gustafson & Rhodes, 2006; Yao & Rhodes, 2015; Beets, Cardinal, & Alderman, 2010; Rachele et al., 2016; Sallis, Prochaska, & Taylor, 2000; Trost & Loprinzi, 2011; Van Der Horst et al., 2007). Parents can impact PA behaviours and levels through the utilization of tangible and intangible support (Beets, Cardinal, & Alderman, 2010). There are many different types of tangible support such as taking their child to participate in PA, paying for equipment, and transportation to and from the activity. Meanwhile, intangible support can include modelling, encouragement, and involvement. When children do not receive any kind of PA support they may be prone to a more sedentary lifestyle. Another important parental influence throughout the literature is cognitions (Ha, Ng, & Wong, 2021; Määtaä, Ray, & Roos, 2014; Vietch et al., 2005). A parent's perception of their child's PA impacts their motivation and competence in PA. Various factors shape parental thoughts about PA thereby directly affecting their children. Parental cognition influences the child's motivation and competence in PA. Research shows parents influence children's attitudes, which affects their free play (Veitch et al., 2005). Furthermore, parents' perceptions of inaccessible PA locations lead to lower child PA levels (D'Haese et al., 2015). Horodyska et al (2018) found parents' safety-related cognitions influences children's PA participation. Additional considerations encompass awareness of social and traffic hazards within the community, which influence parents' decisions to permit their children's participation in the neighbourhood (Prezza et al., 2006). However, in order to gain a deeper understanding of the factors that influence PA behaviours in children, it is beneficial to consider the PA behaviours of parents.

Parents are considered socializing agents for their children, and the parent's PA behaviours often match up with the child's. Since parents are significant characters that play an essential role in the long-term growth and development of their children over time, it can be assumed that the PA behaviours starting at a young age, are because of a child's parents. Parents are influential in shaping their children's behaviours, and there is often a correlation between the PA behaviours of parents and their children (Gustafson & Rhodes, 2006). Numerous studies in the literature have found parental PA behaviours to be an important correlate of child PA behaviours (Bedell et al., 2011; Bois et al., 2005; Dinkel et al., 2021; Fuemmeler, Anderson, & Masse, 2011; Hamilton & White, 2012; Santos et al., 2013; Trost & Loprinzi, 2011; Wright et al., 2019). The theory is that when parents are active, they may try to create healthy active families and make certain their child is physically active (Hamilton & White, 2012). If parents consistently engage in sports, activities, and spend a significant amount of time outdoors, it is probable that their young children will adopt similar behaviours. For instance, when a family frequently engages in biking and walking as a collective activity, the child is likely to adopt and cultivate these PA behaviours. Children often learn through observation and tend to emulate the actions of their parents, siblings, and other influential figures in their lives. The results of a study examining the correlates of home and neighbourhood-based PA revealed that parental behaviours significantly influenced the PA levels of their children in both home and neighbourhood contexts (Hnatiuk et al., 2016). Furthermore, even without being consciously aware, parents often serve as role models for PA (Dinkel et al., 2021). When a parent has a positive relationship with PA, it is likely that their child will observe and subsequently engage in similar activities.

A recent systematic review of 39 studies by Peterson and colleagues (2020) found a majority of the studies have a weak but positive association between parent and child PA, regardless of gender of the parent-child dyad, and type of PA. Included were seven longitudinal and thirty-two cross-sectional studies published between 2008-2018. A majority of studies used in this systematic review used a device-assessed measure that ranged from accelerometers, pedometers, and Actiheart monitors. When using a range of device-assessments, there was an overall positive relationship between parental PA behaviour and their child's PA behaviours. This appeared to be the case for both mothers and fathers. For preschool aged children there were only three longitudinal studies included which looked at PA between parent and child. Among these three longitudinal studies, only two employed a prospective observational approach, investigating the behaviours of parent and child PA using device-assessed measures. The results of these studies found that two had positive outcomes for the parent and child PA relationship; meanwhile one did not find any significant relationships (Jago et al., 2017; Moore et al., 1991; O'Dwyer et al., 2012). Additional findings in the individual studies included Sijtsma and colleagues (2015) who found that higher maternal total PA (n=230) was connected to higher levels of the child's MVPA. Similarly, Barkin and colleagues (2016) found that parent PA levels of both mothers and fathers (n=1003) predict MVPA among preschool girls – though the association between father's PA levels and children's PA levels were found to be stronger than that of mothers. A study conducted in 2018, which examined children aged 5-6 (n=247), revealed significant correlations between MVPA levels of both mothers and fathers and their children (Xu et al., 2018). In another study, Dlugonski and colleagues (2017) demonstrated the importance of parental behaviours in a broader context, revealing the benefits of mothers and children spending an average of 2 hours engaging in activities together. The caveat, however, is that these activities were mostly sedentary behaviours or light PA, rather than MVPA.

While numerous studies have yielded significant results, it is important to highlight that specific investigations into the correlation between parent and child PA, have reported non-significant association between these two variables (Brown et al., 2017; Chiarlitti & Kolen, 2017; Hnatiuk et al., 2017; Jago et al., 2017; Lee et al., 2018; Maltby et al., 2018). Among six studies which included children ages 1 to 10 years old, two were longitudinal studies and four were cross-sectional studies. Within these, it is intriguing to observe the variability in results across studies with similar foci. Upon analyzing the prospective observational longitudinal study which revealed no correlation between parent and child PA, several similarities to the current study emerged, including resemblances in the age distribution of the child sample and the utilization of the same PA assessment device (Jago et al., 2017). Additionally, there has been a diversity in the methods used to assess PA across these studies, mirroring the variability seen in studies with significant results. For studies reporting insignificant associations, the measurement approaches include accelerometers, pedometers, and various PA questionnaires. Despite this, each study primarily relies on device-assessed measures as the principal approach for assessing PA, supplemented by the use of questionnaires as secondary measures. Furthermore, researchers can approach the examination of PA in various ways considering metrics such as MVPA, step counts, total PA, and light PA. This diversity in measurement approaches could account for the variability observed within the Peterson et al (2020) article.

Overall, there has only been a recent emergence of studies examining the relationships between parent and child PA, with relatively few studies focused on preschool aged children, or longitudinal studies that look at the development of the child-parent relationship over time. As indicated above, there were three longitudinal studies looking at PA of preschool children with two having found positive associations between parent and child PA, but one may be attributed to the fact that both parent and child underwent a 10-week active play intervention. The prospective observational longitudinal study involving preschool aged children was published in 1991, rendering the findings considerably outdated (Moore et al., 1991). This indicates a scarcity of literature investigating this relationship longitudinally. Additionally, when reviewing the literature, studies were all focused on TD children, with a noticeable absence of any special or clinical populations. When taken together, it is clear that parent PA behaviours play a crucial role in children's PA. However, there is still limited longitudinal observational research that has investigated the role of parental PA behaviours on child PA, and no research to date have explored the impact of parental PA among children with DCD. Therefore, this present thesis study aims to address a gap in the literature by conducting a longitudinal analysis to explore the parent-child PA relationship. This study not only focuses on TD children but also extends its scope to include a distinct population – children with DCD.

1.4 Research Questions

To address some of the aforementioned limitations, the purpose of this thesis was to better understand parental influences of children's PA over time during the early-to-mid childhood period, and specifically sought to answer the following questions:

1. What is the bi-directional relationship between parental PA and child PA each study year over four years?
2. How does DCD impact the parent-child PA relationship?

1.5 Study Hypotheses

H1: Previous research on parental influence impacting children's PA has found a significant impact on TD children (Bauman et al., 2012; Määtä et al., 2013), and therefore, we hypothesize that there will be a positive association between parent PA behaviours on child PA, and that these relationships will be present over time.

H2: Based on research, there is an intuitive expectation that children with DCD, who experience difficulties with gross and fine motor skills and may require additional support and guidance in participating in PA activities, it is hypothesized that the parent-child PA relationship will be stronger among DCD children than TD children.

H3: Lastly, it is expected that the parent-child PA relationship will be bidirectional, whereby child PA will also be related to parent PA, and that the relationship will be stronger among DCD children than TD children.

Chapter Two. Methods

2.1 Study Participants

The current study utilizes longitudinal data from the Coordination and Activity Tracking in CHildren (CATCH) study. The CATCH study is a longitudinal cohort and case-control design comprised of a community-based sample. The total sample recruited for the CATCH study at baseline was 589 children, including 301 that were considered TD and 288 that were considered at-risk for DCD (DCDr) based on baseline scores from the Movement Assessment Battery for Children Second Edition (MABC-2). Initial case allocation for the DCD group was based on whether participants scored above (i.e., TD) or at the 16^{th} percentile and below (DCDr) for the MABC-2, along with the absence of a medical condition to better explain motor deficits, the accounts of interference with activities of daily living, and a score above 70 on standard intelligence testing. However, given recent findings to suggest a lack of stability of the MABC-2 (Veldhuizen et al., 2023), it has been suggested that multiple assessments be taken into account where possible, particularly among younger populations. Given the availability of multiple motor assessments in the CATCH study, it was determined that the inclusion criteria for the current thesis study was to include CATCH participants that had a minimum of two MABC-2 assessments. Additionally, for inclusion in this thesis study, it was required to have valid accelerometer data from both the CATCH child participants along with a parent. Valid accelerometer will be defined under “data processing”.

A total of 547 child participants completed at least two waves of the CATCH study (n=233 girls, *M*age at baseline = 4.93 $\pm$ .59). Among these child participants, a total of 330 child-parent dyads had valid accelerometer data for at least one year of the four-year cohort study (Parent *M*age = 37.18 ± 4.59). Based on the averaged MABC-2 scores for case allocation, 204 child participants were considered TD and 126 were DCD. Valid accelerometer data were available for 172 child-parent dyads at Year 2 (n=110 TD and n=62 DCD), 135 child-parent dyads at Year 3 (n=90 TD and n=45 DCD), and 89 child-parent dyads at year 4 (n=62 TD and n=27 DCD). Attrition for the parent-child dyad over the four years ranged from 22% to 48%. An illustration of recruitment and sample can be found in Figure 1.

2.2 Study Recruitment

CATCH aimed to have a community-based sample. Recruitment for CATCH began in October 2013 and testing for Year 1 began in February 2014. The main recruitment site for this study was two local school boards, in addition to community groups and organizations in and around Hamilton, Ontario. The target age was 4–5-year-old children, and their parents. There were three ways for a referral to occur for the CATCH study; community referral, self-referral, and referral from other studies. Community referral took place at community sites where eligible participants were approached for interest in the study. Self-referral occurred when interested parents would directly contact the study team. A study package was given to all who were interested, and consent and enrollment then began through a telephone interview that introduced the study and reviewed eligibility criteria. Lastly, referral from other studies that occurred within the lab such as the PANS III and NARS.

There was a two-step screening process used: parents completed the Developmental Coordination Disorder Questionnaire (DCDQ) about their age-eligible child, and if the child scored 55/75 or below they were invited to come in for an in-person lab appointment. In addition, children who scored higher then 55 on the DCDQ were randomly selected to attend an appointment in the laboratory. During the in-person lab appointment, the child completed the MABC-2 with a trained research team member. Those children who scored at or below the 16th percentile were automatically invited into the longitudinal cohort study (and formed the DCDr group). Those children who scored above the 16th percentile on the MABC-2 were randomly selected to be invited into the longitudinal cohort study.

Figure 1: Consort Diagram of CATCH numbers for children and parents

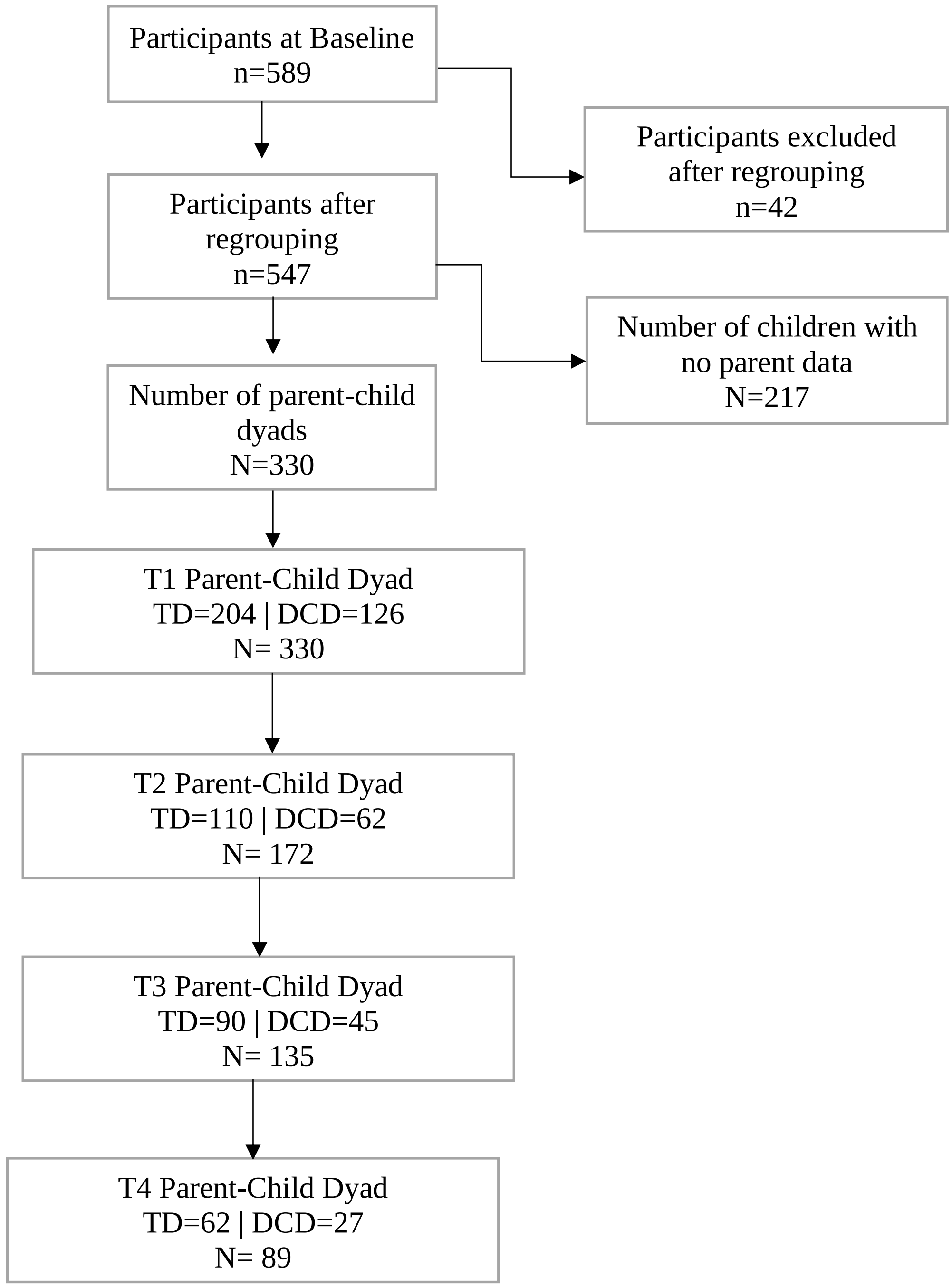

Fig. 1. Illustration of CATCH recruitment and thesis study sample.
Note: TD = typically developing; DCD = developmental coordination disorder.

2.3 Study Procedures

The following will describe the study procedures most relevant to the current thesis study. Data collection for the CATCH study took place in person at the INCH Lab at McMaster University in Hamilton, Ontario. Child participants completed motor and fitness assessments at baseline and during any subsequent follow-up appointments (approximately one year apart). While the child was completing their study activities, their parent or guardian of child participants completed a semi-structured interview about performance of daily activities, and a comprehensive demographic and health-related questionnaire. At the end of the appointment the child and consenting parent(s) were provided accelerometers, accelerometer logs to complete at home. While child PA assessments using accelerometers were required as a part of the primary study, parents were invited to wear accelerometers concurrently with their child to assess their PA (although this was optional). Additionally, a $40 gift certificate and study gift were given to participants at the end of the appointment. A more detailed explanation of the broader CATCH study protocol can be found elsewhere (Cairney et al., 2019).

Each appointment involved multiple assessments conducted at the study lab at McMaster University. These assessments included the Kaufman Brief Intelligence Test Second Edition (KBIT-2), MABC-2, anthropometry measurements, sit and reach test (flexibility), standing long jump, parent interview (listening for DCD) and parent surveys including a medical questionnaire, demographic survey, and the Child Behaviour Checklist (Achenback & Rescorla., 2001). An annual assessment would take place one year after the participants' baseline appointment and continue over the course of three years. The three appointments after baseline in phase 1 were similar to the participants' first appointment in CATCH.

Although unrelated to the current investigation, additional study assessments also included a foot posture assessment, an assessment of aerobic fitness (Bruce protocol on a treadmill), an assessment of anaerobic fitness (a 30-second Wingate test) and a measure of body composition. . All protocols for CATCH have been approved through the Hamilton Integrated Research Ethics Board and Brock Research Ethics Board.

2.4 Study Measures

Below are the relevant measures pertaining to the current investigation.

2.4.1 Demographics

Demographics are asked to the parent about the family. The parent completes a child and family demographic survey during each CATCH appointment. The following questions can give researchers a sense of our participants' socioeconomic status. Questions included sex, weight, height of the child, and if the child has any medical diagnosis or takes medication. This demographic questionnaire also asks the parent who is filling out the survey their gender, weight, relationship to the child, marital status, income level, highest level of education completed, type of dwelling they occupy, (type of place, renting or owning) and how parents feel about their neighbourhood.

2.4.2 Parent Interview

During each appointment, a parental semi-structured interview was conducted to assess children's motor difficulties in active play, self-care and school. This interview was also called listening for DCD and was developed to measure motor difficulties that may occur in children if they are at-risk for DCD. Cairney and colleagues (2019) have indicated that this measure has been used to confirm DCD in studies with children aged 4 and older. To receive a formal diagnosis of DCD, a parent needs to report evidence of a significant functional impact in at least one domain of the DSM-V criteria during the interview. Although an important measure, this was not used to define cases of DCDr. It is important to note that our study did not involve or provide an official clinical assessment or diagnosis, as the study activities were carried out by a trained research team, not clinical professionals.

2.4.3 Movement Assessment Battery for Children 2 (MABC-2)

The MABC-2 was a 20–40-minute assessment administered to all children during the baseline and annual assessments with the aim of identifying and describing any movement problems that the child may have. This assessment is a very popular assessment tool in both clinical and research settings. The MABC-2 looks at three main domains: manual dexterity, aiming and catching, and fine motor. During the MABC-2 assessment, tasks included posting coins, threading beads, drawing trails, catching a beanbag, one-leg balance, walking with heels raised and jumping on mats. Following the assessments, the MABC-2 scoring took place immediately after.

2.4.4 Additional Diagnostic Criteria

At baseline children completed the KBIT-2. This test evaluates intellectual ability by measuring verbal and nonverbal intelligence. This test can be used to test intelligence in children beginning at the age of 4. Three standard scores come from this test: verbal, non-verbal and IQ composite which measures general intelligence and is calculated from the two other scores.

2.4.5 Physical Activity

The central focus of this study is to utilize the ActiGraph accelerometers worn by the child and parent. The ActiGraph wGT3X/ GT3X is a reliable activity monitor that measures human movement (Evenson et al., 2008). Accelerometers are an appealing measure to use for PA tracking as it is a device-assessed measure. The use of accelerometry has become more reliable and less expensive for researchers (Troiano et al., 2012). Accelerometers help to paint a more detailed picture of PA than self-reported measures because they record the frequency, duration, and intensity of PA that occurs when being worn. Accelerometers can be used to measure PA that cannot be skewed by social desirability and recall errors. A study found that social desirability is associated with overreporting of PA when using self-reports (Adams et al., 2005). Additionally, Nusser and colleagues (2012) found that recall errors for PA tend to lead to an overestimation of PA.

It is important to note there are points of time not captured by an accelerometer where a child may participate in PA that is not tracked, such as swimming and cycling (Harrison et al., 2017). Additionally, there is not a standardized method to translate accelerometer output (counts per unit of time) into an exact amount of PA; the most common method is to translate accelerometer output into measures of metabolic equivalents (METs) expenditure that demonstrate similar thresholds of specific intensities of PA (Watson et al., 2013). A metabolic equivalent is used to measure the energy expenditure of PA. It represents a way to express how much energy is being used by the body during different activities in comparison to the energy used when the body is at rest.

The child and parent for this study were asked to wear the ActiGraph accelerometer on right hip for seven days each year. Having the child and parent wear the accelerometers for seven days ensures reliable data and good estimates of PA (Trost et al., 2000). For data cleaning purposes, parents fill out tracking logs of when is the accelerometer is put on and taken off. PA was operationalized as time spent in MVPA and will be explained in greater detail in the data processing section below.

2.5 Data Processing

Over the span of six months, all remaining child and parent files were cleaned and analyzed in ActiGraph's ActiLife software. After loading the file into Actilife, it is imperative to review the log provided by parents and children to ascertain the occurrence of any brief interruptions during which the accelerometer was temporarily remove. When cleaning the data, the parameters we set first included a spike tolerance of 0 for both children and parents. This was done because a spike tolerance of 0 represents a spurious count tolerance where ActiLife will continue scoring non-wear bouts as non-wear until it detects more than the spike tolerance number. Secondly, 'ignore wear period less than 1 minute' was chosen, establishing the minimum duration deemed acceptable for a wear period among children. For parents, wear periods of less than 1 minute are disregarded to ensure comprehensive capture of all instances of parental PA. Lastly, when defining a non-wear period, it indicates when the child or parent has taken off the accelerometer and is the minimum minutes of continuous zeros to be considered as non-wear. For children there must've been sixty minutes of zeros and for adults greater than 90 minutes of consecutive zeros. Non-wear does not go towards the overall wear time. After removing all non-wear periods based on the provided log and research team member discretion, the file can be scored, calculated and subsequently, an Excel file can be downloaded where the data is validated by a research assistant. The Excel file provides a multitude of data, with the most important for this study being the total amount of MVPA. The child and parent must have at least three days of valid data, approximately more than 10 hours (Cairney et al., 2019). A valid day would be considered at least 600 minutes of wear time.

ActiGraph accelerometers worn by parents were also included in this study. Parental PA influence on children's PA was the main objective of this thesis. To examine the accelerometer counts, different cutpoints were used for child and parent. Cutpoints provide a means to describe activity pattern and quantify time spent at various levels of PA intensity (Holmlund et al., 2019). This is crucial because the primary PA being looked at for this study is MVPA. The child cutpoint used was the Evenson (2008) and the parent cutpoint used is the Troiano adult (2008).

Using appropriate cutpoints was important in determining the child's level of activity. The Evenson cutpoint was used to find the average daily minutes of MVPA (Evenson et al., 2008). The Evenson cutpoint values used were sedentary 0 to 100, light 101 to 2295, moderate 2296 to 4011, and vigorous 4012 and above. The MVPA minimum count for the Evenson cutpoint is 2296. This study will use 3-second epochs to analyze the data, which will help to catch short bouts of activity that children tend to do throughout the day (Evenson et al., 2008). In a comparison of five accelerometer cutpoints analyzed, Evenson has exhibited substantial agreement (K= 0.68) (Trost et al., 2011). Moreover, when comparing the differences between five accelerometer child cutpoints, Evenson had the most acceptable classification accuracy for all levels of PA and performed well among children (Trost et al., 2011). Using the Evenson cutpoint ensures that the classification for MVPA is validated correctly when examining children's PA.

For adults, the Troiano cutpoint was used. The cutpoint values for Troiano are sedentary 0 to 99, light 100 to 2019, moderate 2020 to 5998, and vigorous 5999 and above. The MVPA minimum count is 2020. The intensity-threshold criteria were 2020 counts for moderate intensity and 5999 counts for vigorous intensity (Troiano et al., 2007). To determine these thresholds, four past calibration studies were used that relate accelerometer counts to measure activity energy expenditure specifically ambulatory activities such as treadmill and track walking (Troiano et al., 2007). The benefits of using ambulatory activities to determine thresholds is that the use of lifestyle activities used many movement patterns with little vertical acceleration leading to lower counts (Watson et al., 2013). Thresholds for moderate activity of 4 METs found the threshold for those above 18 to be 2020, which is used for Troiano cutpoint. Thresholds for vigorous activity of 7 METs found a threshold for those 18 and above to be 5999, which is also used for the Troiano cutpoint. Watson et al (2013), found that it would be important to use a cutpoint derived from a sample that represents the American adult population, which Troiano has done and is beneficial for the Canadian sample that will be used for this study. When validating the data and ensuring wear time is sufficient, the same process is followed for parent and child.

2.6 Assessment of DCD

The identification of children as DCD is based on the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-V). DCD is often unrecognized and underdiagnosed because children are looked at as clumsy or awkward at a young age. The following criteria come from the DSM-IV when diagnosing DCD (APA, 2013; Harris., Mickelson, & Zwicker, 2015):

1. The acquisition and execution of coordinated motor skills are substantially below that expected given the individual’s chronological age and opportunity for skill learning and use. Difficulties are manifested as clumsiness (e.g., dropping or bumping into objects) as well as slowness and inaccuracy of performance of motor skills (e.g., catching an object, using scissors or cutlery, handwriting, riding a bike or participating in sports).
2. The motor skills deficit in criterion A or #1 significantly and persistently interferes with activities of daily living appropriate to chronological age (e.g., self-care and self-

maintenance) and affects academic/school productivity, prevocational and vocational activities, leisure and play.

3. The onset of symptoms is in the early developmental period.
4. The motor skills deficits are not better explained by intellectual disability (intellectual developmental disorder) or visual impairment and are not attributable to a neurological condition affecting movement (e.g., cerebral palsy, muscular dystrophy, degenerative disorder).

The CATCH study utilized various assessments to ensure accurate identification of the DCD group. These assessments included the MABC-2, which evaluates motor coordination and can detect children with at-risk DCD (DCDr) if they scored $\leq 16^{th}$ percentile. The MABC-2 is widely used for identifying DCD. The KBIT-2 was employed to rule out criterion four in the DSM-IV, thereby ensuring that intellectual disability or visual impairment was not a result of motor difficulties. If the child received ≤ 16 percentile and above 70 on the KBIT-2 they were included in the DCD group. Interviews with parents identified both onset of symptoms and other medical conditions that could possibly better explain motor impairments.

2.7 Statistical Analysis

The Actor-Partner Interdependence Modeling (APIM) was used to analyze data to answer the primary research question. This approach was selected as it can specifically examine the association between dyads and is the reason it is chosen in studies where a dyadic relationship is being studied (Burns, 2019; Berg et al., 2001; Lucas et al., 2021; McCabe, 2017). APIM offers a framework for analyzing outcomes in dyadic relationships by separating the effects of the individuals' actors and their partners, meanwhile also taking into account the interdependencies that frequently occurs within these relationships (Burns, 2019; Cook & Kenny, 2005; Cook et al., 2018; Shamali et al., 2019; Yang et al., 2020). In other words, it takes into account the interdependence in close relationships and has an emphasis on assessing bidirectional effects between partners (Cook & Kenny, 2005; Cook et al., 2018). This model estimates both the actor effect (effect of a person's own variable) and the partner effect (the effect of the same variable from the partner) (Cook & Kenny, 2005). The interdependence of this model acknowledges the dependence of one variable on another variable (Cook & Kenny, 2005; Cook et al., 2018). For example, how the behaviour of one affects the behaviour of another. Therefore, this analysis will be able to examine the child's PA dependence on the parent's PA, and the relationship that occurs between the two. All participants in this model are treated as both actors and partners.

The APIM model will be utilizing path analysis. This study, like past studies, has utilized APIM involving path analysis. Path analyses is similar to APIM as it looks at causal modeling when exploring correlations (Horodyska et al., 2019). Leavitt and colleagues (2019) utilized a longitudinal path analysis with APIM as path analyses "allows multiple multivariate regression models to run simultaneously in one large model (p.443). Additionally, on these paths we can look at both the actor and partner effects through the APIM model. Path analysis looks at the effects of a variable on an outcome, meanwhile APIM looks at the direct actor and partner effects that these paths take (Gabriel et al., 2016; Gana et al., 2013; Leavitt et al., 2019). Utilizing path analysis through APIM we can look at both the exogenous variables and endogenous variables, and for this analysis all variables are observed. Exogenous variables are independent of other variables in the model and are not influenced by them, whereas endogenous variables are influenced by another variable within the model. In the context of this thesis, the observed exogenous variable pertains to the parent and child PA values recorded during Year 1. Moreover, the observed endogenous variables refer to the parent and child PA values recorded in

Years 2 to 4. Additionally, the unobserved exogenous variable are the error terms denoted as S, U, W, T, V and Z in figures 2 to 4 in the Results chapter.

Our longitudinal approach examines relationships between child and parent PA, and its potential cross-over effects as assessed through accelerometers over four years. All path models were constructed using IBM SPSS AMOS (version 28) to determine the influence of actor-partner effects applied on each subsequent time point. Maximum likelihood estimations were used to estimate each model, while all models were adjusted for regression weights. Hence, all the models consider various pathways and the strengths of estimates and regression weights when formulating the final model. Full maximum likelihood was employed to address missing data in our analysis. Cook and Kenny (2005) have indicated that traditional model-fit statistics are not presented due to APIMs recursive, and throughout literature researchers utilizing APIM have not followed the traditional model-fit statistics.

Chapter Three. Results

3.1 Descriptive Statistics

A total of 330 child-parent dyads that met the eligibility criteria were included for the current study. Among parent participants, the vast majority of the sample were white (83% children and 87% parents), living in a married household (89%) and were mothers of the child participants (84%). The mean age for the parents of the TD group was 36.41 years ± 4.75, with a majority of parents being 35-45 years old (72%), and for the DCD group the average age was slightly higher at 37.65 years ± 4.43 with most being between 35-45 years old (63%). Furthermore, more than half of the parent participants completed college and university (63%), meanwhile more parents (26%) went on to pursue a professional/postgraduate degree. Additionally, many of the families have at least one parent working full-time (55%). A large part of the parent sample has a household income of above $100,000 (64%), with a sizable but somewhat smaller subset earning more than $150,000 (30%) which displays the affluence of the sample. A detailed description of child and parent participants can be found in Tables 1 and 2.

3.2 Test of Differences

One-Way ANOVA and Chi-square tests were conducted to compare demographic factors between the participants included in our analyses (n=330) and the participants included in the overall CATCH study (N=589). This test was undertaken to identify any potential biases that may arise from excluded participants from the overall CATCH study. The first test was for the children, based on sex and DCD status. The tests completed for parents were based on sex, mean age, ethnicity, household income, parental education, and marital status. Table 1 and 2 below indicate the demographic factors of the entire sample (N=589), on the left-hand side is the subsample (n=330) with the ineligible participants on the right-hand side (n=259). Throughout the test of differences, there were no statistically significant differences.

Table 1. Group Differences in Demographic Characteristics for Children

	Included Sample (N=330)	X^2 or F	p-value	Ineligible Sample (n=259)	X^2 or F	p-value
Girl:	n=106 (52%)	25.478	.<.001	n=203 (78%)	1.836	.175
Boy:	n=98 (48%)			n=56 (22%)		
TD	n=204 (62%)	20.175	<.001	n= 97 (37%)	.116	.733
DCD	N=126 (38%)			n=162 (63%)		

**p<.001*

Note: TD= Typically Developing; DCD= Developmental Coordination Disorder

Table 2. Group Differences in Demographic Characteristics for Parents

	TD (n=204)	DCD (n=126)	X^2 or F	P-Value	Ineligible Sample (n=259)	X^2 or F	P-Value
Gender							
Woman:	n=172(84%)	n=106 (84%)	.002	.964	n=61 (28%)	1.086	.297
Man:	n=32 (16%)	n=20 (16%)			n=198 (72%)		
Age	*(M= 36.41 ± 4.75)*	*(M= 37.65 ± 4.43)*	5.713	.017	*(M= 37.20 ± 5.26)*	1.067	.373
Ethnicity:							
White:	n=178(87%)	n=109 (87%)	.195	.659	n=184 (71%)	3.019	.082
Other	n=26 (13%)	n=17 (13%)			n=75 (29%)		
Marriage Status:							
Married:	n=181(89%)	n=101(80%)	1.674	.196	n= 222 (86%)	2.370	.124
Other:	n=36 (11%)	n=25 (20%)			n=24 (14%)		
Highest Education:							
university/ college/ graduate degree:	n=180(88%)	N=108 (86%)	3.349	.067	n= 85 (64%)	.047	.828
Other:	n=24 (12%)	n=18 (14%)			n=174 (13%)		
HH Income:							
Lower than $50,000	n=7 (3%)	n=22 (17%)	8.132	.004	n=45 (17%)	2.797	.094
Above $50,000	n=192(94%)	n=103(82%)			n=210(81%)		
No answer:	n=5 (3%)	n=1 (1%)			n=4 (2%)		

**p<.001; Note*: TD= Typically Developing; DCD= Developmental Coordination Disorder

3.3 Moderate-to-Vigorous Physical Activity

All mean times in MVPA and wear time are reported in Table 3. Bivariate correlations of child and parent MVPA were conducted to first establish relationships between PA of children and parents at the group level for each of the four time points. In the correlation table, it was evident that both parent and child were significantly positively correlated with their own MVPA, *r's* ranged from .450-.675 (*p's*<.01), but child and parent MVPA relationships were not significant (*p's*>.05). All correlation coefficients can be found in Table 4.

3.4 Determination of Inclusions for Covariates

One-way ANOVAs were used to examine the relationships between socio-demographic factors and child and parent MVPA, to determine if any socio-demographic factors were required to be included for the primary APIM analyses. For child participants, one-way ANOVA was run to test for sex differences in the observed variable (F=19.142, df=1,280 *p*=<.001). For parent participants, we test for differences in MVPA based on sex, age, education, and household income. Results did not find any significant differences in MVPA for parent education (F=2.609, df=1,279, *p*=.107) or household income (F=2.117, df=1,273, *p*=.147). For Year 1 sex for parent MVPA, there was indication there was a small relationship but no relationship after Year 1, F(4.041, df=1, 279, *p*=.045) therefore it will not be used as a covariate in the final analysis. When incorporating child sex as a covariate in the model, the pathways did not show statistical significance, suggesting that it did not have a confounding effect on the relationship between parent and child PA, and were thus removed from our final analyses.

Table 3. Descriptive Statistics on Child and Parent MVPA

	Child Participant			Parent Participant		
	n	*Mean*	*SD*	*n*	*Mean*	*SD*
MVPA						
Year 1	281	71.28	18.33	281	28.22	17.63
Year 2	172	72.58	20.18	172	29.52	18.51
Year 3	135	70.03	19.02	135	30.86	18.33
Year 4	89	67.46	18.55	89	33.77	22.51
Wear time						
Year 1	281	721.74	41.12	281	847.00	72.31
Year 2	172	726.48	41.58	172	848.01	67.27
Year 3	135	745.40	40.30	135	843.13	94.39
Year 4	89	742.72	43.29	89	854.09	63.30

Note: MVPA= Moderate-to-vigorous physical activity

Table 4. **Correlation Table**

	1	2	3	4	5	6	7
2.Year 1 Parent MVPA	0.91						
3.Year 2 Child MVPA	**.675****	.071					
4.Year 2 Parent MVPA	-.002	**.505****	.061				
5.Year 3 Child MVPA	**.450****	.080	**.663****	.118			
6.Year 3 Parent MVPA	.126	**.625****	.166	**.738****	**.194***		
7.Year 4 Child MVPA	**.637****	.124	**.604****	.064	**.649****	.155	
8.Year 4 Parent MVPA	**.246***	**.684****	.197	**.675****	**.274***	**.758****	.206

***correlation is significant at the 0.01 level (2-tailed)*
**correlation is significant at the 0.05 level (2-tailed)*
Note: MVPA= Moderate-to-vigorous physical activity

3.5 Full Sample Longitudinal Actor-Partner Interdependence Model

The first APIM model examined included the full sample, comprised of both TD and DCD children and their parents. Results indicate that the model successfully converged (X^2 =55.772; df=12; p=<.001). Although traditional model-fit statistics are less applicable because APIMs are recursive (Cook & Kenny, 2005), fit statistics for the full sample APIM is shown in Table 5. Estimates from the APIM for the full sample indicates that all actor effects were significant. That is, child MVPA at all preceding time points significantly predicted each subsequent time point (Estimates =.655-.764 *p*'s<.01). Similarly, parent MVPA at all preceding time points significantly predicted each subsequent time point (Estimates = .509-.795 *p*'s<.01). However, results indicate that there were no significant partner relationships (Estimates = -.065 - .075 *p*'s>.05). That is, neither child nor parent MVPA at all preceding time points did not predict any subsequent time point. All estimates are shown in Table 6, and the complete APIM model is illustrated in Figure 2.

Figure 2: Full Sample Actor-Partner Interdependence Model

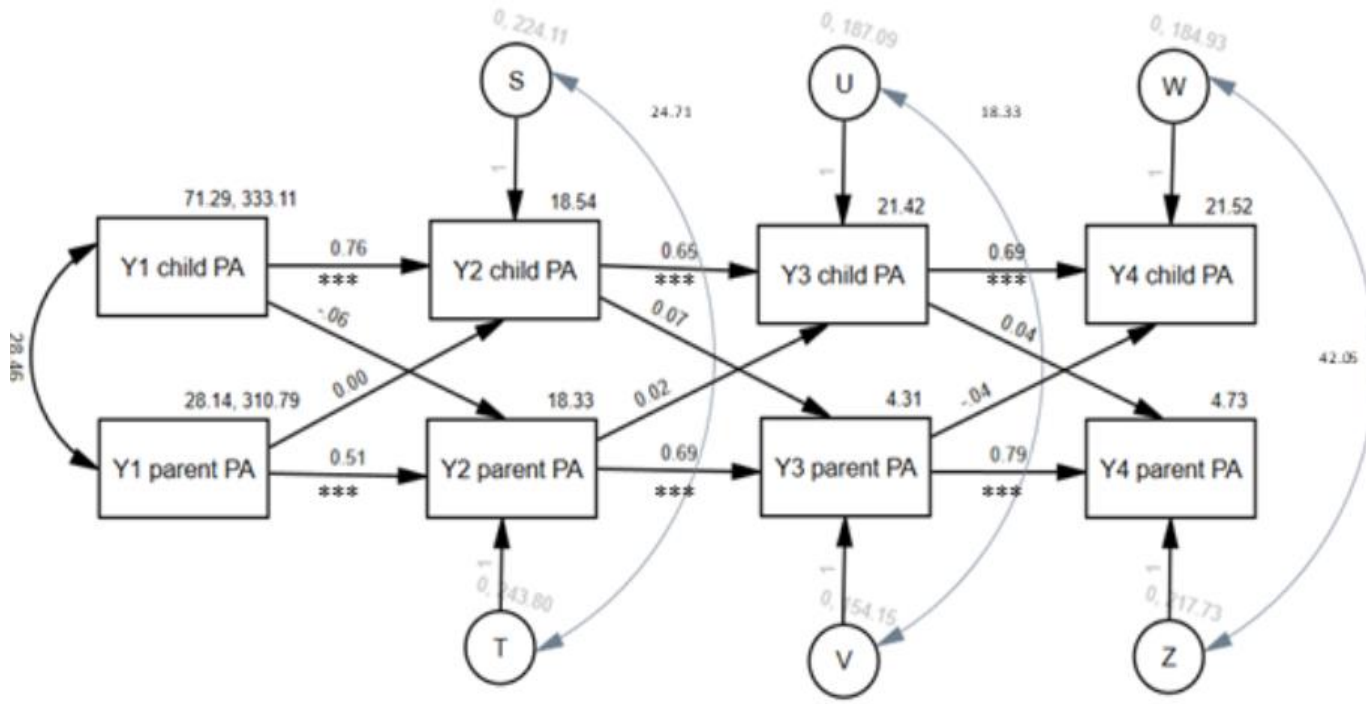

Fig. 2. Results of APIM via path analysis for child and parent PA using total sample.
Note: PA stands for physical activity

Table 5. Fit Statistics for Full Sample APIM

	Value	P-Value
Chi-Square	55.772	.001
AIC	119.772	
BCC	121.572	
CFI	.900	
RMSEA	.105	.001

Note: X^2 df = 12; AIC= Akaike information criteria; BCC= Browne-Cudeck criterion; CFI= comparative fit index; RMSEA= root mean square error of approximation

Table 6. Regression Weights of APIM Pathways

Relationship/ Pathway	Estimate	SE	CR	P-Value
Year 1 Child to Year 2 Child	**.764**	**.064**	**12.004**	***
Year 1 Parent to Year 2 Parent	**.509**	**.069**	**7.373**	***
Year 1 Child to Year 2 Parent	-.065	.067	-.967	.334
Year 1 Parent to Year 2 Child	-.002	.068	-.025	.980
Year 2 Child to Year 3 Child	**.655**	**.060**	**10.973**	***
Year 2 Parent to Year 3 Parent	**.690**	**.062**	**11.157**	***
Year 2 Child to Year 3 Parent	.023	.069	.334	.738
Year 2 Parent to Year 3 Child	.075	.055	1.354	.176
Year 3 Child to Year 4 Child	**.686**	**.081**	**8.433**	***
Year 3 Parent to Year 4 Parent	**.795**	**.096**	**8.299**	***
Year 3 Child to Year 4 Parent	.041	.090	.452	.651
Year 3 Parent to Year 4 Child	-.043	.090	-.482	.630
Variances				
Year 1 Child MVPA	**333.106**	**27.864**	**11.955**	***
Year 1 Parent MVPA	**310.791**	**26.199**	**11.863**	***
S	**224.107**	**25.235**	**8.881**	***
T	**243.799**	**26.850**	**9.080**	***
U	**187.091**	**24.239**	**7.719**	***
V	**154.151**	**20.173**	**7.641**	***
W	**184.931**	**30.109**	**6.142**	***
Z	**217.726**	**35.493**	**6.134**	***

****p<.001*

Note: MVPA= moderate-to-vigorous physical activity

3.6 Longitudinal Typically Developing Actor-Partner Interdependence Model

The second APIM model examined included the TD sample. Results indicate that the model successfully converged (X^2 =42.555; df=12 p<.001), and complete fit statistics for the full sample APIM is shown in Table 7. Estimates from the APIM for the full sample indicates that all actor effects were significant. That is, child MVPA at all preceding time points significantly predicted each subsequent time point (Estimates = .699 - .741 p's<.01). Similarly, parent MVPA at all preceding time points significantly predicted each subsequent time point (Estimates = .569-.870 p's<.01). However, results indicate that there were no significant partner relationships (Estimates = -.068- .074 p's<.01). That is, neither child nor parent MVPA at all preceding time points did not predict any subsequent time point (Estimates = -.009- .039 p's<.05). All estimates are shown in Table 8, and the complete APIM model is illustrated in Figure 3.

Figure 3: Typically Developing Actor-Partner Interdependence Model

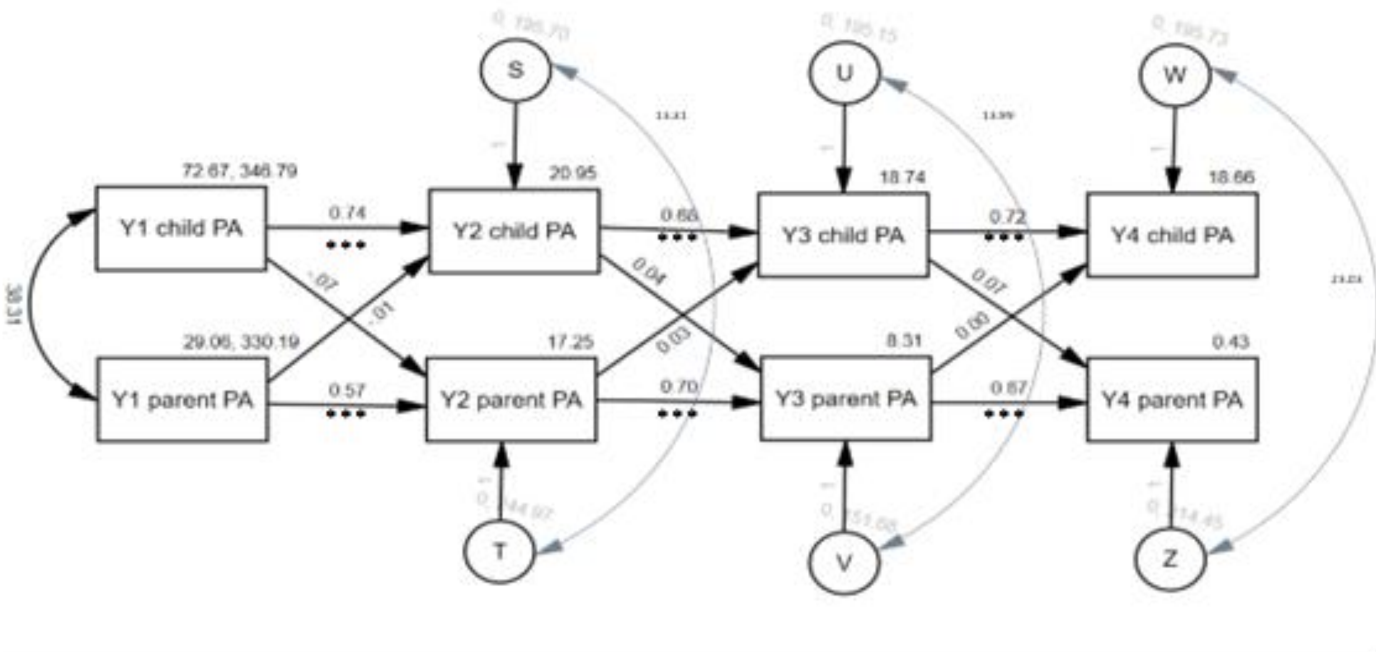

Fig. 3. Results of APIM via path analysis for child and parent PA using TD sample
Note: PA= physical activity; TD= typically developing

Table 7. Fit Statistics for TD APIM

	Value	P-Value
Chi-Square	42.555	.001
AIC	106.555	
BCC	109.524	
CFI	.907	
RMSEA	.112	.003

Note: X^2 df = 12; AIC= Akaike information criteria; BCC= Browne-Cudeck criterion; CFI= comparative fit index; RMSEA= root mean square error of approximation; TD= Typically Developing

Table 8. Regression Weights of APIM Pathways

Relationship/ Pathway	Estimate	S.E	C.R	P-Value
Year 1 Child to Year 2 Child	**.741**	**.073**	**10.090**	***
Year 1 Parent to Year 2 Parent	**.569**	**.084**	**6.771**	***
Year 1 Child to Year 2 Parent	-.068	.082	-.828	.408
Year 1 Parent to Year 2 Child	-.009	.077	-.113	.910
Year 2 Child to Year 3 Child	**.685**	**.077**	**8.893**	***
Year 2 Parent to Year 3 Parent	**.699**	**.071**	**9.780**	***
Year 2 Child to Year 3 Parent	.039	.069	.560	.576
Year 2 Parent to Year 3 Child	.025	.082	.306	.760
Year 3 Child to Year 4 Child	**.717**	**.098**	**7.304**	***
Year 3 Parent to Year 4 Parent	**.870**	**.111**	**7.850**	***
Year 3 Child to Year 4 Parent	.074	.105	.704	.481
Year 3 Parent to Year 4 Child	-.003	.108	.704	.975
Variances				
Year 1 Child MVPA	**346.789**	**36.494**	**9.503**	***
Year 1 Parent MVPA	**330.189**	**34.961**	**9.445**	***
S	**195.697**	**27.775**	**7.046**	***
T	**244.967**	**33.989**	**7.207**	***
U	**195.151**	**30.602**	**6.377**	***
V	**151.677**	**24.049**	**6.307**	***
W	**195.729**	**38.162**	**5.129**	***
Z	**214.448**	**42.050**	**5.100**	***

****p<.001*

Note: MVPA= moderate-to-vigorous physical activity

3.7 Longitudinal DCD Actor-Partner Interdependence Model

The third APIM model examined included the DCD sample. Results indicate that the model successfully converged (X^2=37.673; df=12 p<.001), and fit statistics for the full sample APIM is shown in Table 9. Estimates from the APIM for the full sample indicates that all actor effects were significant. That is, child MVPA at all preceding time points significantly predicted each subsequent time point (Estimates = .526- .821 p's<.001). Similarly, parent MVPA at each preceding time points significantly predicted each subsequent time point (Estimates =.326-.611 p's<.01). However, results indicate that there were no significant partner relationships (Estimates = -143 -.094 p's<.01). That is, neither child nor parent MVPA at all preceding time points did not predict any subsequent time point (Estimates = -.214- .013 p's<.05). All estimates are shown in Table 10, and the complete APIM model is illustrated in Figure 4.

Figure 4*: **Developmental Coordination Disorder Actor-Partner Interdependence Model***

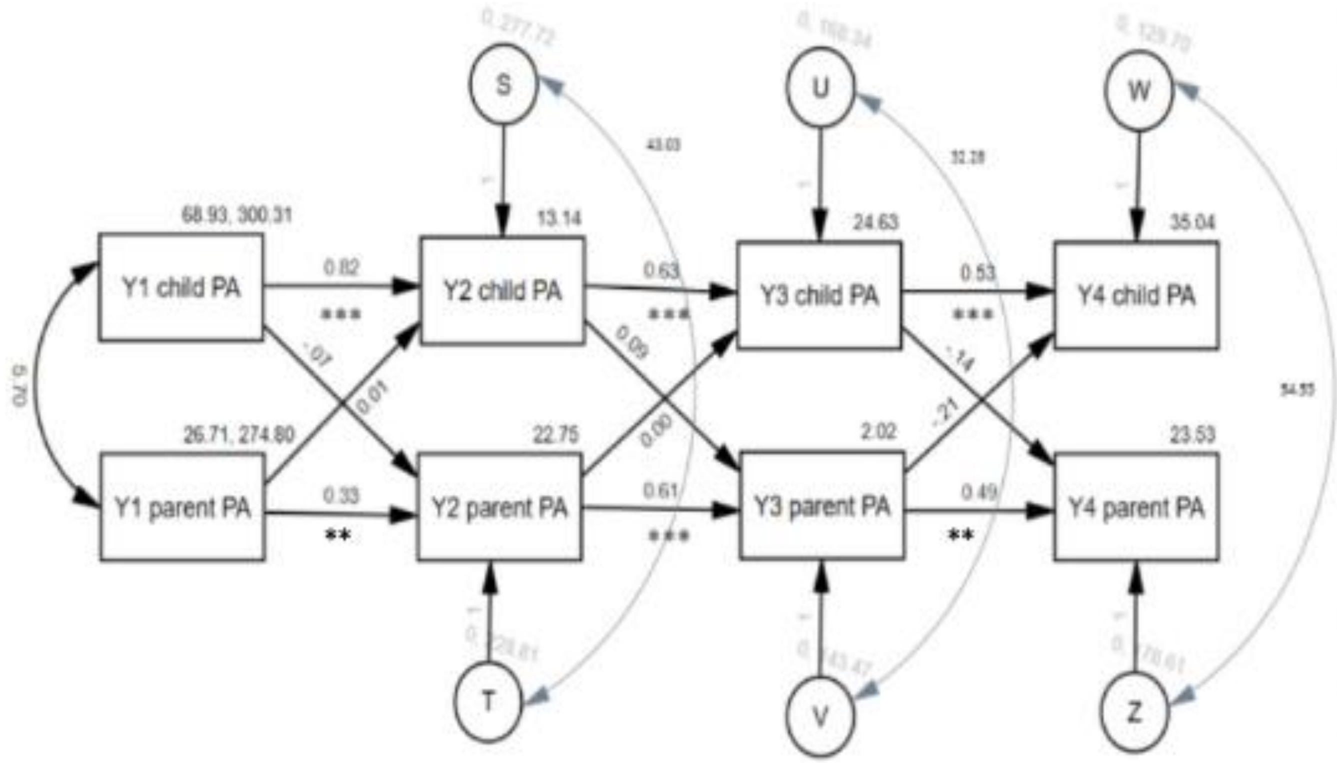

Fig. 4. Results of APIM via path analysis for child and parent PA using DCD Sample
Note: PA= physical activity; DCD= Developmental Coordination Disorder

Table 9. Fit Statistics for DCD APIM

	Value	P-Value
Chi-Square	37.673	.001
AIC	101.673	
BCC	106.639	
CFI	.722	
RMSEA	.131	.003

Note: X^2 df = 12; AIC= Akaike information criteria; BCC= Browne-Cudeck criterion; CFI= comparative fit index; RMSEA= root mean square error of approximation; DCD= Developmental Coordination Disorder

Table 10. Regression Weights of APIM Pathways

Relationship/ Pathway	Estimate	S.E	C.R	P-Value
Year 1 Child to Year 2 Child	**.821**	**.123**	**6.665**	***
Year 1 Parent to Year 2 Parent	**.326**	**.120**	**2.718**	**
Year 1 Child to Year 2 Parent	0.070	.113	-.617	.537
Year 1 Parent to Year 2 Child	.013	.133	.099	.921
Year 2 Child to Year 3 Child	**.627**	**.094**	**6,672**	***
Year 2 Parent to Year 3 Parent	**.611**	**.120**	**5.110**	***
Year 2 Child to Year 3 Parent	.094	.089	1.054	.292
Year 2 Parent to Year 3 Child	-.001	.133	-.008	.994
Year 3 Child to Year 4 Child	**.526**	**.128**	**4.094**	***
Year 3 Parent to Year 4 Parent	**.487**	**.183**	**2.656**	**
Year 3 Child to Year 4 Parent	-.143	.151	-.943	.346
Year 3 Parent to Year 4 Child	-.214	.159	-1.346	.178
Variances				
Year 1 Child MVPA	**300.308**	**41.536**	**7.230**	***
Year 1 Parent MVPA	**274.796**	**38.427**	**7.151**	***
S	**277.717**	**51.561**	**5.386**	***
T	**228.808**	**41.475**	**5.517**	***
U	**168.339**	**39.103**	**4.305**	***
V	**143.474**	**33.265**	**4.313**	***
W	**129.695**	**38.074**	**3.406**	***
Z	**178.605**	**51.149**	**3.492**	***

****p<.001; **p<.01*
Note: MVPA= moderate-to-vigorous physical activity

Chapter Four. Discussion

4.1 General Discussion

The purpose of the current thesis was to examine the relationship between parent and child PA behaviours over time, and to investigate the potential differences between TD and DCD children. Utilizing a dyadic approach of APIM with path analysis, overall results from these APIM models indicate significant actor, but non-significant partner effects. In other words, contrary to our initial hypothesis for research question one, current results did not find significant relationships between parent and child MVPA, nor child MVPA on parent MVPA. Contrary to hypothesis two, the relationships between parental and child MVPA were largely consistent between DCD and TD children. Together, the results would suggest that despite child PA behaviours being predictive of their future MVPA during the early to mid-childhood period, the influence of parental MVPA on child PA is not significant.

4.2 Actor Effects

Throughout each APIM model, there were significant actor effects observed. This is consistent with several longitudinal studies that have found past behaviour being a significant predictor of future PA levels across the lifespan. A longitudinal study conducted by Melby et al. (2021) investigated the PA levels of children at the age of six and then again at age 13 and found a significant association between the PA levels a child completed at both timepoints. A different study that looked at children of a similar age also found a significant positive relationship for childhood PA and PA during early adolescence (Lima et al., 2017). Similarly, a 21-year tracking study also found that if a child participated in MVPA from ages 9-18, they were more likely to continue these high levels of activity into adulthood (i.e., ages 24-39) (Telama et al., 2005). However, it is important to note that very few studies have focused on longitudinal PA behaviours beginning during early childhood.

When comparing the different APIM models that were conducted, for the disaggregated models (i.e., TD and DCD children separately) versus the aggregate data (i.e., full sample), findings were largely consistent with one another. This finding may not be entirely surprising, as in one of the first studies examining PA among children with DCD during early childhood using baseline CATCH data, King-Dowling and colleagues (2019) did not find any differences in MVPA between TD children and DCDr children. Although their case allocation only applied MABC-2 scores at baseline, overall movement behaviours during this early childhood period appear similar between groups. These findings may be attributable to the fact that there may not be as many motor demands for activities during early childhood with children being able to choose their own play activities. Indeed, most studies have found differences in PA behaviours among TD and DCD children; however, the literature has focused on children during mid-to-late childhood and beyond (Rivilis et al., 2011). In the systematic review by Rivilis and colleagues (2011), they found 20 of the 21 included studies having evidence of a PA deficit among children with DCD , although smaller effects when PA was reported using device-assessed measures. That being the case, Kwan and colleagues (2016) still found significant baseline differences in MVPA at 12 and 13 years of age as assessed through accelerometers. Although the estimates for TD children remained fairly consistent over time (β's 0.66-0.74), it may be notable that the strength of the relationships for children with DCD diminishes over time (β's: T1=0.82, T2=0.63, T3=0.53). This could potentially suggest that the MVPA during the early childhood period may become less predictive of MVPA as children with DCD age, and a contributing factor towards children with DCD being less physically active during later childhood and adolescence.

Significant actor effects were also present for parents, suggesting that their levels of MVPA were predictive of their behaviours at each subsequent timepoint. As indicated earlier, there is longitudinal evidence that suggest childhood PA behaviours track well into adulthood (Telama et al., 2005). A study by Rossi and colleagues (2018) also examined patterns and correlates of PA in adults and found that the frequency, duration, and intensity of PA tends to remain fairly stable over time during adulthood. Lastly, in a study examining PA over the lifespan, it was found that baseline PA was a good predictor of activity during follow-up (Hirvensalo & Lintuene, 2011). Our finding support these studies suggesting that parent MVPA is significantly related to their future engagements in MVPA.

4.3 Partner Effects

Contrary to our initial hypotheses, partner pathways were not significant. In other words, this suggests that neither parent nor child MVPA levels were predictive of future amounts of MVPA for each other at any timepoint. Importantly, parent PA was not found to be a significant predictor of child PA during early childhood regardless of DCD status. This finding may not be entirely surprising given some specific and recent studies that also found null findings between parents and child PA (Donnelly et al., 2020; Jago et al., 2014; Jago et al., 2017; Lee et al., 2018; Peterson et al., 2020). Despite the general conclusions that parental PA are influential of child PA within the systematic review by Peterson and colleagues (2020), it should be noted that results from the individual studies were equivocal.

Within the systematic review, 16 of the 39 (41%) studies used to look at the association between parent and child PA found null findings (Peterson et al., 2020). When focusing on the studies involving young children in the systematic review that utilized accelerometers, a clear division emerged, with a 50/50 split between the studies. Half of the studies reported significant findings, while the other half did not find any significant results. Eight of the 16 studies had significant findings when looking at the relationship between parent and child PA (Abbott et al., 2016; Barkin et al., 2017; Moore et al., 1991; O'Dwyer et al., 2012; Oliver et al., 2010; Ruiz et al., 2011; Song et al., 2017; Xu et al., 2018). Additionally, eight of 16 studies had insignificant findings between parent and child PA (Dlugonski et al., 2017; Jago et al., 2010; Jago et al., 2014; Jago et al., 2017; Maltby et al., 2018; Sijtsma et al., 2015; Solomon-Moore et al., 2017; Walsh et al., 2017). When examining the review further, three of the studies that included device-assessed measures and preschool aged sample had a longitudinal sample design similar to the current study. Within these longitudinal studies, two had positive findings and one had null findings (Jago et al., 2017; Moore et al., 1991; O'Dwyer et al., 2012). However, it is crucial to highlight that in the O'Dwyer et al (2010) article participants were explicitly engaged in a program aimed at enhancing child PA and it was not an observational study tracking daily behaviours through device-assessed measures. As observed in the systematic review, the findings are ambiguous when looking at parent and child PA, and the present study's research adds to the existing literature by presenting another study with non-significant results.

Upon delving further into the literature, it was discovered that there were additional studies that reported results similar to our current study. This trend was evident in Donnelly and colleagues' study (2020) which recruited a comparable overrepresentation of mothers (81%) and utilized ActiGraph GT3X to assess levels of MVPA. Similarly, three other studies (Fisher et al., 2011; Hnatiuk et al., 2016; Lee et al., 2018) also revealed no associations between parent and child PA.

Intuitively, it was expected that parent PA would be influential on child PA. Parents are likely to often dictate children's day-to-day behaviours, and likely to have children participate in activities when together. A study conducted in 2022 looking at children aged 3-6 years old found that when parents actively participate with their child, there were positive associations reported between child and parent (Cai et al., 2022). This is important as interventions targeting families have been shown to be effective. A 15-week intervention program which included both parents and children participating together found that there were more family social behaviours and improved quality of leisure time PA (Pluta et al., 2017). O'Dwyer and colleagues (2012) completed a study focusing on a family-centred active play intervention for preschool children. The study involved both parents and children participating in the intervention to assess whether it could reduce sedentary time and increase PA within the family. The results of the study showed that the play-based intervention positively influenced the PA levels of both parents and children. However, the null findings may be attributable to the fact that parents and children may not have been together during much of the accelerometer wear time.

Another explanation for null hypotheses for the current study may be related to the analyses that were conducted. Various statistical analyses can be employed to examine the relationship between parent-child PA. It is important to note that most studies within the Peterson et al (2020) systematic review did not involve dyadic analysis such as the APIM when examining parent-child relationship. That is, most analyses examined the relationship between group means. In the current study, the APIM was deliberately chosen to facilitate a focused examination of dyadic relationships. This helps to elucidate the divergent findings, as previous studies have employed various analyses when investigating this relationship.

One final consideration for our current findings is related to the use of accelerometers. For example, results can be influenced by cleaning processes such as epoch length and cutpoint values. In the current study, Evenson cut-points were applied for child MVPA, assessed by 3-

second epochs. Evenson was chosen as it was considered the best classification accuracy for MVPA (Trost et al., 2011). Utilizing 3-second epochs allows for the accelerometer to catch short bouts of activity. For parents, the Troiano cutpoint is used as it pulls together four other cutpoints to accurately assess MVPA (Watson et al., 2013), using 1 minute epoch. Therefore, there may be some limitations examining and comparing MVPA for parents and child participants. Another limitation of accelerometers is that it is not capable of tracking all activities and may not have captured some water-based activities or cycling.

4.5 Strengths and Limitations

As with all research studies, this current thesis has both strengths and limitations. One of the most notable strengths was the longitudinal design of the CATCH study. Using longitudinal data allowed us to test PA relationships over time, and across the broader early- to mid-childhood period. Another strength of the current study is the application of the APIM model, which effectively captures and accounts for both the actor and partner effects, allowing for examination of relationships simultaneously. Finally, another strength of the study was the utilization of accelerometers to assess MVPA levels for both parents and children. As mentioned previously, accelerometers help in avoiding recall biases that can arise from surveys, which often leads to a tendency to overestimate PA (Schaller et al., 2016).

Despite these strengths, there are several limitations that are worthwhile to note. The first limitation of this study is related to the sample recruited. Despite wider community recruitment efforts, the sample we acquired tended to be predominately white, well-educated, with higher household incomes. This potentially limits the generalizability of our findings to the wider population. For example, this was seen in a study that found that a child's socioeconomic position was associated with movement trajectories, particularly for girls (Wilhite et al., 2023). A second limitation of this study was with regards to attrition. All parents whose children participated in the CATCH study were given the opportunity to voluntarily participate. Parents who willingly agreed to wear an accelerometer for one week allowed for the tracking of both child and parent MVPA data. To be included in the present study, both the parent and child needed to have valid data for at least one of the four years. Unfortunately, over the course of the four years, there was a significant decrease in the number of participating parents, resulting in an attrition rate as high as 48%. Although a useful measure, there are also limitations that come with the application of accelerometers. For example, accelerometer measurements may not accurately capture all types of PA, particularly during the summer months when children and parents may engage in swimming or other water activities (Mikalsen et al., 2022), whereby the device is to be removed. Furthermore, accelerometers provide us with specific values for PA, they do not provide any context about the type of activity being performed while the accelerometer is worn. Instead, the accelerometers provide overall movement counts that are expressed or characterized into established MVPA cut-points. Additionally, it is important to highlight that a total of 660 pieces of parent accelerometer data were collected over a period of four years. However, only half of these had valid accelerometer wear indicating that the remaining half did not meet the necessary criteria for inclusion in the study. Finally, it should be noted that there were multiple cases where different children (i.e., siblings) had the same parent participate. This violates the assumption of independence; however, was included to preserve sample size.

4.6 Conclusions

Overall, this thesis examined the relationships between parent and child levels of MVPA over a four-year period among a cohort of children beginning at age 4 and 5 years. Upon application of a dyadic analytic approach to understanding the potential longitudinal associations, results from this study found only actor effects to be significant. Partner effects were not found to be significant. This means that while parent and child levels of MVPA significantly predicted their own levels of MVPA in the future, neither parent nor child MVPA levels were related to future MVPA levels of each other. Furthermore, these relationships were generally consistent for both DCD and TD children. The findings of this study emphasize that the lack of standardization in the use of accelerometers contribute to the persistence of varied results on the relationship between parent and child PA. These variations in results underscore the need for establishing standardized protocols to enhance the consistency and reliability of future research in this area. Addressing these methodological challenges will not only facilitate more accurate and comparable findings, but also advance our understanding of the subject matter.

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