Exploring self-efficacy as a predictor of activity behaviours in children with cerebral palsy

by

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Abstract

Children with physical disabilities spend most of their time sedentary and often experience barriers to physical activity participation. Increased sedentary behaviour has been associated with increased risk of cardiovascular disease later in life and conversely, increased physical activity is associated with decreased risk of cardiovascular disease. While there has been research describing physical activity of children with physical disabilities, sedentary behaviour is a relatively new focus of research. This thesis is comprised of two studies: a scoping review (Chapter 2) and a cross-sectional, descriptive study (Chapter 3). The scoping review is a summary of research on sedentary behaviour in children with physical disabilities. Most of the studies were observational and confirmed that ambulatory children with physical disabilities spend a large amount of their time sedentary. Accelerometry was the most common measurement method for measure sedentary behaviour with children with cerebral palsy. Only three interventional studies have been conducted to evaluate the effects of interventions on decreasing sedentary behaviour. None of the studies supported the effectiveness of the interventions. The aim of this cross-sectional, descriptive study was to explore self-efficacy as a predictor of sedentary behaviour and moderate to vigorous physical activity time of children with cerebral palsy. Total participants with sufficient data were 26 children with cerebral palsy aged 9-18 years were included in the analysis. Two regression models were developed which included age, self-efficacy and Gross Motor Function Classification System level as independent variables, and proportion of time spent sedentary and in moderate to vigorous physical activity intensity as dependent variables. Correlation coefficients were also calculated to examine associations between these variables. Variation in daily sedentary time was partially explained by gross motor function (β = .43, $p<.01$) and age (β = .60, $p<.01$) (R^2=.58). Variation in daily moderate to vigorous physical activity time was partially explained by gross motor function (β = -.46, p<.01), age (β -.34, p<.01) and self-efficacy (β=.28, p=.08) (R^2=.50). Self-efficacy was negatively associated with sedentary behaviour time (r=-.33, p=.04) and positively correlated with time spent in moderate to vigorous physical activity (r=.42, p=.01), but did not significantly contribute to the multiple regression model (β =.28, p=.08). Given the small sample size, more research on the relationship between self-efficacy and physical activity and sedentary behaviour in children with cerebral palsy is needed. Embedding assessment and strategies to develop self-efficacy in physical activity and sedentary behavior counselling could potentially be included in physical therapy interventions.

Preface

This thesis is original work by Felipe Ganz. The research project, of which this thesis is a part, received ethics approval from the University of Alberta Research Ethics Board as “Physical activity and children with cerebral palsy”, No. Pro00084363, October 18, 2018. No part of this thesis has been previously published.

Dedication

To my fiancé Maria Jose Romero, without your love and support, this would not have been possible. To my parents Luis Ganz and Patricia Leiva, thank you for always supporting me and believing in me. To international students, who made the decision to pursue graduate school, which can provide an unparalleled learning experience.

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Chapter 1

Introduction

Cerebral palsy

Cerebral palsy is defined as "group of permanent disorders of the development of movement and posture, causing activity limitation, that are attributed to nonprogressive disturbances that occurred in the developing fetal or infant brain" (1) (pg.9). Cerebral palsy is one of the most common neurodevelopmental disabilities with a prevalence of approximately 2.11 per 1,000 live births (2). Children with cerebral palsy experience challenges with coordination, selective motor control, postural control, muscle weakness and muscle and joint contractures (3,4). These impairments can affect functional mobility ranging from challenges with balance and coordination during higher level motor skills, such as running, to difficulty initiating voluntary movement.

It is well known that regular participation in physical activity is important for the physical, mental and social health of all children, including children with disabilities (5,6). However, children with cerebral palsy are less physically active, spend more time sedentary, and engage in more recreation screen time (7,8). In fact, there is evidence that ambulatory children with cerebral palsy spend the majority of their day (76-79%) sedentary and engage in moderate to vigorous physical activity for a very small proportion (2-7%) of their day (9). Over the past ten year, there has been more attention on increasing physical activity for children with cerebral palsy to improve functional abilities and long-term health (9). Given the clinical emphasis and the known benefits of physical activity in the general population, it is important to understand the factors that facilitate increased physical activity among children with cerebral palsy, especially given the challenges that children with cerebral palsy may face sustaining physically activity over the long-term.

Conceptualization and measurement of physical activity and sedentary behaviour in children with cerebral palsy

Physical activity is described as any body movement using skeletal muscle that results in energy expenditure > 1.5 metabolic equivalent of task (MET), while sedentary behaviour is defined as any waking behaviour characterized by an energy expenditure 1.5 or less MET while in a sitting, reclining or lying posture (10,11). Therefore, the spectrum of physical activity includes physical activity and sedentary behaviour. These constructs should be treated independently (12) because they have unique contributions to long-term cardiovascular health (13). For example, health benefits effects of physical activity have been identified for school-aged youth. A systematic review reported that physical activity improves adiposity levels in those with a normal body weight, blood pressure in normotensive youth, plasma lipid and lipoproteins levels, cardiovascular risk factors (inflammatory markers, endothelial function and heart rate variability), and mental health outcomes (self-concept, anxiety and depression) (6). In addition, research with typically developing children aged 10–14 years old has revealed that children who have more prolonged sedentary bouts (≥20 min per day) have increased cardiometabolic risk factors; and those who engaged in longer daily breaks of sedentary time have a lower risk of abdominal obesity and elevated blood pressure (14). Increased cardiometabolic risk associated with increased sedentary behavior exists independent of physical activity and therefore children who meet the recommended guidelines for physical activity, may still be at risk if they spend a significant amount of time sedentary.

Researchers evaluating physical activity programs have used subjective and objective tools to measure physical activity and sedentary behaviour in children with cerebral palsy. Subjective tools include questionnaires such as the Physical Activity Questionnaire for Adolescents (PAQ-

A) (7), the child-adapted activity questionnaire for adults and adolescents (AQuAA) (15), the Activity Scale for Kids-performance version (ASKp) (16), the Dutch questionnaire (17), and the Frequency of Participation in Physical Education at School and Physical Activity in Leisure Time (18). Limitations with subjective methods include recall error, misrepresentation, and social desirability bias (19). Therefore, objective tools, such as accelerometry are considered to be the gold standard for measuring children's physical activity.

Accelerometers have been widely used as an objecyive measure physical activity and sedentary behaviour in children with cerebral palsy (20). Triaxial accelerometers measure body acceleration and combine this information into vector magnitude (21). The acceleration signal is digitized and generates a series of numbers to represent acceleration known as the activity count, expressed as counts per minute (CPM) over a certain period of time (epoch). The activity count per minute is classified according to established cut points to estimate physical activity intensity (i.e., sedentary, light, moderate, vigorous) (22). Cut points for each intensity of physical activity have been determined for adults (23), toddlers (18-36 months) (24), and children and adolescents with cerebral palsy (25,26). Even though accelerometers have been utilized to measure physical activity and periods of sedentary behavior for people with cerebral palsy, they may not capture extraneous limb movements frequently observed in children with more severe disabilities, thus the ability to measure true activity, particularly for someone who uses a wheelchair, may be limited.

Predictors of physical activity and sedentary behaviour

Knowledge of predictors of physical activity and sedentary behaviour could inform approaches to physical activity interventions in pediatric physical therapy. With the exception of gross motor function level, there has been limited research on the factors that predict physical activity in children with cerebral palsy (27). It is likely that a myriad factors influence physical activity levels including individual (personal) and environmental factors, including social and policy environments. The International Classification of Functioning, Disability and Health (ICF) (5) provides a useful conceptual framework for exploring factors that influence physical activity participation. The ICF model, a universal framework of human functioning includes two parts, each with two components (28). Part One, Body Functions and Structures, represents physiological functions and anatomical parts of the body while Part Two includes the components of activity, (the execution of a task or action by an individual) and participation (involvement in a life situation). Contextual factors, including environmental and personal factors, are recognized as potential influences on functioning. Environmental factors can be defined as the physical, social and attitudinal environment in which people live and conduct their lives and personal factors are individual factors, such as gender, age and lifestyle. Potential predictors of physical activity among children and youth with cerebral palsy are discussed in greater detail below, according to the components of the ICF.

i) Activity component

Motor performance of children and youth with cerebral palsy is typically classified and described using the Gross Motor Function Classification System (GMFCS), a five-level system to categorize gross motor performance. GMFCS levels range from level I, children who can walk without assistance and who may have some challenges with higher level motor skills, such as running, to children classified as level V, who have difficulty initiating voluntary movement and are often transported in a manual wheelchair (29). GMFCS levels have been associated with levels of moderate to vigorous physical activity and sedentary time for children in GMFCS levels I-III (30). There is also evidence that physical activity decreases and sedentary behavior increases with increasing GMFCS levels (31–33). For example, children classified as GMFCS levels III to V spend more time sedentary compared to those classified at GMFCS levels I and II (21,34–36). While gross motor function appears to be related to physical activity levels in children with cerebral palsy, the influences of other potentially modifiable factors, such as self-efficacy, have not been thoroughly evaluated. not been thoroughly evaluated.

ii) Personal factors

Self-efficacy is a widely known precursor to behaviour change and therefore may play a role in predicting physical activity levels of children with cerebral palsy. Self-efficacy, is defined as "one's beliefs regarding their capability to produce performances that will lead to anticipated outcomes" (38, pg 371). It is one of the most important concepts of Social Cognitive Theory related to exercise (38) as it relates to an individual's confidence in achieving and maintaining behavioral change (39). Individuals with strong self-efficacy pursue more challenging tasks, expend greater effort and show persistence when they experience difficulties (40). Research with children with Developmental Coordination Disorder suggests that they might not perceive themselves to be sufficiently adequate to meet their own personal performance expectations (41). This lower sense of generalized self-efficacy towards physical activity predicts a proportion of the variance in their physical activity (41). Decreased self-efficacy may explain why these children prefer sedentary behaviour and avoid structured physical activity to avoid risk of failure and humiliation (41). Self-efficacy has not specifically been evaluated as a factor contributing to physical activity of children with cerebral palsy with one study being an exception (42). Low self-efficacy in children with cerebral palsy may relate to their experiences of not feeling good enough or dependent on others in physical activity participation (43). Understanding the role that self-efficacy plays in engagement in physical activity is important since intervention programs aimed to increase physical activity or decrease sedentary behaviour might be enhanced by incorporating self-efficacy as a component of behaviour change.

The construct of self-efficacy can be divided into regulatory and task efficacy (40). Regulatory efficacy refers to an individuals' beliefs about his or her ability to manage difficulties or barriers to performing an activity (40). Task efficacy represents an individual's feelings that he/she can be more or less efficacious in different situations and/or particular tasks (37). Both types of self-efficacy have been correlated with physical activity behaviour in school-aged children who are typically developing (44). Research with children with cerebral palsy has demonstrated that perceptions of self-efficacy can be improved with targeted feedback (45) and children with higher levels of self-efficacy might independently overcome environmental barriers to be active (27). However, little is known about how self-efficacy contributes to physical activity levels of children with cerebral palsy.

Age may also play a role in determining the extent to which children and adolescents engage in physical activity. Age related differences in physical activity and sedentary behavior are present in children without disabilities (46). For example, sedentary behaviour patterns tend to increase in early childhood and continue throughout adolescence and into adulthood (47). For children with cerebral palsy, physical activity patterns can also vary over time (31,33,36,48). For example, children with cerebral palsy are more physically active than adolescents with cerebral palsy (31) and research has demonstrated that sedentary behaviour time in children with cerebral palsy increases from 3 years of age (21). For example, one group of researchers reported that non-ambulatory toddlers with cerebral palsy spend approximately 74% of their time sedentary compared to 93% of the day for non-ambulatory children with cerebral palsy aged 4 to 5 years (34,36).

iii) Environmental factors

Environmental factors are defined in the ICF as the ‘physical, social and attitudinal environment in which people live and conduct their lives’ (5). Environmental features have been associated with accessibility to the community. For example, physical activity programs or clubs for children with cerebral palsy suited to different ages and motor abilities, may increase physical activity levels (49). Physical activity participation of children with cerebral palsy can be related to parents’ attitude and social acceptance by their peers. That is, friends and adults can help to facilitate participation in physical activity (50). Parents’ attitudes, cultural background and previous life experiences that influence family culture can either facilitate or determine children’s motivation to be physically active (50). Moreover, qualitative research with parents of children with developmental coordination disorder revealed that once their children mastered their goals, they gained confidence and tried new activities that were important for social acceptance and physical activity participation (51). More research is needed to understand the environmental factors that impact PA levels of children with cerebral palsy.

Statement of the problem

Participation in physical activity is important for children with cerebral palsy. Increased sedentary behaviour and decreased physical activity can contribute to long term cardiovascular disease risk (13). Adults with cerebral palsy have a higher risk of mortality due to cardiovascular disease, including stroke, chronic obstructive pulmonary disease, and other heart conditions (52–54). Children with cerebral palsy have increased sedentary behaviour (21) compared to children with typical development and since increased sedentary behaviour and decreased physical activity have negative long-term effects on health, interventions to increase physical activity and decrease sedentary behaviour have become common in pediatric physical therapy. Studies should include different strategies depending on the behaviour that is targeted. For example, while school-aged children who are typically developing have been encouraged by teachers and peers to engage in active games, standing easels have been used to assist standing during lessons to reduce their sedentary time (55). Healthcare providers can play an important role in the prevention of chronic diseases with promotion of physical activity by encouraging children with cerebral palsy and families to integrate physical activity into their daily routines. Physical activity and sedentary behavior counselling could potentially be included in physical therapy interventions.

Recommendations of daily amounts of physical activity and sedentary behaviour have been made for children with and without cerebral palsy (9,56). These guidelines address daily activities, but they do not address possible factors that may affect children's activity behaviour. While self-efficacy has been identified as a common precursor for behaviour change, the role of self-efficacy in predicting physical activity and sedentary behaviour has not been thoroughly examined with children with cerebral palsy. Self-efficacy is defined as "one's beliefs regarding their capability to produce performances that will lead to anticipated outcomes" (40)(pg.371). Individuals who successfully perform an action will believe that they have the competence to engage in that action in the future. Children who have positive experiences with physical activity will likely develop self-efficacy, which may play a role in promoting ongoing engagement in physical activity. Children with increased self-efficacy have greater persistence even when faced with barriers and have a high degree of commitment to achieve their goals (57). Self-efficacy is a strong predictor of physical activity behaviour in children with typical development (44). Research that evaluates self-efficacy as a predictor of physical activity and sedentary behaviour in children with cerebral palsy could inform development of effective intervention programs for changing activity behaviour, and improve physical activity and sedentary behaviour guidelines.

Research Objectives

The general objective of this research was to investigate physical activity and sedentary behaviour of children with cerebral palsy. The two specific objectives were to:

1) Summarize existing research regarding sedentary behaviour of children with physical disabilities, identify gaps in the literature and highlight future research priorities.

2) Investigate self-efficacy as a potential predictor of physical activity and sedentary behaviour of children with cerebral palsy classified as GMFCS levels I to III.

The thesis includes two parts: 1) a scoping review was conducted to summarize existing research regarding sedentary behaviour of children with physical disabilities and, 2), a cross-sectional study to investigate self-efficacy as a predictor of physical activity and sedentary behaviour using data from an ongoing, multi-centre, randomized controlled trial, as well as children recruited in Alberta, Canada.

Organization of the Thesis

This thesis was constructed using a paper-based format. **Chapter 1** includes a review of relevant literature, the study objectives, key concepts, and the theory used to inform the research. **Chapter 2** is a scoping review of the scientific literature to summarize the evidence related to sedentary behaviour in children with physical disabilities to provide a broad perspective on assessment and interventions related to decreasing sedentary behavior. **Chapter 3** is a cross sectional study which aims to investigate self-efficacy as a potential predictor of physical activity and sedentary behaviour of children with cerebral palsy classified as GMFCS levels I to III. **Chapter 4** is a general discussion of the findings, clinical implications and future research directions.

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Chapter 2:

Sedentary Behaviour in Children with Physical Disabilities: A Scoping Review

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Sedentary Behaviour in Children with Physical Disabilities: A Scoping Review

Abstract

Introduction: Rising childhood obesity rates and associated adverse long-term health outcomes have resulted in increased attention to cardiovascular disease risk factors such as decreased physical activity and increased sedentary behaviour. Children with physical disabilities are generally less active than their peers without disabilities and therefore there is growing concern over decreasing sedentary behaviour. The purpose of this scoping review was to summarize the evidence related to sedentary behaviour in children with physical disabilities to answer the following questions: (1) What is known about sedentary behaviour patterns in children with physical disabilities? (2) How is sedentary behaviour among children with physical disabilities measured? (3) What is the current state of the evidence regarding the effectiveness of interventions to decrease sedentary behaviour in children with physical disabilities? **Methods**: A scoping review was conducted using the methodology described by Arksey and O'Malley (2005). Articles were considered for inclusion if participants were 0–18 years of age, had physical disabilities, and the focus of the research was on sedentary behaviour patterns, measurement of sedentary behaviour or evaluation of interventions to decrease sedentary behaviour. **Results:** Full text articles (n=198) were reviewed for inclusion and 36 articles were selected. The majority of the studies were observational describing sedentary behaviour patterns (n=29), primarily with children with cerebral palsy (n=22) (objective 1). Accelerometry was the most frequently used measure of sedentary behaviour for ambulatory children however, questionnaires, surveys and interviews were also used (objective 2). Only three studies conducted to evaluate interventions for decreasing sedentary behaviour (objective 3) were included and they represented a weak evidence base that does not support effectiveness of strategies to reduce sedentary behaviour in children with physical disabilities. Across this body of research, older, ambulatory children and adolescents represented an area of focus; few studies addressed sedentary behaviour in younger children or children who use wheelchairs. **Conclusion**: Research is needed to evaluate interventions to decrease sedentary behaviour in children with physical disabilities. Future research should also include validation of physical activity measures, particularly with children who use wheelchairs as their primary method of mobility.

Introduction

Interventions to increase moderate to vigorous physical activity have been emphasized as potential management strategies for children with physical disabilities (1). Recently, literature in pediatric rehabilitation has also highlighted the need to consider the other end of the physical activity spectrum; replacing sedentary behaviour with light physical activity (2). Although sedentary behaviour is often thought of as a lack of physical activity, it has unique contributions to health outcomes to those related to decreased moderate to vigorous physical activity. For example, individuals who meet physical activity guidelines while still engaging in excessive sedentary behaviour still experience increased cardiovascular and metabolic risk (3) and cardiovascular disease related mortality (4). Physical activity is described as any body movement using skeletal muscle that results in energy expenditure > 1.5 metabolic equivalent of task (MET), while sedentary behaviour is defined as any waking behaviour characterized by an energy expenditure 1.5 or less METS while in a sitting, reclining or lying posture (5,6). Health benefits of increased physical activity include reduced adiposity, and improved musculoskeletal, cardiovascular, and mental health (7). These benefits have been demonstrated early in life among school-aged children and youth (8).

Children with motor impairments often experience decreased efficiency of movement (9), which can translate to lower moderate to vigorous physical activity levels and increased sedentary time. In addition, many children with physical disabilities experience barriers to participation in leisure and sports activities in their communities and challenges with integrating physical activity into their busy daily routines (10). For children who experience challenges with moderate to vigorous physical activity, efforts to replace sedentary behaviour with light physical activity throughout the day may be more feasible (11). Potential health benefits and increased feasibility of sedentary behaviour interventions warrants exploration of effectiveness of sedentary behaviour reduction strategies that could potentially be used in clinical settings.

While there have been several published reviews on physical activity among children with disabilities (12-14), there is an absence of reviews focusing on sedentary behaviour. A summary of research on sedentary behaviour patterns of children with physical disabilities, measurement methods and effectiveness of intervention strategies would provide information needed to guide future research and clinical practice in this area.

Methods

A scoping review was selected as the field of sedentary behaviour in children with physical disabilities is an emerging area of research. In addition, a preliminary literature search revealed few evaluations of effectiveness of sedentary behaviour interventions. Scoping reviews are used to summarize existing research in a particular area, identify gaps in the literature and highlight future research priorities (15). The methodology developed by Arksey and O'Malley (16) was used to conduct this review. Steps described by Arksey and O'Malley include 1) Identifying the research question, 2) Identifying relevant studies, 3) Study selection, 4) Charting the data, and 5) Collating, summarizing, and reporting results.

1. Identifying the Research Questions

The aim of this scoping review was to summarize the evidence related to sedentary behaviour in children with physical disabilities to answer the following questions: (1) What is known about sedentary behaviour patterns in children with physical disabilities? (2) How is sedentary behaviour measured among children with disabilities? (3) What is the current state of the evidence regarding the effectiveness of interventions to decrease sedentary behaviour in children with physical disabilities?

2. Identifying Relevant Studies

The search terms (sedentary and child* or school-aged or kindergarten* or pediatric* or paediatric* or youth* or adolescen* or teen*) AND (disab* or special needs or motor impair* or physical impair* or physical* limitation* or cerebral palsy or wheelchair* or muscular dystroph* or spina bifida or neural tube defect* or epilep* or arthritis* or traumatic brain injur* or parapleg* or quadripleg* or spinal cord injur*) were used to search the following five electronic health and science databases: CINAHL (1946 to 2018), MEDLINE (1890 to 2018), ERIC (1959 to 2018) EMBASE (1883 to 2018) and SPORTDiscus (1953 to 2019) up to and including articles published in November 2018. See Appendix 1 for an example search strategy. Reference lists of articles identified in the original search were also reviewed to identify additional articles not included in the original searches.

3. Study Selection

Articles were eligible for inclusion if participants were 0–18 years of age, had physical disabilities, and the focus of the research was on sedentary behaviour patterns, measurement of sedentary behaviour or evaluation of interventions to decrease sedentary behaviour. We defined physical disabilities as primary motor or physical impairments. Studies that focused on children and youth with intellectual, visual, or hearing impairments without motor disabilities were excluded. Studies that also included individuals with these diagnoses or individuals older than 18 were included if data for the population of interest were presented separately in the manuscript. Papers were excluded if they focused on physical activity and did not address sedentary behaviour. Study protocols, conference abstracts, books, theses, or studies published in languages other than English were also excluded.

The initial search resulted in 1080 publications. Duplicates (n=335) were identified within Refworks, the reference platform used to facilitate organization of the articles included in the review, and removed, resulting in a total of 745 publications. Article titles and abstracts were screened for relevance by the first author and 547 were excluded. Full text articles were obtained for the remaining 198 records and reviewed independently by two of three reviewers (FG, NH, or LPW). Discrepancies in ratings were resolved through discussion with a third rater, when necessary. Following exclusion of 162 articles that did not meet eligibility criteria, a total of 36 articles were selected for inclusion in the review. The article selection flow chart is presented in Figure 1.

4. Charting the Data

The following descriptive information was extracted from each article: title, year of publication, characteristics of the study sample (number, age, sex, diagnosis, geographical location), study objective, study design, intervention and results.

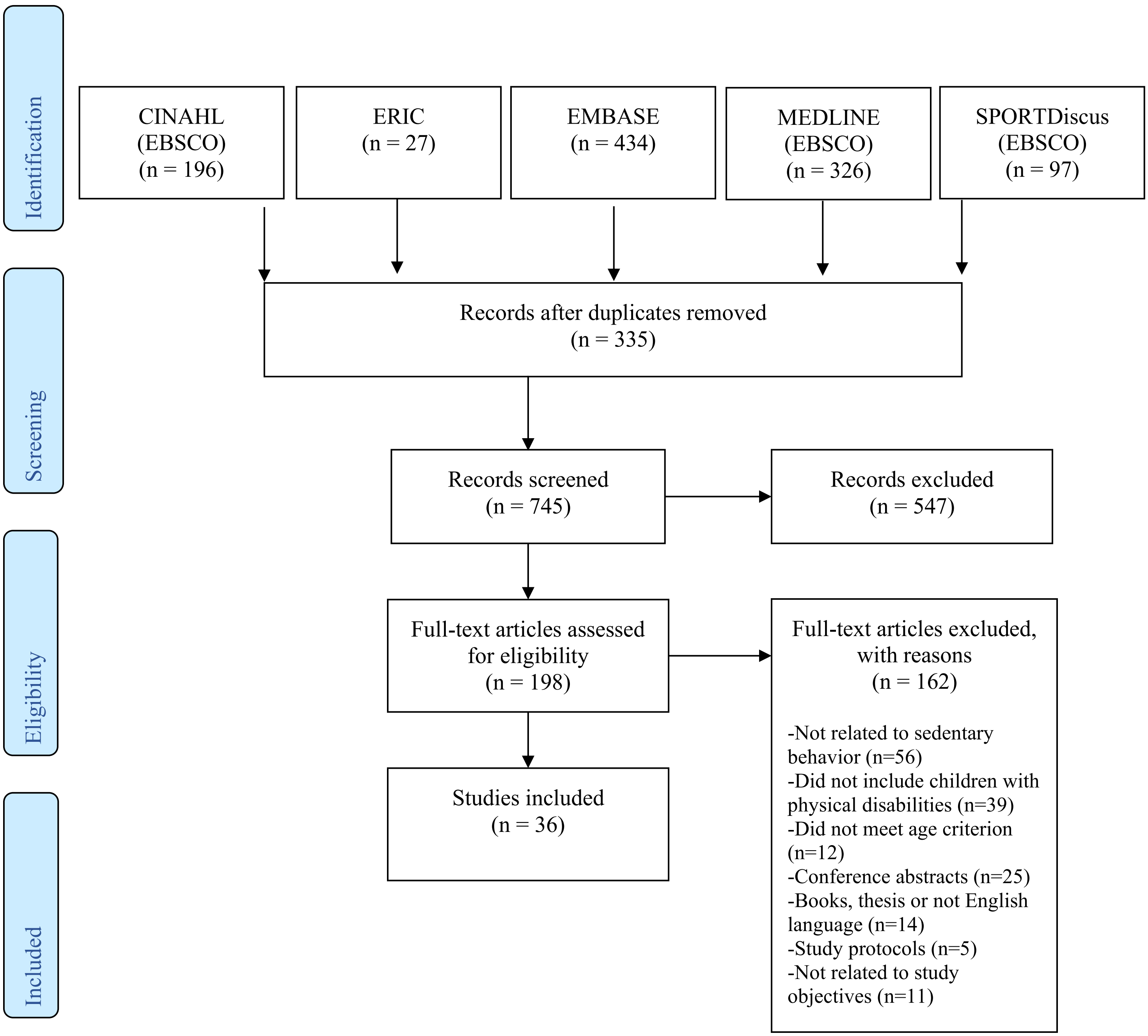

Figure 1. Article selection flow chart

5. Collating, Summarizing, and Reporting the Data

Articles (n=36) selected for inclusion are summarized in Tables 1, 2 and 3. The majority of the studies described sedentary behaviour patterns (n=29) (2, 17-44) (Table 1). Measurement methods are summarized in Table 2. Seven studies (45-51) focussed on sedentary behavior measurement validation. Only three evaluations of interventions to decrease sedentary behaviour were included (42-44) (Table 3). One intervention study conducted to evaluate the effects of motor skills training on physical activity with children with cerebral palsy (20) was included in Table 1 because the authors included data on sedentary time; the intervention did not specifically include strategies to reduce sedentary behaviour and therefore it was excluded from the summary of intervention studies in Table 3.

Publication Years and Countries of Origin

Publications increased steadily since the earliest publication in 1996 (40). The majority (n=26) of the publications were published after 2013, indicating a recent increase in this area of research. Of the 36 included research articles; 16 were conducted in Australia, followed by the USA (n=5), Ireland (n=4), Canada (n=3), the Netherlands (n=3), China (n=2), Spain (n=2) and Sweden (n=1).

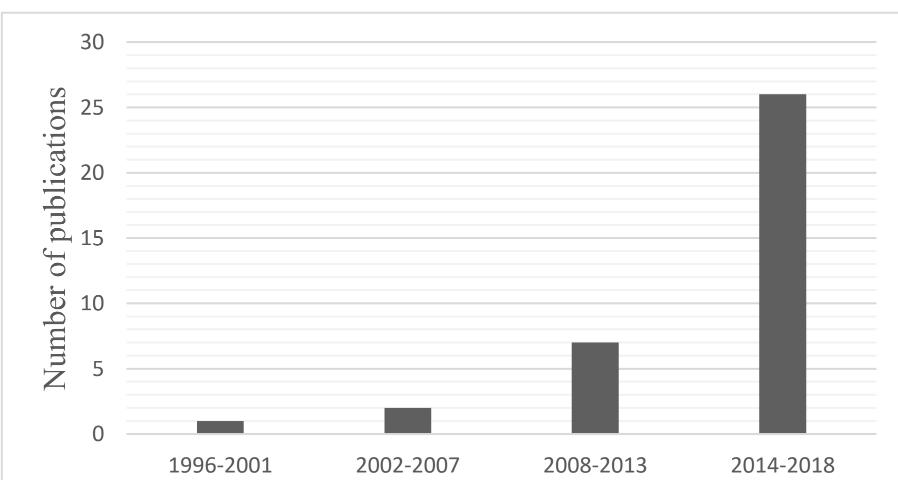

Figure 2 Publication years of articles on sedentary behaviour of children with physical disabilities

Table 1. Description of Sedentary Behaviour Patterns of Children with Physical Disabilities (n=29)

Author (year)/Country	Participants	Objectives	Methodology	Results
Baque et al. (2017)(17) Australia	Children with ABI GMFCS levels I (n=29) and II (n=29) (n=58, 32 males; age=8-16Y; $\bar{x}$age=11Y, 11 months ± 2Y, 6 months).	To examine characteristics associated with physical activity capacity and performance in children with ABI	Cross-sectional	Children with ABI spent an average of 5 hours and 49 min per day sedentary.
Bos et al.(2016)(18) Netherlands	Children with JIA (n=76, 26 males; age=8-13Y; $\bar{x}$age=10.0Y ± 1.4Y) compared to control (n=131, 49 males; $\bar{x}$age=10.4Y ± 1.2Y).	To compare PA in children with JIA to controls and to analyze the effects of JIA on PA	Cross-sectional	Children with JIA spent more time in sedentary ($\bar{x}$=19.3 h/day ± 1.3 h/day) activities compared to control ($\bar{x}$=18.2 h/day ± 1.3 h/day) ($p<0.01$).
Capio et al. (2012)(19) China	Children with CP, GMFCS I-III (n=31; $\bar{x}$age=7.41Y ± 2.48Y).	To objectively monitor the PA of a sample of children with CP using an accelerometer and examine the association between PA and FMS proficiency and compare the data with those from a group of TD children	Cross-sectional	Children with CP had more sedentary time compared to children with TD and both groups had lower sedentary time on weekdays compared to weekends ($p\leq0.05$).
Capio et al. (2015)(20) China	Children with CP, GMFCS I-III (n=24, 12 males; CP training group (n=12; $\bar{x}$age=6.92Y ± 3.04Y) and children with TD (n=26; $\bar{x}$age=7.17Y ± 2.7Y).	To determine if improving motor skills is related to enhanced PA in children with and without disabilities; to determine if improving motor skills will have a greater impact on children with disabilities compared to children without disabilities	Pre-post test	Children with TD and CP spend more sedentary time on weekends.
Castner et al. (2014)(21) USA	Children with PWS (n=24; 12 males; age=8-16Y; $\bar{x}$age=11.2Y ± 2.3Y) compared to children with non-syndromal obesity (n=40; $\bar{x}$age=9.8Y ± 1.1Y).	To describe PA in children with PWS and compare PA to youth with non-syndromal obesity	Cross-sectional	Children with PWS and youth with non-syndromal obesity spent similar time sedentary during weekdays (PWS=657 min/day, Obese=640 min/day; p=0.3) and weekends (PWS=667 min/day, Obese=633 min/day; p=0.2). For children with PWS, there were no differences in weekdays versus weekends for sedentary time (p=0.75).

Downs et al. (2017)(22) Australia	Children with RS (n=64; age=3y, 6 months-38Y; $\bar{x}$age=17Y,7 months ± 9Y).	To describe capacity to walk, walking based activity and sedentary time and to determine the influence of age, walking ability scoliosis and the severity of epilepsy	Cross-sectional	Participants spent an average of 62% (7.2h) of their waking hours sedentary. Females ≥13 years were more sedentary than females <13 years.
Esposito et al. (2012)(23) USA	Children with DS (n=104, 57 males; age=8-16Y; $\bar{x}$age=11.8Y ± 2.21Y).	To examine PA activity patterns of children with DS	Cross-sectional	Sedentary time increased with age. Children 14-15Y were more sedentary (622 min/day) than those aged 12-13Y (597min/day) p<0.05, and both the 8-9Y (542 min/day) and 10-11Y age group (542 min/day) p<0.001.
Foerste et al. (2016)(24) Australia	Children with PWS (n=16, 7 males; $\bar{x}$age=12.1Y ± 4.1Y), Children with Trisomy 21 (n=17, 6 males; $\bar{x}$age=13.8Y ± 2.6Y); and Children lifestyle related obesity (n=19, 10 males; $\bar{x}$age=11.7Y ± 2.9Y).	To investigate the presence of hyperphagia and levels of PA and SB in children and adolescents with trisomy 21 compared with individuals with lifestyle related obesity and PWS	Cross-sectional	Children with lifestyle related obesity spend the most time sedentary (44 h/week) compared to children with trisomy 21 (35 h/week) and PWS (31 h/week).
Fogarty et al. (2007)(41) USA	Children with spina bifida (n=49, 25 males; age=6-17.9Y; $\bar{x}$age=13.7Y ± 2.99Y).	To describe PA behaviors of youth with spina bifida	Cross-sectional	Youth with spina bifida spent more time in sedentary (watching TV, playing video games) and solitary activities than other activities.
Izquierdo-Gomez et al. (2015)(25) Spain	Adolescents with DS (n=98, 63 males; age=11-20Y; $\bar{x}$age=15.3Y ± 2.54Y).	To identify correlates of SB and TV viewing time	Cross-sectional survey	Total sedentary time was significantly positive associated with maternal age (p=0.00), and perceived benefits of PA (p=0.001); and negative associated with birth order (p=0.008) and availability of shops in the neighborhood (p=0.002).
Keawutan et al. (2017)(26) Australia	Children with CP GMFCS I-V (n=67, 31 males; age=4-5Y; $\bar{x}$age=4Y,10 months ± 4 months).	To describe habitual PA and SB in children with CP and compare to the Australian physical activity guidelines	Cross-sectional	Sedentary time was significantly associated with GMFM-66 score (R^2=0.74, p<0.001). Children in GMFCS levels I-II; III, and IV-V spend 57.6%, 73.6% and 92.7% of their time sedentary.
Keawutan et al. (2017)(27) Australia	Children with CP GMFCS I-V (n=95, 62 males; age=18-60 months).	To describe habitual PA and SB in young children with CP; compare HPA and SB between time points; examine the rate of change in HPA and SB across all gross motor functional abilities	Longitudinal	Sedentary time was higher in both GMFCS groups (i.e., I-II and III-V) at 4 to 5Y compared to 18 months to 2Y. Children classified at GMFCS level III-V spend more sedentary time than children classified at GMFCS I and II at all time points.

				Sedentary time increased 2.4%/Y (GMFCS levels I and II) and 6.9%/Y (GMFCS levels III-V).
Keawutan et al. (2018)(29) Australia	Children with CP (n=67, 43 males; age=4-5Y; $\bar{x}$age=4.9Y).	To investigate the relationships between HPA, sedentary time, motor capacity and capability	Cross-sectional	Children (GMFCS levels III-V) had significantly higher sedentary time than children classified as GMFCS level I. Motor capacity (GMFM) and capability (PEDI) are negatively associated with sedentary time in ambulatory children classified as GMFCS levels I to III.
Kwan et al. (2016)(28) Canada	Children with suspected DCD (n=49, 28 males; $\bar{x}$age=12.4Y ± 0.51Y) compared to children with TD (n=54; $\bar{x}$age=12.4Y ± 0.52Y).	To examine the longitudinal PA and sedentary time in children with and without suspected DCD in relation to sex differences, and whether sex moderates the relationship between suspected DCD and PA levels	Longitudinal nested case-control	Sedentary time increased from grade 7 (DCD=471 min/day; TD=485 min/day) to grade 9 (DCD=535 min/day; TD=517 min/day) in children with and without suspected DCD. Females spent more sedentary time compared to males across the 2-year period.
Lauruschkus et al. (2017)(42) Sweden	Children with CP GMFCS I to V (n=11, 5 males; age=7-11Y).	To evaluate the feasibility of PA prescription and its effectiveness on participation in PA and SB	Pre-post test	GMFCS I and II: Baseline sedentary time as measured by IPAQ (median 360 min/day), Diary (543 min/day) and accelerometer 464 min/day. GMFCS III-V: Baseline sedentary time as measured by IPAQ (median 240 min/day), Diary (305 min/day) and accelerometer 673 min/day.
Maher et al. (2007)(30) Australia	Adolescents with CP GMFCS I -V (n=112, 76 males; age=11-17; $\bar{x}$age=3Y, 11 months ± 23 months).	To investigate physical activity and SB patterns of adolescents with CP compared with age and sex matched datasets (TD)	Cross sectional survey	SB patterns (TV and computer use) of adolescents with and without CP were similar. Adolescents spent an average of 28.5h per week in screen time. Male sex was a significant determinant of SB. No relationship was found between SB, gross motor function and age.
Maher et al. (2010)(44) Australia	Children with CP GMFCS I-III (n=41; age=11-17Y; $\bar{x}$age=13.6Y ± 1.8Y) Intervention group (n=20, 12 males); Control group (n=21, 14 males).	TD determine the effectiveness of an internet- based, lifestyle, PA intervention	RCT	$\bar{x}$ (SD) daily screen time for intervention and control groups was 280.1 ± 104.5 min/day and 220.1 ± 83.1, respectively.
Matute-Llorente et al. (2013)(31) Spain	Adolescents with DS (n=19, 9 males; age=10-17Y; $\bar{x}$age=14.7Y ± 2.2Y).	To describe PA patterns in adolescents with DS, compare to peers with TD and determine relationships between	Cross sectional, descriptive	Adolescents with DS spend more sedentary time (540 min/day) than controls (470 min/day) ($p<0.05$).

	compared to children with TD (n=14).	PA and risk of low bone mass in adolescents with DS		
Mitchell et al. (2015)(2) Australia	Children with CP GMFCS levels I and II (n=102, 52 males; age=8-17Y; $\bar{x}$age=11Y, 3 months ± 2Y,4 months).	To assess PA of children and adolescents with unilateral CP	Cross sectional	Children spent an average of 8h 36min/day sedentary and there was no difference between children classified at GMFCS level I or II or between weekdays and weekends. Adolescents spend more sedentary time (9h 14min) than children (8h 20min) ($p<0.01$).
Oates et al. (2011)(32) Australia	Children with DS (n=208, 118 males; age=5-18Y).	To describe friendships and leisure participation of school-aged children with DS. Explore how body functions and structures and personal and environmental factors are related to friendships and leisure	Cross sectional	The majority of the recreation activities engaged in were sedentary and solitary; 10.6% reported high technology use (>29 h/week), 50.5% moderate use (15-28 h/week), and 38.9% reported low use 0-14 h/week.
Obeid et al. (2014)(33) Canada	Children with CP GMFCS I-III (n=17, 15 males; age=8-17Y; $\bar{x}$age=13.0Y ± 2.2Y) compared to children with TD (n=17, $\bar{x}$age=12.9Y ± 2.5Y).	To measure sedentary time and frequency of breaks in ambulatory children and adolescents with CP and compare to children TD	Cross sectional	Children with CP engaged in more sedentary time and fewer breaks from SB compared to the TD group.
Oftedal et al. (2015)(34) Australia	Children with CP GMFCS I-V (n=58, 38 males; $\bar{x}$age=2.4Y ± 0.5Y).	To compare toddlers with and without CP in regards to: (a) sedentary time, (b) duration of sedentary bouts and breaks in sedentary time; and (c) levels of habitual PA and SB compared to Australian physical activity recommendations	Cross sectional	No difference was found in sedentary time between the children with TD and children with CP (GMFCS I and II) ($\bar{x}$ =52% ± 7), however children classified as GMFCS III spent more time sedentary (($\bar{x}$ =62% ± 9) which was less than children classified at GMFCS levels IV and V ($\bar{x}$ =74% ± 11). Mean duration of sedentary bouts (>10min) was longer in children with CP (IV to V) and the number of sedentary breaks was lower for children with CP (IV to V) than for children with TD and children CP (GMFCS I and II).
Oftedal et al. (2016)(35) Australia	Toddlers with CP GMFCS I-V (n=175, 109 males; age=18-60 months; $\bar{x}$age=2Y,10 months ± 11 months).	To investigate the longitudinal relationship between stature, growth velocity, energy intake, HPA, and sedentary time in children with CP	Longitudinal	Children at age 18-24 months and at 60 months spent 56% and 66% of their time sedentary, respectively.

Oftedal et al. (2017)(36) Australia	Children with CP GMFCS I-V (n=161, 61% males; age=18-60 months; $\bar{x}$age=2.8Y ± 0.9Y).	To investigate the longitudinal relationship between anthropometric and body-composition measures and modifiable lifestyle factors	Prospective cohort (Compared to normative data-CDC Growth charts)	Children aged 18-24 months and those aged 60 months spent 56% and 66% of their time sedentary, respectively.
Ryan et al. (2014)(37) Ireland	Children with CP GMFCS I-III (n=90, 57 males; age=6-17Y).	To investigate the prevalence of overweight, obesity and elevated blood pressure among ambulatory children with CP; evaluate associations among PA, SB, overweight/ obesity, and blood pressure in children with CP	Cross sectional	Proportion of daily time sedentary increased with GMFCS levels (31.7% ± 12.2; 37.2% ± 11.9; 42.3% ± 15.8 for GMFCS levels I, II and III, respectively.
Ryan et al. (2015)(38) Ireland	Children with CP GMFCS I and II (n=55, 34 males; age=6-17Y; $\bar{x}$age=11.3 ± 0.2Y).	To determine the association between SB, PA intensity and cardiorespiratory fitness in children with CP	Cross sectional	Participants spent 33% of their time sedentary.
Ryan et al. (2015)(39) Ireland	Children with CP GMFCS I-III (n=33, 17 males; age=6-10Y; $\bar{x}$age=8.5Y ± 1.2Y) and 33 age-and sex-matched controls.	To describe LPA, MPA, VPA and SB in preadolescent children with and without CP and to compare PA and SB between the two groups	Cross sectional	Children with CP spent more time sedentary ($\bar{x}$=193 min/day ± 68) activities compared to controls ($\bar{x}$=123 min/day ± 49) ($p<0.01$).
Ulrich et al. (2011)(43) USA	Children with DS (n=46; age=8-15 years) Intervention group (n=19, 9 males; $\bar{x}$age =12.4 ± 2.2Y) Control group (n=27, 11 males; $\bar{x}$age=12.0 ± 1.9Y).	To investigate the effects of teaching children to ride a 2-wheeled bicycle on PA and health-related outcomes	RCT	At baseline: $\bar{x}$ (SD) sedentary time (531.7 ± 101.1 min/day) (intervention group) and (537.1 ± 104.7 min/day) (control group).
Steele et al. (1996)(40) Canada	Children with PD (n=101, 48% male; age=11-16Y).	To identify health promotion needs among youth with PD compared to a national sample	Cross sectional survey (compared to a national sample)	39% of children with PD stated they had never exercised compared to 6% of the national sample. 39% of the youth with disabilities watched TV more than 4 h/day compared with 13% of the national sample.

Abbreviations: ABI, acquired brain injury; Y, years; $\bar{x}$, mean; ±, standard deviation; GMFCS, gross motor function classification system; min, minute; JIA, juvenile idiopathic arthritis; PA, physical activity; h, hour; CP, cerebral palsy; RS, Rett syndrome; FMS, fundamental motor skills; TD, typically developing; PWS, Prader Willi syndrome; DS, Down syndrome; GMFM, Gross Motor Function Measure; SB, sedentary behaviour; HPA, habitual physical activity; PEDI, Pediatric Evaluation of Disability Inventory; DCD, developmental coordination disorder; RCT, randomized controlled trial; LPA, light physical activity; MVPA, moderate to vigorous physical activity; VPA, vigorous physical activity; PD, physical disabilities.

Table 2. Sedentary Behaviour Measurement Validation Studies (n=7)

Author (year)/Country	Participants	Purpose/Objectives	Results
Armbrust et al. (2017)(45) Netherlands	Children with JIA (n=61, 24 males; age=8-13Y; $\bar{x}$age=10.1Y ± 1.4Y).	Determine convergent validity of a 7-day activity diary and accelerometry in children with JIA; Determine how many days of PA are needed to obtain reliable diary and accelerometry results; Analyze the effect of using the diary to correct for non-wear accelerometer time.	Convergent validity between the diary and accelerometer was moderate for PA level and rest (ICC=0.41). One week was sufficient to measure PA (all levels) reliably with the accelerometer for research and 3 weeks were required for clinical use. Additional use of the activity diary enabled correction for non-wear accelerometer time.
Clanchy et al. (2011)(46) Australia	Children with CP GMFCS I-III (n=29, 17 males; age=8-16Y; $\bar{x}$age=12.6Y ± 2Y).	Evaluate the validity of the Actigraph accelerometer for the measurement of different intensities of PA in ambulatory children and adolescents with CP using oxygen uptake (VO2) as the criterion measure; Determine if intensity-related Actigraph cut points developed for TD youth are valid for children with CP; Determine whether classification accuracy could be enhanced by deriving new intensity cut points for children and adolescents with CP.	The Freedson/Trost, Evenson, Puyau, and Treuth cut-points exhibited excellent classification accuracy for SB. The Evenson et al. (2008)(52) cut points had the highest classification accuracy for SB (92%).
Keawutan et al. (2016)(47) Australia	Children with CP GMFCS I-V (n=84; age=4-5Y; $\bar{x}$age=4.8Y ± 0.5Y).	Derive the triaxial accelerometer cut-points against a criterion measurement in children with CP; Validate the developed cut-points in an independent sample of children with CP; Validate previously established cut-points for children with TD by Butte et al. (2014)(53) in the present sample of children with CP and compare their validity with the newly developed CP cut-points.	This study supported previously established cut-points for sedentary time (Butte, 2014)(53) of 820 CPM in children with CP aged 4 to 5 years across all functional abilities.
Oftedal et al. (2014)(48) Australia	Children with CP GMFCS I- III (n=51, 16 males; age=18-36 months); and GMFCS IV and V (n=25, age=18-36 months); and children with TD (n=28; age=18-36 months).	Develop uniaxial and triaxial Actigraph cut points for SB. Evaluate and compare predictive validity of these cut points in children with CP and TD.	No significant difference between observed and predicted time spent sedentary. The uniaxial accelerometer cut point overestimated sedentary time for children in GMFCS I-III and had wider limits of agreement than the triaxial cut point for children in GMFCS IV-V. Uniaxial cut points are not recommended for use with toddlers.
Ryan et al. (2014)(49) Ireland	Children with CP GMFCS I-III (n=18, 10 males; age=6-17Y, $\bar{x}$age=11.4Y ± 3.2Y).	Investigate the ability of published cut points to detect SB, LPA, and MVPA in ambulatory children and adolescents with CP; to develop 2 new cut points in children with CP that discriminate between sedentary activity and LPA and determine if these cut points improve classification of PA intensity.	RT3 is an objective and feasible method of measuring PA in ambulatory children and adolescents with CP. RT3 counts increased with increasing PA intensity. Using ROC curve analysis, 51.9 CPM was identified as the optimal cut point for discriminating between sedentary and LPA (AUC 96.5% CI 84.6-99.8)

Trost et al. (2016)(50) USA	Children with CP GMFCS I (n=27; $\bar{x}$age= 12.4Y ± 3.3Y), GMFCS II (n=12; $\bar{x}$age= 12.3Y ± 3.4Y) GMFCS III (n=12; $\bar{x}$age= 12.7Y ± 3.1Y).	Use decision tree models to identify PA thresholds and compare classification accuracy of the models to previously published cut points.	For measuring sedentary activity, METs and accelerometer output were comparable across GMFCS levels. The Everson and Clanchy SB cut points (100 CPM) provided excellent classification accuracy (>90%).
Verschuren et al. (2014)(51) Netherlands	Children with CP GMFCS levels I-V (n=19, 13 males; age=4-20Y).	Determine energy expenditure and muscle activation during lying, sitting and standing.	Energy expenditure was > 1.5 METs during standing for all GMFCS levels (therefore exceeding the cut off for SB). Children classified as GMFCS required significantly more energy consumption than the others ($p<0.05$).

Abbreviations: JIA, juvenile idiopathic arthritis; Y, years; $\bar{x}$, mean; ±, standard deviation; PA, physical activity; CP, cerebral palsy; GMFCS, gross motor function classification system; TD, typically developing; SB, sedentary behaviour; LPA, light physical activity; MVPA, moderate to vigorous physical activity; MET, metabolic equivalent of task.

Table 3. Evaluations of Sedentary Behaviour Interventions (n=3)

Author (year)/Country	Participants	Study objective	Design	Intervention	SB Outcomes	SB Outcome measures	Findings
Lauruschkus et al. (2017)(42) Sweden	Children with CP GMFCS I-V (n=11, 5 males; age=7-11Y).	Evaluate the feasibility of PA prescription (PAP) and its effectiveness on participation in PA and SB	Pre-post test	Motivational interviewing and self-selected PA as an agreement between children, parents and physiotherapists (3 to 6 months).	Sedentary Time (min/day)	Triaxial accelerometer Activity diary IPAQ	All children spent most of their day sedentary. Changes in sedentary time as measured by accelerometry, diary and IPAQ were variable (pre-post differences were not analyzed).
Maher et al. (2010)(44) Australia	Children with CP GMFCS I-III, (n=41; age=11-17Y; $\bar{x}$age=13.6Y ± 1.8Y) Intervention group (n=20, 12 males) Control group (n=21, 14 males)	Determine the effectiveness of an internet-based, lifestyle, PA intervention	RCT	Social cognitive theory based, interactive internet-based program. Participants were encouraged to log in at least weekly for the program's 8-week duration by email, phone or text message).	Average daily screen time	MARCA questionnaire	At 10 and 20 weeks, self-reported screen time (MARCA) showed no change and no difference between groups.
Ulrich et al. (2011)(43) USA	Children with DS (n=46; age=8-15Y) Intervention group (n=19, 9 males; $\bar{x}$age=12.4 ± 2.2Y) Control group (n=27, 11 males; $\bar{x}$age=12.0Y ± 1.9Y).	To investigate the effects of teaching children to ride a 2-wheeled bicycle on PA and health-related outcomes	RCT	Bicycle training for 75 min/day for 5 consecutive days.	Sedentary Time (min/day)	Actical (Phillips Respironics) accelerometer worn on the hip for 7 days.	The intervention group spent significantly less time sedentary 7 weeks after the end of intervention (p=0.035) and at the 12 month follow-up (p=0.04) compared to the control group.

Abbreviations: CP, cerebral palsy; GMFCS, gross motor function classification system; Y, years PA, physical activity; SB, sedentary behaviour; min, minutes; IPAQ, international physical activity questionnaires; $\bar{x}$, mean; ±, standard deviation; RCT, randomized controlled trial; MARCA, Multimedia Activity Recall for Children and Adolescents; DS, Down syndrome.

Table 4. Sedentary behaviour Objective Measurement Tools

Author (year)	Wear Time		SB Cut point (CPM)	Age Group	Placement	Diagnosis
	Protocol*	Valid				
Actigraph Triaxial Accelerometer						
Baque et al. (2017)(17)	4 d during waking h	4d (>8 h/d)	100	C/A	Least affected hip	ABI
Castner et al. (2014)(21)	8 d during waking h	4 d (>10 h/d) on 3 wk and 1 w/e d)	100	C/A	Right hip	PWS
Izquierdo-Gomez et al. (2015)(25)	7 d during waking h	3 d (>8 h/d)	100	C/A	Lower back	DS
Keawutan et al. (2017)(26)	3 d during waking h (2 wk and 1 we days)	3 d (>6 h/d)	820	P	Lower back	CP
Keawutan et al. (2017)(27)	3 d during waking h (2 wk and 1 we days)	3 d (2 wk and 1 w/e d)	GMFCS I-III (age 18m -3Y): 480; GMFCS IV-V (age 18m -3Y): 120; GMFCS I-V (age 4-5Y): 820	T/P	Lower back	CP
Keawutan et al. (2018)(29)	3 d during waking h (2 wk and 1 we days)	3 d (2 wk and 1 w/e d)	820	P	Lower back	CP
Lauruschkus et al. (2017)(42)	7 d during waking h	≥ 5 h of wear time on ≥ 2 d	100	C	Right hip	CP
Mitchell et al. (2015)(2)	4 d during waking h (2 wk and 2 we days)	1 d (>8 h/d)	100	C/A	Least affected hip	CP
Oftedal et al. (2015)(34)	3 d during waking h (2 wk and 1 we days)	3 d (>50% of waking h)	GMFCS I-III (age 18m -3Y): 480; GMFCS IV-V (age 18m -3Y): 120	T	Lower back (center)	CP
Oftedal et al. (2016)(35)	3 d during waking h (2 wk and 1 we days)	NR	NR	T/P	NR	CP
Oftedal et al. (2017)(36)	3 d during waking h (2 wk and 1 we days)	NR	GMFCS I-III (age 18m -3Y): 480; GMFCS IV-V	T/P	NR	CP

			(age 18m -3Y): 120; GMFCS I-V (age 4-5Y): 820			
RT3 Triaxial accelerometer						
Ryan et al. (2014)(37)	7 d during waking h	4 d (>10 h/d)	41	C/A	Right hip (or least affected side in the case of asymmetry)	CP
Ryan et al. (2015)(38)	7 d during waking h	4 d (>10 h/d)	41	C/A	Right hip (or least affected side in the case of asymmetry)	CP
Ryan et al. (2015)(39)	7 d during waking h	3 d (>9 h/d)	41	C	Right hip (or least affected side in the case of asymmetry)	CP
Actical Triaxial Accelerometer						
Esposito et al. (2012)(23)	7 d during waking h	4 d (≥10 h/d at least 1 w/e d)	25	C/A	Right hip	DS
Kwan et al. (2016)(28)	7 d during waking h	NR	100	A	Right hip	DCD
Ulrich et al. (2011)(43)	7 d during waking h	4 d (≥10 h/d at least 1 w/e d)	100	C/A	Right hip	DS
Actigraph Uniaxial Accelerometer						
Obeid et al. (2014)(33)	7 d during waking h	≥4 d (≥5 h/d on 3 wk and 1 w/e d)	100	C/A	Right hip	CP
Capio et al. (2012)(19)	7 d during waking h	5 d (5-18h/d on 3 wk and 2 w/e d)	100	C**	Hip (side NR)	CP
Capio et al. (2015)(20)	7 d during waking h	5 d (5-18h/d on 3 wk and 2 w/e d)	100	C**	Hip (side NR)	CP
Matute-Llorente et al. (2013)(31)	7 d during waking h except contact sports	4 d (≥10 h/d at least 1 w/e d)	25	C/A	Right hip	DS
Izquierdo-Gomez et al. (2015)(25)	7 d during waking h	3 d (>8 h/d)	100	C/A	Lower back	DS
Step Watch						
Downs et al. (2017)(22)	7 d during waking h	4 d (≥9 h/d at least 1 w/e d)	0 Steps	T/C/A	Right ankle	RS

*Accelerometers removed during water activities. **Based on mean age, range NR Abbreviations: CPM, cut points per minute; d, day; h, hour; ABI, acquired brain injury; wk, week; w/e, weekend; SB, sedentary behaviour; PWS, Prader Willi syndrome; DS, Down syndrome; CP, cerebral palsy; GMFCS, gross motor function classification system; m, months; Y, years; T, toddlers (defined as 2-3 years of age); P, preschoolers (defined as 4-5 years of age); C, children (defined as 6-11 years of age); A, adolescents (defined as 12-18 years of age); NR, not reported; DCD, developmental coordination disorder; RS, Rett syndrome.

Table 5. Sedentary behaviour Subjective Measurement Tools

Author (year)	Measurement Tool	Age	Diagnosis
Bos et al. (2016)(18)	Bouchard Activity Diary(54)	C/A	JIA
Foerste et al. (2016)(24)	Children's Leisure Activities Study Survey (CLASS)(55)	C/A	DS/PWS/ LRO
Fogarty et al. (2007)(41)	Semi-structured interviews	C/A	SB
Izquierdo-Gomez et al. (2015)(25)	Youth Behaviour Sedentary Questionnaire (adapted)	C/A	DS
Lauruschkus et al. (2017)(42)	International Physical Activity Questionnaire (IPAQ)(56)	C	CP
Maher et al. (2007)(30)	Physical Activity Questionnaire for Adolescents (PAQ-A)(57)	C/A	CP
Maher et al. (2010)(44)	Multimedia Activity Recall for Children and Adolescents (MARCA)(58)	C/A	CP
Oates et al. (2011)(32)	Questionnaire	P/C/A	DS
Steele et al. (1996)(40)	Health Behaviours in School-Aged Children Survey (HBSC)	C/A	PD
Abbreviations: preschoolers (defined as 4-5 years of age); C, children (defined as 6-11 years of age); A, adolescents (defined as 12-18 years of age); JIA, juvenile idiopathic arthritis; DS, Down syndrome; PWS, Prader Willis syndrome; LRO, Lifestyle related obesity; SB, spina bifida; CP, cerebral palsy; PD, physical disabilities.			

Study Design

Of the 36 included studies, 22 were cross-sectional, three were longitudinal, one was a prospective cohort study (with a control group), two were pre-post trials, two were randomized controlled trials and six were measurement validation studies.

Sample Characteristics

Research on sedentary behaviour has focused on children and adolescents; 11 of the 36 studies included infants and younger children (22,26,27,29,32,34-36,47,48,51). The majority of the studies (n=22) included children with cerebral palsy (2,19,20,26,27,29,30,33-39,42,44,46-51). The remaining studies included children with diagnoses of Down syndrome (n=6) (23-25, 31, 32, 43), Prader Willi Syndrome (n=2) (21,24), acquired brain injury (n=1) (17), myelomeningocele (n=1) (41), confirmed or suspected Developmental Coordination Disorder (n=1) (28), juvenile idiopathic arthritis (n=2) (18,45), Rett syndrome (n=1) (22), and one study with a sample of heterogeneous physical disabilities (n=3) (40).

Question #1

What is known about sedentary behaviour patterns in children with physical disabilities?

Children with cerebral palsy

The research confirms that children with cerebral palsy spend more sedentary time than their peers without disabilities. For example, children with cerebral palsy under five years of age classified as Gross Motor Function Classification System (GMFCS) (59) levels III-V spend more time sedentary than their peers without disabilities (34) and more time sedentary than children classified at levels I and II (26). Oftedal et al. (2015) (34) reported that toddlers classified as GMFCS levels I, II and III spend 52%, 62% and 74% of their waking time sedentary, respectively. A similar sedentary behaviour pattern has been reported in school-aged children (26).

Two of the studies (with overlapping samples) were longitudinal and demonstrated that amount of time spent sedentary increased over time (27,35). Participants were followed for five years, from 18 to 60 months of age, revealing an increase in sedentary time after 3 years (27). At 18-24 months of age and at 60 months of age, children spent 56% and 66% of their time sedentary, respectively. In addition, there is some evidence from cross sectional studies that suggests that preschool children with cerebral palsy are more sedentary than toddlers (26,34). In their cross-sectional study, Mitchell et al. (2) demonstrated that children (GMFCS I and II) spent less time sedentary than adolescents.

The majority of the studies reported total daily sedentary time only; only two studies evaluated sedentary behaviour patterns (bouts and breaks) (33,34). Obeid et al. (2014) reported that children with cerebral palsy take fewer breaks from sedentary time than their peers without physical disabilities (33). Another study, conducted with infants and toddlers with cerebral palsy (34), reported that mean duration of sedentary bouts (>10min) was longer and the number of sedentary breaks was lower for children with cerebral palsy (GMFCS IV and V) than for children with typically development and children with cerebral palsy (GMFCS I and II).

Factors associated with sedentary behaviour have been identified in children with cerebral palsy. Two studies conducted (with overlapping samples) demonstrated that sedentary time was negatively associated with motor skills (as measured by the Gross Motor Function Measure – 66) and capability (as measured by the Pediatric Evaluation of Disability Inventory) (26,29).

Children with other diagnoses

Studies have demonstrated that children with other physical disabilities spend a significant amount of their time sedentary. Fogarty et al. (41) reported that children with myelomeningocele spent most of their time in sedentary activities, including listening to music, watching TV, video games and computer activities. Similarly, studies have demonstrated that children with Rett syndrome and Down syndrome spend approximately 60% of their time in sedentary activities (i.e. technology use) (22, 32). No studies have evaluated sedentary behaviour patterns (bouts and breaks from sedentary time) in this group of children.

Studies have been conducted to compare sedentary behaviour patterns of children with and without physical disabilities. Studies conducted with children with juvenile idiopathic arthritis and Down syndrome demonstrated that they spend more time sedentary than their typically developing peers (18, 31). Two studies have demonstrated that some children with physical disabilities are not more sedentary than their peers without disabilities. Castner et al. (21) reported that children with Prader Willi Syndrome spend no more time sedentary than children with non-syndromal obesity and Foerste et al. (24) reported that children with non syndromal obesity are more sedentary than those with Prader Willis syndrome and Trisomy 21. Sedentary time appears to increase with age. A cross sectional study conducted with children with Down syndrome indicated that sedentary time increased at 14 and 15 years of age compared to younger children (i.e. 8 to 11 years of age) (23). Increased age has also been associated with increased sedentary time with children with acquired brain injury (17).

In children with Down syndrome, factors associated with sedentary behaviour included modifiable and non-modifiable factors such as maternal age, birth order, proximity to shopping, parental perceived benefits of physical activity, TV viewing time with parents, and time spent indoors on weekdays (25).

Question # 2

How is sedentary behaviour measured with children with disabilities?

Measurement methods used in the studies are presented in Table 4 and 5, and measurement validation studies are summarized in Table 3. Most often, objective tools were used to measure sedentary behaviour. The majority of studies that used objective measurement tools used accelerometry (n=21), one indirect calorimetry (51). The majority of the studies with children with cerebral palsy used accelerometry (n=14, 64%). Subjective tools were used exclusively in seven studies (18,24,30,32,40,41,44) and three other studies used both subjective and objective measures (25, 42,45).

Age specific sedentary behavior cut points have been validated with toddlers (18-36 months of age) (48), preschool-age children (4-5 years) (47), and children and adolescents with cerebral palsy (6-17 years) (46,49,50). Gross motor function levels were used in one study to establish cut points for children and adolescents with cerebral palsy for children classified as GMFCS levels I-III (50). No studies that validated cut points for sedentary behaviour in children with diagnosis other than cerebral palsy met the criteria for inclusion in the review. While the majority of the studies used a sedentary behaviour cut point of 100 counts per minute (CPM) with children and adolescents, others used cut points of 41 CPM (37-39) and 25 CPM (23,45). In addition, specific age-related cut points (i.e., 120 CPM, 240 CPM and 820 CPM) have been advocated for use with infants, toddlers, and preschool children with cerebral palsy, respectively (26,27,34,36).

Accelerometer placement and wear time also varied according to the age of the children. Most of the studies that included children and adolescents attached the accelerometer on the hip for at least 4 days (2,17,19-21,23,28,31,33,37-39,42,43), with the exception of one study (25). Some studies with infants, toddlers and preschoolers used lower back placement for a minimum period of 3 days (26,27,29,34).

Subjective measurement of sedentary behaviour typically involved the use of questionnaires, activity diaries and semi-structured interviews. Most of the studies in children with diagnoses other than cerebral palsy used subjective measures while accelerometry was the predominant measurement method used with children with cerebral palsy. Questionnaires typically gather information about sedentary activities, such as reading, listening to music, watching TV, playing video games and computer activities (32,41). Screen time has also been used to represent overall sedentary time (40,44).

Question # 3

What is the current state of the research regarding the evaluation of interventions to decrease sedentary behaviour in children with physical disabilities?

Only three studies have been conducted to evaluate interventions to decrease sedentary behaviour in children with physical disabilities (42-44). Maher et al. (2010) (44) conducted a randomized controlled trial with adolescents with cerebral palsy aged 11-17 years. A study website was used to improve exercise knowledge, attitudes, self-efficacy and intention, functional capacity and decrease sedentary behaviour in children with cerebral palsy, GMFCS levels I-III. The intervention group received emails and text messages as reminders to view the intervention web site. The intervention did not result in decreased daily screen time at 10 or 20 weeks' post-intervention. A randomized controlled trial (43) conducted with children with Down syndrome aged 8 to 12 years demonstrated that learning to ride a 2-wheel bicycle during the 5-day intervention decreased sedentary time at the 12 months post-intervention follow-up. Finally, Lauruschkus et al. (42) conducted a pre-, post-test study with children with cerebral palsy to evaluate the effects of physical activity prescription on physical activity and sedentary behaviour. Physical activity prescription consisted of an agreement between children, parents and physical therapists on strategies to enhance physical activity and decrease sedentary behaviour. Motivational interviewing by physical therapists focusing on self-selected physical activity by children was the main component of the intervention program. While the intervention was perceived as a feasible and acceptable by families, sedentary time did not decrease at post-intervention, or at the follow-up assessment.

Discussion

This review highlighted increases in sedentary behaviour through childhood and into adolescence that mirrors the sedentary behaviour patterns of children without disabilities (60). Knowledge of how sedentary behaviour changes throughout childhood and adolescence would help guide intervention strategies in pediatric rehabilitation. Children with cerebral palsy start to demonstrate increases in sedentary time around the age of three (27). Since increased sedentary behaviour and decreased physical activity contributes to increased risk of long-term cardiovascular disease (61) and it has been established that adults with cerebral palsy have a higher risk of cardiometabolic conditions such as hypertension, and myocardial infarction (62), it is important to consider strategies to decrease sedentary behaviour at an early age. While use early consideration of strategies to decrease sedentary behavior have been encouraged, strategies to increase physical activity or decrease sedentary behaviour at any age must be balanced with consideration for energy conservation and ensuring that mobility methods fit with the environment to optimize participation and engagement in meaningful activities.

Since sedentary behaviour is a relatively new area of focus for children with physical disabilities, it is not surprising that this review revealed some significant gaps in the literature including only three studies that evaluated the effects of interventions to decrease sedentary behaviour. The literature that does exist, however, does indicate that researchers are beginning to incorporate individualized approaches in intervention programs, including strategies to increase motivation (42) and self-efficacy (44). Future research would benefit from consideration of patterns of sedentary behaviour (such as incorporation of active breaks and replacement of sedentary behaviour with light physical activity throughout the day) (63) in addition to approaches that support families at various stages of behavior change, including the development of task self-efficacy, which can be defined as individual's feelings related to the successful engagement in incremental physical activity and coping self-efficacy, which refers to an individuals' beliefs about his or her ability to manage difficulties to performing an activity (64). In addition, other factors may need to be considered in order to facilitate sustained behavior change. For example, qualitative studies (65,66) with parents of children with developmental coordination disorder and cerebral palsy have revealed that parental attitudes and social acceptance by peers influence physical activity participation.

The literature with children with physical disabilities reveals a narrow conceptualization of the parameters of sedentary behaviour with a focus on sedentary time and a lack of emphasis on sedentary behaviour patterns including sedentary breaks, which are defined as any activity registered above the sedentary threshold (100 CPM) (67) and sedentary bouts, described as uninterrupted periods of sedentary behaviour (6). In the adult literature, the number of sedentary bouts is a more significant predictor of cardiovascular disease than total sedentary time (68). In addition, number of breaks has shown to improve cardiometabolic biomarkers, independent of total sedentary time (69). Prolonged sedentary bouts (≥ 20 minute) have been associated with insulin and diastolic blood pressure; and number of breaks has been associated with adiposity, triglycerides, 2-hours plasma glucose, HDL cholesterol, and systolic blood pressure (70,71). Prolonged sedentary bouts have been associated with increased cardiometabolic risk factors and longer daily breaks of sedentary time with lower risk of abdominal obesity and elevated blood pressure in children who are typically developing (71). Increasing the number and duration of sedentary breaks may also be more feasible than decreasing overall sedentary time (1,11) and therefore perhaps these parameters of sedentary behaviour require further investigation with children with disabilities. For example, adults with multiple sclerosis have reduced their sedentary time by standing during sedentary activities (72). Since addressing the number and length of breaks from sedentary behaviour may be more attainable than increasing moderate to vigorous physical activity for some children, we suggest a broader conceptualization of sedentary behaviour when considering and evaluating sedentary behaviour interventions for children with disabilities is warranted.

The common definition of sedentary behavior as any waking behaviour in a sitting, reclining or lying posture (6) may also require further examination with this group of children. The current definition does not capture the physical activity required to manually propel a wheelchair, for example. Many children with physical disabilities also often require increased effort to maintain postural control in independent sitting compared with children without disabilities (73-75) which may move unsupported sitting out of the sedentary behaviour category. Moreover, children with significant spasticity and/or involuntary movements (76,77) may expend more energy maintaining postures and moving than children without physical disabilities. Movements that are typically low intensity, such as reaching for a toy while sitting, may require increased energy for children with spasticity and impaired selective motor control. A more appropriate definition of sedentary in children with physical disabilities proposed by Yates et al. (78), clarified a muscle activity during sedentary behaviour as the time when "the majority of the body's large muscle groups are under relaxation". Additional research similar to the measurement validation study conducted by Verschuren et al. (51) is needed to establish definition parameters for children with physical disabilities.

In addition to consideration of definition, this body of literature reveals some measurement challenges in children with physical disabilities. Many studies with children with cerebral palsy included objective measurement using accelerometry. Accelerometry cut points for classifying sedentary behaviour have been validated in children with cerebral palsy, Gross Motor Function Classification System I-III only (47-49); there are no validation studies in children with other diagnoses and accelerometers have not been validated with children who use wheelchairs. Since accelerometers may not capture extraneous limb movements that are frequently observed in children with more severe disabilities, the ability to measure true activity, particularly for someone who uses a wheelchair, may be limited. A complex accelerometry system with multiple data collection locations may be required to adequately capture the movements of this group of children. Nooijen et al. (79) evaluated a system with multiple accelerometers placed at the sternum, both wrists, and both thighs (for children who are partly ambulatory), and concluded that the device produced valid measurement of physical activity behaviour for children who use wheelchairs. A recent study conducted by Bloemen et al. (2019) (80) reported sedentary time of wheelchair-using youth with spina bifida placing one recorder on the sternum and one on each wrist. Additional research is needed to investigate validity of accelerometers with children who use wheelchairs and to understand sedentary behaviour patterns in children who are non-ambulant.

While researchers are primary using accelerometry as an objective measure of sedentary behaviour, this review revealed variability in parameters used to measure and classify sedentary behaviour. Cut points, location, wear time and valid wear time varied across studies. For example, accelerometer cut points for sedentary behaviour ranged from 25 to 820 CPM and some researchers use the right hip or lower back while others consider level of involvement and place the accelerometer on the least affected hip. Wear time instructions and criteria for valid wear time also varied between the studies with instructions ranging from 3-8 days and valid wear time ranging from 1-5 days. Some researchers specified the number of weekdays and weekends while others did not. Consideration of measurement days is important since sedentary behaviour time may differ according to whether it is measured on a weekend or weekday (19,20,26).

Conclusions/Summary

This review revealed gaps in the literature regarding sedentary behaviour for children with physical disabilities. Future studies can focus on the sedentary behaviour patterns of children with physical disabilities such as sedentary behavior breaks and bouts instead of only total sedentary time. Future research should also include validation of physical activity measures, particularly with children who use wheelchairs as their primary method of mobility. The majority of the studies were observational describing sedentary behaviour patterns, primarily with children with cerebral palsy, additional studies aimed to investigate sedentary behaviour children with other physical disabilities and to evaluate effectiveness of interventions that incorporate strategies to decrease sedentary behaviour in children with physical disabilities are needed.

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Chapter 3

Exploring self-efficacy as a predictor of activity behaviours in children with cerebral palsy

Abstract

Objective: The aim of the cross-sectional, descriptive study was to explore self-efficacy as a predictor of physical activity and sedentary behaviour of children with cerebral palsy. Total participants with sufficient data were 26 children with cerebral palsy aged 9-18 years classified at Gross Motor Function Classification System I to III. **Methods:** Task self-efficacy was measured with the Self-Efficacy Scale. Sedentary time and moderate to vigorous physical activity intensity were measured using ActiGraph accelerometers. **Analysis:** Two regression models were developed including age, self-efficacy and gross motor function as independent variables, and proportion of time spent in sedentary and moderate to vigorous PA as dependent variables. Correlation coefficients were also calculated to examine associations between these variables. **Results:** Variation in daily sedentary time was explained by gross motor function ($\beta = .43$, $p<.01$) and age ($\beta = .60$, $p<.01$) (R^2=0.58) and variation in daily moderate to vigorous physical activity time was explained by gross motor function ($\beta = -.46$, $p<.01$), age (β -.34, $p<.01$) and self-efficacy ($\beta = .28$, $p<.08$) (R^2=.50). Although self-efficacy did not significantly contribute to variance in moderate to vigorous physical activity, it was identified as a confounding variable and retained in the model. Self-efficacy did not significant contribute to variance of sedentary behaviour time in the regression model and therefore it was excluded from this model. Self-efficacy was negatively associated with sedentary behaviour time ($r=-.33$, $p=.04$) and positively correlated with time spent in moderate to vigorous physical activity ($r=.42$, $p=.01$). **Conclusion**: Given the small sample size in this study, more research on the relationship between self-efficacy to physical activity and sedentary behaviour in children with cerebral palsy is needed.

Introduction

Cerebral palsy is defined as “group of permanent disorders of the development of movement and posture, causing activity limitation, that are attributed to nonprogressive disturbances that occurred in the developing fetal or infant brain”(1) (pg.9). Cerebral palsy is one of the most common neurodevelopmental disabilities with a prevalence of approximately 2.11 per 1,000 live births (2). Children with cerebral palsy experience challenges with coordination, selective motor control, postural control, muscle weakness and muscle and joint contractures (3,4). These impairments can cause a range of effects on functional mobility; ranging from challenges with balance and coordination during higher level motor skills, such as running, to difficulty initiating voluntary movement. These impairments may impede their ability to participate in physical activities (5). There is evidence that children with cerebral palsy spend most of day (76-79%) sedentary and engage in moderate to vigorous intensity physical activity for a small proportion (2-7%) of their day (6); their sedentary time is higher compared to children without disabilities (481-645 min/day; 67%) (7).

Decreasing sedentary behavior has become a topic of interest in the rehabilitation management of children with cerebral palsy. The adverse health effects of increased sedentary behaviour are independent of those that result from decreased moderate to vigorous intensity; they have unique contributions to health (8). For example, individuals can meet physical activity guidelines and still experience increased cardiovascular disease risk factors if they are sedentary most of their day (9,10). While additional research is needed to understand how physical activity and sedentary behaviors affect children with cerebral palsy, clinically, physical therapists are already exploring strategies to decrease sedentary behavior (11).

Many potential factors, including physical, environmental and personal factors, contribute to physical activity levels among children and youth with cerebral palsy. Gross motor function likely affects physical activity levels (12) as children who are marginally ambulant and non-ambulant spend more sedentary time compared to children who are independently ambulant (13,14). Environmental factors have also been associated with physical activity levels in children with physical disabilities (15). For example, Lauruschkus et al. (2017) suggested that parents' attitude and social acceptance by their peers can affect physical activity of children with cerebral palsy (16). Personal factors such as age and self-efficacy have also been associated with physical activity levels (12,17,18). Research has demonstrated that children with cerebral palsy start to increase their sedentary behaviour at 3 years of age and cross-sectional studies in these children have shown increasing levels of sedentary behaviour from infancy to adolescence (13,14,19–21).

While self-efficacy is a widely known precursor for behaviour change (22), the role of self-efficacy in predicting physical activity and sedentary behaviour has not been thorough examined with children with cerebral palsy. Self-efficacy is defined as "one's beliefs regarding their capability to produce performances that will lead to anticipated outcomes" (23)(pg.371). Individuals who successfully perform an action will believe they have the abilities to engage in that action in the future. Children who have positive experiences with physical activity will likely develop self-efficacy; which may play a role in promoting ongoing engagement in physical activity. Even when facing barriers to physical activity, children with high self-efficacy will likely be more persistent and have a higher degree of goal commitment compared to children with lower self-efficacy (24). Evidence has demonstrated that self-efficacy is a strong predictor of physical activity behaviour in children with typical development (17). Knowledge of predictors of physical activity and sedentary behaviour could inform approaches to physical activity interventions in pediatric physical therapy.

The aim of this study was to investigate Task Self-efficacy as a potential predictor of daily moderate to vigorous physical activity time and daily sedentary behaviour time with children with cerebral palsy classified as Gross Motor Functional Classification System (GMFCS) levels I to III.

Methods

This is a cross-sectional study that included combined data from two sources: 1) an ongoing multi-centre, randomized controlled trial (RCT) (25), and 2) participants recruited specifically for this study. Ethics approval was provided by the University of Alberta Research Ethics Board (Pro00084363). Informed consent was obtained from all parents or legal guardians and informed assent was obtained from children.

Participant Recruitment

Participants were recruited in collaboration with the Cerebral Palsy Association in Alberta, Cerebral Palsy Association in Edmonton, and Alberta Cerebral Palsy Sport Association. Families who had participated in previous studies and provided consent to be contacted for future studies were contacted about their interest in participating. Children were eligible for inclusion if they were aged 9 to 18 years, able to read and speak English, and had a diagnosis of cerebral palsy, classified as GMFCS I to III. The exclusion criterion was the presence of any skin lesions or discomfort around participant's waist that would interfere with accelerometer placement.

Data collection

Demographic characteristics were collected using a questionnaire, which was completed by parents, and included name, age, sex, and gross motor function. Height and weight were also recorded. Independent variables were age, total score of the Self-Efficacy Scale (17) and gross motor function as classified by the GMFCS. The dependent variables were daily moderate to vigorous physical activity and sedentary time as measured with accelerometry. Additional information about variable measurement is included below.

1. Gross Motor Function

Gross motor function was determined using the Gross Motor Function Classification System Expanded and Revised (GMFCS-ER), a five-level system used to classify gross motor function performance of children and youth with cerebral palsy (26) in different environmental settings (i.e. school, home, and community) (27,28). Reliability and validity of the GMFCS-ER has been evaluated in children with cerebral palsy (29) and is the international standard for classification of motor functioning (30).

2. Self-efficacy

Task self-efficacy was assessed using the Self-Efficacy Scale developed by McAuley and Mihalko (1998) (23) and adapted for use in children and adolescents by Foley et al. (2008) (23). The Task Self-Efficacy Scale (17) is three-item tool that assesses perceived competence related to successful engagement in incremental physical activity (17,23). Children rate their confidence (0–100% confidence) regarding participation in physical activity at each of three different intensity levels (i.e., light, moderate and hard) (17). The scale has three items organized according to physical activity intensity and each of these items includes three questions related to duration of physical activity. For example, one question is: "How confident are you that you can complete 10 minutes of physical activity at a light intensity level three times next week?" followed by "How confident are you that you can complete 30 minutes of physical activity at a light intensity level three times next week?". The total score is calculated by adding the scores for each item and then dividing the total by the number of items, with higher total scores representing greater task efficacy. The scale was administered by an assessor who guided and assisted participants, as needed. Task Self-Efficacy Scale is included in Appendix A.

3. *Physical Activity and sedentary behaviour*

Physical activity and sedentary behaviour were measured using an actigraph accelerometer GT3X+, a triaxial accelerometer that measures body acceleration in three axes (vertical, mediolateral and anteroposterior) and combines this information into vector magnitude (31,32). The GT3X accelerometer has shown good concurrent validity with oxygen consumption and good to excellent reliability in children with cerebral palsy classified GMFCS levels I–III (33,34). The accelerometer converts voltage signal into a series of numbers (counts), which are the summation of the measured accelerations during a certain period of time (epoch). Epochs typically are frequently recorded from 1 to 60 seconds. Short epochs are recommended in children because they tend to be active in sporadic burst of energy (35). Accelerometer data are downloaded into specific software and then expressed in physical activity as counts.

Participants wore the actigraph accelerometer GT3X+ on their right hip for 5 days, including all waking hours, except for swimming, bathing or sleep time. Parents completed a logbook, which recorded wear and non-wear time (20,36–38). The logbook and accelerometer instructions are included as Appendix B. Activity data were downloaded via ActiLife version 6 software. The minimum required period of valid wear time was 3 days, two weekdays and one weekend day, at least 8 hours per day (33). Non-wear time was considered as any interval of at least 60 consecutive minutes of 0 counts per minute (cpm), with allowance for up to 2 minutes of some limited movement (<100 cpm). Non-wear times were checked against the logbook and deleted from the analysis (32). Accelerometry data were digitized with a rate of 30Hz and integrated over a 3-second epoch interval (38). Everson cut points were used to provide sedentary time and moderate to vigorous intensity physical activity (34,39): Sedentary behaviour (≤100 cpm), light physical activity (101 to 2,295 cpm), and moderate to vigorous physical activity (≥2,296 cpm). These cut points are valid for measuring physical activity in children with CP classified at GMFCS levels I to III (34,39).

Data analysis

Data were analyzed using IBM SPSS (version 25) software. Descriptive statistics were calculated for all variables. Correlation coefficients were calculated to determine the relationships between gross motor function, age and self-efficacy (independent variables) and the dependent variables (daily percentage of sedentary time and moderate to vigorous physical activity time).

Two linear regression models were built to examine the associations between the independent variables (age, task self-efficacy, and GMFCS Level) and each dependent variable, (daily percentage of sedentary time, and daily percentage of moderate to vigorous-intensity physical activity time). The following four steps were used to build each model (40). First, univariable regression models were used to determine which independent variables were associated with the outcome (p-value≤0.20). Variables with p<0.20 were entered into the regression models. Second, independent variables with p ≤0.05 remained in the models. Each independent variable with p≥0.05 was then entered back into the model to examine if the other beta-coefficients changed by 10% or more (41), in which case they were classified as confounding variables (42). Assumptions of linearity and homoscedasticity were checked with p-plots of the relationships between actual regression standardized residuals and the regression standardized predicted value. Additionally, linearity was checked with scatterplots of the relationship between each independent variable and the dependent variables. Normal probability plots and histograms of the regression standardized residuals were checked for normality. To assess multicollinearity, the variance inflation factor was calculated and correlation of all the predictor variables were checked.

Results

Participants were 26 children and adolescents with cerebral palsy (11 boys, 15 girls) with a mean age of 13.92 years classified at GMFCS levels I (n= 5), II (n= 6) and III (n= 15). All participants had valid accelerometry data and 25 participants returned the activity logbook. Descriptive information about the participants is included in Table 1.

Table 1. Participant characteristics

	GMFCS I and II (n=11)	GMFCS III (n=15)	Total sample (n=26)
Age $\bar{x}$(SD)	13.91 (3.0)	13.93 (1.4)	13.92 (2.1)
Sex			
Female (n)	6	9	15
Male (n)	5	6	11
Height (cm) (n=24)* $\bar{x}$ (SD)	147.3 (16.8)	143.7 (10.0)	144.5 (11.7)
Weight (kg) (n=24)* $\bar{x}$ (SD)	96.7 (19.2)	93.1 (29.5)	96.6 (26.2)
Wear time (minutes) $\bar{x}$(SD)	781.4 (76.6)	769.2 (111.9)	774.4 (96.9)
Sedentary Time			
Minutes/day $\bar{x}$ (SD)	621.0 (59.7)	666.7 (116.0)	647.4 (97.4)
Daily %**	79.4	86.6	83.6
MVPA			
Minutes per day $\bar{x}$(SD)	39.4 (22.5)	14.3 (12.0)	24.9 (21.0)
Daily percentage,%*	5.0	1.9	3.2
Self-Efficacy Scale $\bar{x}$(SD)	75.5 (18.5)	64.6 (21.3)	69.2 (20.5)

Abbreviations: GMFCS, Gross Motor Function Classification System; MVPA, moderate to vigorous physical activity intensity; kg, kilograms; cm, centimeters. Task Self-efficacy was rated on a confidence scale ranging from 0 (not at all confident) to 100 (completely confident) with higher values indicating greater Task Self-efficacy for physical activity.
*change in n represents missing data **Time spent per day as percentage of total wear time

On average, participants wore the accelerometer for 12.9 hours per day (SD=1.6 hours), spent 10.8 hours (SD=1.6 hours) (83.7% of recorded time) sedentary (647.4 minutes per day), and spent 24.9 minutes (SD=21 minutes) (3.2% of recorded time) in moderate to vigorous physical activity intensity per day.

Relationships between independent and dependent variables

Age and GMFCS level were positively associated with percentage of daily time spent sedentary (r=.62 and r=.46, respectively, p<.01), and negatively associated with daily moderate to vigorous physical activity (r=.-40 and r=-.53, respectively, p<.05). Self-efficacy was negatively associated with daily percentage of sedentary time (r=-.33, p<.04) and positively associated with daily moderate to vigorous physical activity (r=.42 p<.01) (Table 2).

Regression model for moderate to vigorous physical activity

In the univariable analysis, age, GMFCS level and self-efficacy were associated with moderate to vigorous physical activity (Table 3). Age and GMFCS level were retained in the model; self-efficacy was removed as it was not significant (β = .28, p=.08). The addition of self-efficacy in the model changed the β coefficients by more than 10%. Self-efficacy was therefore classified as a confounder and retained in the model. The model explained 50% of the variance in daily percentage of moderate to vigorous physical activity (R^2 = .50, F(3, 22) = 7.58, p<.01). GMFCS significantly predicted daily percentage of moderate to vigorous physical activity (β = -.46, p<.01), as did age (β = -.34, p<.01).

Regression model for sedentary time

In the univariable analysis, age and gross motor function were associated with moderate to vigorous physical activity (Table 3). Self-efficacy was excluded from the model based on the initial univariable analysis (p>0.2). The final model explained 58.4% of the variance in daily percentage of sedentary time (R^2 = .58, F(2, 23) = 16.13, p<.01). GMFCS (β = .43, p<.01) (Table3).

Table 2 Pearson correlations between independent and dependent variables				
	Sedentary time (%)		MVPA (%)	
	correlation	p	correlation	p
Age	.62	.00	-.40	.02
GMFCS	.46	.00	-.53	.00
Self-efficacy	-.33	.04	.42	.01

Abbreviations: MVPA, moderate to vigorous physical activity; GMFCS, Gross Motor Function Classification System.

Table 3
Univariable regression models for daily MVPA time and sedentary time

	MVPA[1]			Sedentary time[1]		
Variable	B	SE	β (95%CI)	B	SE	β (95%CI)
Age	-.47	.21	-.4**(-.92 to -.02)	2.04	.52	.62*(.96 to 3.11)
GMFCS	-2.67	.86	-.54*(-4.4 to -.89)	6.54	2.52	.46**(1.3 to 11.7)
Self-efficacy	.05	.02	.42**(.0 to .1)	-.11	.07	-.33(-.25 to .02)
Multiple regression models for daily MVPA time and sedentary time						
	B	SE	β (95%CI)	B	SE	β (95%CI)
Constant	9.91	3.2	(3.12 to 16.69)	46.5	6.73	(32.66 to 60.51)
Age	-.39	.17	-.34*(-.76 to -.03)	1.97	.44	.60*(1.06 to 10.03)
GMFCS	-2.29	.76	-0.46*(-3.87 to -.72)	6.14	1.88	.43*(2.24 to 10.03)
Self-efficacy	.03	.01	.28 (-.005 to .07)			
R^2			.50			.58

[1]Time spent per day as a percentage of total wear time *p<0.01 **p<0.05
Abbreviations: MVPA, moderate to vigorous physical activity; GMFCS, Gross Motor Function Classification System; SE, standard error; CI, confident interval.

Discussion

The aim of this study was to explore self-efficacy as a predictor for moderate to vigorous physical activity and sedentary time in children with cerebral palsy. Factors that significantly contributed to explaining the variance in these activity behaviours were GMFCS and age. Even though self-efficacy did not significantly contribute to explaining the variance in the moderate to vigorous physical activity of children with cerebral palsy, we observed a negative relationship between self-efficacy and sedentary behaviour and a positive relationship between self-efficacy and physical activity. The presence of these relationships suggests that the role of self-efficacy should be further investigated to explain activity behaviour in children with cerebral palsy. Evidence in adults with stroke has demonstrated that strategies based on Social Cognitive Theory such as verbal persuasion and mastering experiences could potentially reduce sedentary time (43). In adolescents with cerebral palsy, Maher et al. (2010) (11) implemented an intervention program based on the principles of Social Cognitive Theory using strategies that increase self-efficacy to reduce sedentary behaviours. Even though they did not demonstrate a behaviour change, to the best of our knowledge, this is the first study that explored self-efficacy in interventions to reduce sedentary behaviour with children with cerebral palsy. Self-efficacy plays an important role in helping individuals to adapt their behaviour to overcome environmental barriers (44). Potential ways to increase self-efficacy in children with cerebral palsy include vicarious experience (i.e. learning by watching other children performing the same activity) which could be achieved by providing physical therapy in group settings, providing verbal persuasion (i.e., encouraging children to change their behaviour through increasing belief that they have the ability to do it) or master experience (i.e. facilitating the achievement of small tasks so the child can experience success).

The lack of significance of self-efficacy in our model may suggest that measurement of physical activity related self-efficacy in children needs further development. The psychometric properties of the Self-Efficacy Scale (17) need to be evaluated in children with cerebral palsy. Another potential issue in this study was the small sample size, which may have affected the power to identify self-efficacy as a factor related to daily sedentary time or moderate to vigorous physical activity. In addition, the task self-efficacy scale focused on self-efficacy for physical activity and did not address efficacy regarding specific actions related to sedentary behavior. The lack of a specific tool to measure self-efficacy related to decreasing sedentary behavior may have affected the results of this study and may explain why self-efficacy was not significant in the sedentary behavior model. Task self-efficacy was the only type of self-efficacy evaluated in this study. Research has demonstrated barrier self-efficacy as a predictor of physical activity of children with typically developing (17). Future studies should investigate the distinct types of self-efficacy for predicting physical activity behaviours of children with cerebral palsy.

This study explored some factors related to activity behaviours in children with cerebral palsy. Future research could explore environmental factors that have been identified in the literature including parental support (45), family culture and attitudes (16). To the best of our knowledge, parental support for physical activity and family culture related to physical activity have not yet been investigated as a predictor of physical activity with children with cerebral palsy.

We did not evaluate sedentary behaviour patterns and physical activity patterns such as bouts and breaks (46). Sedentary behaviour patterns can include sedentary breaks, which are defined as any activity registered above the sedentary threshold, usually limited to 100 cpm (46); and sedentary bouts, described as uninterrupted periods of sedentary behaviour (47). In adults without disabilities, increased breaks have demonstrated to improve cardiometabolic biomarkers, independent of total sedentary time (48). For children with cerebral palsy classified as level IV and V, increasing the number and duration of sedentary breaks may be more feasible than decreasing overall sedentary time, and therefore replacing sedentary time with short and light activity breaks, may be more feasible than increasing moderate to vigorous physical activity.

Limitations

Only children with cerebral palsy classified ad GMFCS level I to III were selected for participation in this study. This group was selected to allow for a more homogeneous sample given that the characteristics associated with physical activity for children classified as GMFCS levels

IV and V may be quite different (21). Therefore, the findings can only be generalized to this particular group and further research is necessary to examine if these findings apply to other pediatric populations with physical disabilities. Despite considerable effort including advertisement in the Cerebral Palsy Association in Alberta, Cerebral Palsy Association in Edmonton, Alberta Cerebral Palsy Sport Association (ACPSA), The Steadward Centre, the community program "You Can Ride 2"; and contacting families through the Cerebral Palsy Registry research database and those that had participated in previous studies, the target sample size of 30 participants was not achieved. This study may have been underpowered. A sample size of 26 participants could be considered to be small to provide statistical strength in analyzing predictor factors of physical activity, which may have been why self-efficacy was not significant in the models. Additional research that considers a large sample size to explore self-efficacy for explaining sedentary behaviour and physical activity in children with cerebral palsy is needed.

Conclusion

GMFCS levels and age are predictors of activity behaviours in children with cerebral palsy. This study also demonstrated a relationship between self-efficacy and moderate to vigorous physical activity, and a relationship between self-efficacy and sedentary time. Additional research that investigates the role of self-efficacy in activity behaviours of children with cerebral palsy is needed.

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Chapter 4:

General Discussion and Conclusions

Main Findings

This thesis included two parts: 1) a scoping review aimed to synthesize the evidence regarding sedentary behaviour patterns, measurement of sedentary behaviour and effectiveness of interventional studies aimed to decrease sedentary behaviour in children with physical disabilities, and 2) a cross-sectional study to identify self-efficacy as a predictor of physical activity and sedentary behaviour in children with cerebral palsy. Most of the studies included in the scoping review were observational and have confirmed that ambulatory children with physical disabilities spend a large amount of their time sedentary and that sedentary behaviour might increase over time. Studies have validated accelerometry as an objective measure of sedentary behaviour in children with cerebral palsy, and interventional studies have not demonstrated effectiveness for decreasing sedentary behaviour in children with physical disabilities. In addition, the scoping review revealed lack of consistency in how accelerometry is used with children with disabilities. The cross-sectional study demonstrated gross motor function and age are predictors of activity behaviours in children with cerebral palsy. Task self-efficacy as measured by the Self-Efficacy Scale, contributed to the variance in daily moderate to vigorous physical activity time. While relationships between self-efficacy and both sedentary behaviour and moderate to vigorous physical activity were demonstrated, the small sample size might have resulted in lack of significance of self-efficacy as a predictor in the regression model. This study did, however, demonstrate a positive relationship between self-efficacy and moderate to vigorous physical activity and a negative relationship with sedentary time. This study suggests that the contributions of self-efficacy in activity behaviours of children with cerebral palsy should be evaluated further.

Clinical and Research Implications

Studies in other populations have demonstrated that self-efficacy is an important predictor of physical activity and, therefore, more research on the role that self-efficacy plays in activity behaviours with children with cerebral palsy is needed. Since models of activity behaviour can explain only a part of the variance in sedentary time and moderate to vigorous physical activity, clinicians should be aware about other possible factors that might influence children's behaviour. Clinicians should consider identifying potential barriers to ongoing physical activity and parental behaviours that would support physical activity engagement. For example, identifying family barriers and facilitators to physical activity and problem solving with families to find programs that are a good fit, might affect children's physical activity behaviours (1).

A valid assessment of self-efficacy is important to explain activity behaviours of children with cerebral palsy. Although task self-efficacy related to physical activity was evaluated, the Self-Efficacy Scale needs to be validated in this population. Researchers have considered different measurement methods to assess self-efficacy and different types of self-efficacy (2–4). Continued refinement of measurement tools appropriate for children with cerebral palsy would contribute to ongoing research in this area.

Knowledge Translation

The findings of this research will add to the literature regarding sedentary behaviour in children with physical disabilities. The cross-sectional study can be considered as preliminary evidence of the negative relationship between self-efficacy and sedentary behaviour and the positive relationship between self-efficacy and physical activity. Findings will be disseminated to families that participated in this study, the Cerebral Palsy Association in Alberta (CPAA), scientific conferences and two papers will be submitted to peer-reviewed, scientific journals.

Future research directions

Future research could include 1) validation of objective methods to measure sedentary behaviour in children with cerebral palsy who use wheelchairs; 2) longitudinal description of sedentary behaviour patterns (sedentary time, break and bout) across all functional levels (Gross Motor Function Classification System I -V); 3) evaluation of the role of self-efficacy in increasing physical activity and decreasing sedentary behaviour; 4) evaluation of the roles of specific types of self-efficacy (i.e. task, coping and scheduling) that have been associated with sustained physical activity (3); and 5) evaluation of effectiveness of intervention programs aimed to decrease sedentary behaviour that are based on stages of behaviour change, and incorporate approaches that aim to change family culture regarding physical activity (7).

Results obtained from this thesis will encourage researchers to further investigate sedentary behaviour in children with physical disabilities and the role of self-efficacy in physical activity and sedentary behaviour.

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Chapter 1

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Appendices

Appendix A: The Task Self-Efficacy Scale

WHAT IS PHYSICAL ACTIVITY?

WHEN YOU ANSWER THE FOLLOWING QUESTIONS, KEEP IN MIND THAT PHYSICAL ACTIVITY INCLUDES THINGS SUCH AS:

ORGANIZED SPORTS LIKE: HOCKEY, TRACK & FIELD, BASKETBALL, TENNIS, GOLF, VOLLEYBALL, BASEBALL.

ORGANIZED ACTIVITIES LIKE: SWIMMING LESSONS, DANCING, AEROBICS.

OTHER PHYSICAL ACTIVITIES YOU DO IN YOUR SPARE TIME LIKE: SKATING, SKATEBOARDING, RIDING YOUR BIKE, WALKING THE DOG, GOING FOR A WALK, GOING FOR A RUN, SKIPPING.

THESE ARE NOT ALL THE PHYSICAL ACTIVITIES YOU CAN DO. YOU WILL PROBABLY BE ABLE TO THINK OF MORE.

WHAT ARE LIGHT / MODERATE / HARD ACTIVITIES?

Below is the description of what light, moderate and hard activities are:

LIGHT ACTIVITIES: Are when you are moving around, but your heart rate and breathing do not increase very much. You probably will not be sweating doing these unless the weather is really hot. You would be able to talk easily through the activity.

MODERATE ACTIVITIES: Are when your breathing and heart rate increase. You may start to sweat, your legs might feel a little bit tired and you may feel out of breath. You may also find it hard to talk during the activity.

HARD ACTIVITIES: Are when your heart beats very fast, your breathing is fast and you start sweating. You may also feel exhausted and out of breath. Your legs would probably be feeling pretty heavy. It would be very hard to talk during the activity.

In answering the following questions, you will be asked to think about how confident you are that you can participate in physical activities that are described as light / moderate / hard. The word "confident" refers to the belief that you have in yourself that you can do something well.

LIGHT ACTIVITIES: Are when you are moving around, but your heart rate and breathing do not increase very much. You probably will not be sweating doing these unless the weather is really hot. You would be able to talk easily through the activity.

1. How confident are you that you can complete **10 minutes** of physical activity at a **light** intensity level three times next week?

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

I am not confident at all | I am not really confident | I am kind of confident | I am reasonably confident | I am almost certainly confident | I am completely confident

2. How confident are you that you can complete **30 minutes** of physical activity at a **light** intensity level three times next week?

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

I am not confident at all | I am not really confident | I am kind of confident | I am reasonably confident | I am almost certainly confident | I am completely confident

3. How confident are you that you can complete **60 minutes** of physical activity at a **light** intensity level three times next week?

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

I am not confident at all | I am not really confident | I am kind of confident | I am reasonably confident | I am almost certainly confident | I am completely

MODERATE ACTIVITIES: Are when your breathing and heart rate increase. You may start to sweat, your legs might feel a little bit tired and you may feel out of breath. You may also find it hard to talk during the activity.

4. How confident are you that you can complete **10 minutes** of physical activity at a **moderate** intensity level three times next week?

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

I am not confident at all	I am not really confident	I am kind of confident	I am reasonably confident	I am almost certainly confident	I am completely confident

5. How confident are you that you can complete **30 minutes** of physical activity at a **moderate** intensity level three times next week?

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

I am not confident at all	I am not really confident	I am kind of confident	I am reasonably confident	I am almost certainly confident	I am completely confident

6. How confident are you that you can complete **60 minutes** of physical activity at a **moderate** intensity level three times next week?

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

I am not confident at all	I am not really confident	I am kind of confident	I am reasonably confident	I am almost certainly confident	I am completely confident

HARD ACTIVITIES: Are when your heart beats very fast, your breathing is fast and you start sweating. You may also feel exhausted and out of breath. Your legs would probably be feeling pretty heavy. It would be very hard to talk during the activity.

7. How confident are you that you can complete **10 minutes** of physical activity at a **hard** intensity level three times next week?

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

I am not confident at all	I am not really confident	I am kind of confident	I am reasonably confident	I am almost certainly confident	I am completely confident

8. How confident are you that you can complete **30 minutes** of physical activity at a **hard** intensity level three times next week?

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

I am not confident at all	I am not really confident	I am kind of confident	I am reasonably confident	I am almost certainly confident	I am completely confident

9. How confident are you that you can complete **60 minutes** of physical activity at a **hard** intensity level three times next week?

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

I am not confident at all	I am not really confident	I am kind of confident	I am reasonably confident	I am almost certainly confident	I am completely confident

Appendix B: Physical Activity Logbook and Accelerometer Instructions

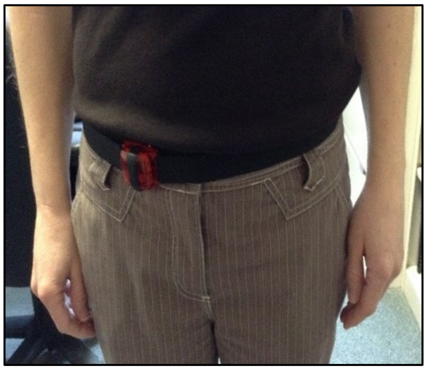
5-Day Accelerometer Wear Time Log

Please *write out* the date and times, and *check* the 'YES' or 'NO' options for each day

	Day 1	**Day 2**	**Day 3**	**Day 4**	**Day 5**
Date (M/D/Y)					
Device put **ON** at what time? (AM)	___: ___	___: ___	___: ___	___: ___	___: ___
Device taken **OFF** at what time? (PM)	___: ___	___: ___	___: ___	___: ___	___: ___
Was the device **removed** during **wear** time?	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
If **YES,** during which times:	___ : ___ **To** ___ : ___	___ : ___ **To** ___ : ___	___ : ___ **To** ___ : ___	___ : ___ **To** ___ : ___	___ : ___ **To** ___ : ___
Did you take the device off a **second time**? During which times?	___ : ___ **To** ___ : ___	___ : ___ **To** ___ : ___	___ : ___ **To** ___ : ___	___ : ___ **To** ___ : ___	___ : ___ **To** ___ : ___

Did you experience any problems? Please explain:

Instructions for Wearing the Accelerometer actigraph



PLACEMENT: The Actigraph should be worn around your waist, above your right hip bone (3-4" from your navel). It should be on the front of your body.

Adjust the Velcro strap for comfort. If you want to loop the straps through belt loops, that is fine.

SCHEDULE: Please put the Actigraph on right away when you get up in the morning and wear it throughout the day. When you take it off at night, put it somewhere that you will remember to put it on first thing in the morning such as with your glasses, clock, or watch.

CARE: Do not leave the Actigraph in hot places such as the dashboard of a car. Please treat it with reasonable care. The ActiGraph is not waterproof. For water activities (showering, swimming), please take the Actigraph off.

<u>Please wear the Accelerometer actigraph for a total of 5 days</u>

If you have questions or concerns, please call Felipe Ganz at: 587-936-3856. We'll give you a call on Day 3 or 4 to see if you have questions.