IMPLEMENTATION AND EFFECTIVENESS EVALUATION OF A SCHOOL-BASED DAILY PHYSICAL ACTIVITY POLICY IN BRITISH COLUMBIA ELEMENTARY SCHOOLS

by

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Abstract

This thesis comprises three integrated studies exploring the implementation and effectiveness of a school-based Daily Physical Activity (DPA) policy in elementary schools. The purposes of the three manuscripts were to: (i) summarize the implementation and effectiveness literature on DPA policies across Canada, (ii) explore the factors that affect implementation of the DPA policy during instructional time by teachers in British Columbia (BC), and (iii) determine if BC students are accumulating more physical activity and less sedentary behaviour during the school day when they are given additional opportunities to be active during instructional time compared to only non-instructional opportunities. Study 1 was a scoping review that summarized the implementation and effectiveness research of DPA policies across Canada and examined the barriers and facilitators to DPA policy implementation using the Theoretical Domains Framework (TDF). The findings revealed inconsistencies in DPA implementation and effectiveness and the majority of factors that affect implementation related to the Environmental context and resources, Beliefs about the consequences and Social influences. Study 2 used teacher interviews and the TDF to examine teachers' barriers and facilitators to the implementation of the DPA policy in one BC school district. The first three domains of this study were comparable to the findings from Study 1. Study 3 used mixed methods to examine how teachers implement the DPA policy and compared the differences in children's physical activity and sedentary behaviour at school based on DPA implementation approach. Children who were given additional PA opportunities during instructional time were more active and less sedentary than children who were only given non-instructional time to be active; however, neither group met the DPA guidelines. Collectively, this research has provided evidence suggesting that current implementation approaches differ by teacher and create variations in

children's physical activity levels at school. Based on this research, evidence-based intervention strategies can be employed to modify barriers and enhance facilitators associated with DPA policy implementation and improve the effectiveness of this policy. Future interventions targeting the theoretically relevant barriers are suggested as possible next steps to enhance the implementation and effectiveness of the DPA policy in BC.

Preface

All procedures within this research have received ethical approval from the University of British Columbia Office of Research Services Behavioural Research Ethics Board (#H15-01069), and the appropriate school board committee. Chapter 2 of this thesis is under revision for publication to Implementation Science under the title "A Theoretical Analysis of the Barriers and Facilitators to the Implementation of School-Based Physical Activity Policies in Canada: A Mixed Methods Scoping Review". This manuscript is the work of Ms. Katie Weatherson in collaboration with her co-authors: Dr. Heather Gainforth and Dr. Mary Jung. Specifically, Ms. Weatherson conceived of the study and collected the data and KW and HG analyzed the data. KW drafted the manuscript and HG and MJ read and approved the final manuscript. Chapter 3 of this thesis is in submission to Implementation Science under the working title "Barriers and Facilitators to the Implementation of a School-Based Physical Activity Policy in Canada: Application of the Theoretical Domains Framework". This manuscript is the work of Ms. Katie Weatherson and the co-authors for this study include: Ms. Rhyann McKay, Dr. Heather Gainforth and Dr. Mary Jung. KW conceptualized the study, and MJ/HG provided intellectual input into the methodological design. KW conducted the interviews, transcribed and analyzed the interview data and drafted the manuscript. RM provided double extraction and coding of implementation barriers and facilitators. All authors reviewed and approved the final manuscript. Chapter 4 of this thesis is in submission to the International Journal of Behavioral Nutrition and Physical Activity under the working title "Effectiveness of a School-based Physical Activity Policy in British Columbia, Canada: A Mixed Methods Observational Study". This manuscript is the work of Ms. Katie Weatherson and co-author, Dr. Mary Jung. Ms. Katie Weatherson was responsible for developing the study, conducting the data collection, managing and analyzing the datasets,

interpreting the results and writing the initial draft of the manuscript. Dr. Jung provided methodological guidance during the design of the study and revised the manuscript.

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List of Abbreviations

BC – British Columbia

BCT – Behaviour Change Techniques

BCW – Behaviour Change Wheel

COM-B – Capability Opportunity Motivation – Behaviour

DPA – Daily Physical Activity

ECR – Environmental Context and Resources

LPA – Light Physical Activity

MANCOVA – Multivariate Analysis of Covariance

MVPA – Moderate-to-Vigorous Physical Activity

PA – Physical Activity

PABAK – Prevalence Adjusted Bias Adjusted Kappa

PE – Physical Education

SB – Sedentary Behaviour

TDF – Theoretical Domains Framework

WHO – World Health Organization

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Dedication

To Tim

Chapter 1: General Introduction

1.1 Childhood Physical Inactivity and Sedentary Behaviour

Physical activity is essential to the health of school-aged children and youth. There is ample experimental and epidemiological evidence to support that physical activity has beneficial effects on children's physiological functioning and psychosocial well-being (Janssen & LeBlanc, 2010; Larun et al., 2006; Poitras et al., 2016). International and national health authorities have created evidence-based physical activity guidelines recommending the minimum level of physical activity required to achieve optimal benefits (Australian Government Department of Health, 2014; Office of Disease Prevention and Health Promotion, 2008; Department of Health, 2011; Tremblay et al., 2011; World Health Organization [WHO], 2010). Specifically, in Canada, it is recommended that children participate in a minimum of 60 minutes of moderate-to-vigorous physical activity (MVPA) every day (Tremblay et al., 2016), with additional activity at higher intensities considered more beneficial (Janssen & LeBlanc, 2010). Unfortunately, levels of physical activity are assiduously low among children and youth in Canada (ParticipACTION, 2016) and worldwide (WHO, 2004). Objectively measured physical activity has revealed that only 9% of boys and 4% of girls between the age of 6 and 17 currently meet these guidelines in Canada (Colley et al., 2011). Within British Columbia (BC), conservative estimates suggest that 50% of children are insufficiently active (Naylor, Macdonald, Reed & McKay, 2006).

Concomitantly, there is evidence that links sedentary behaviour to negative health outcomes. Sedentary behaviour (SB) refers to any waking activity characterized by an energy expenditure $\leq$1.5 metabolic equivalents while in a sitting or reclining posture (Sedentary Behaviour Research Network, 2012) and affects health independently of MVPA levels

(Tremblay, Colley, Saunders, Healy, & Owen, 2010). Sedentary behaviour has been linked to metabolic dysfunction, decreased bone mineral density, and poorer vascular health and shows a dose-response relationship with obesity, cancer, and cardiovascular and metabolic diseases (Tremblay et al., 2010). Currently, Canadian children spend an average of 8.5 hours of their day in sedentary activity (LeBlanc et al., 2015). In British Columbia, one study reported that children age 8 to 11 spend almost 540 minutes (8.9 hours) in sedentary time per day (Nettlefold, McKay, Naylor, Bredin, & Warburton, 2012).

Physical inactivity and increased sedentary behaviour in childhood are risk factors for being overweight or obese (Tremblay & Willms, 2003), conditions that can subsequently persist into adulthood (Reilly & Kelly, 2011). Moreover, obesity is associated with numerous chronic diseases, including type II diabetes and cardiovascular disease (Ball & McCargar, 2003). Nearly one third of Canadian children are considered overweight or obese (Statistics Canada, 2014). As a result, there has been an increase in public health strategies and interventions by researchers, governments, and community stakeholders to combat Canada's physical inactivity and obesity crisis in children (Gray et al., 2014; Naylor & McKay, 2009; Taylor, McKenna & Butler, 2010; Waters et al., 2011). Establishing healthy lifestyle behaviours, like physical activity, is imperative during childhood, as these behaviours extend across the life span (Telama, 2009) and have long-term health implications (Reilly & Kelly, 2011).

1.2 School-Based Physical Activity Policies

Schools have been identified as critical settings for the promotion of public health initiatives, including physical activity (Hatfield & Chomitz, 2015; WHO, 2004). In Canada, school attendance is mandatory, and therefore schools represent an environment through which to reach a large and diverse population of youth, who spend a majority of their waking time in

school (Lagarde & LeBlanc, 2010; Naylor & McKay, 2009). Additionally, schools provide a context to overcome disparities amongst communities with unequal opportunities for physical activity through provision of physical education (PE) and infrastructure to facilitate physical activity (Olstad, Campbell, Raine, & Nykiforuk, 2015). Finally, school-based physical activity programs offer a cost-effective method to reduce obesity in the population (Wang, Yang, Lowry & Wechsler, 2003).

As a result, there are many examples of interventions targeting children's physical activity within the school context. Interventions have included: improving the amount and quality of PE instruction, modifying play spaces, improving access to equipment at recess, and providing after-school programs and in-class activity lessons and breaks (Hynynen et al., 2016; Naylor et al., 2015). Multicomponent interventions that provide additional opportunities for physical activity across the whole school day (van Sluijs, McMinn, & Griffin, 2007) and target changes in the school environment (Naylor & McKay, 2009) have shown to be effective compared to interventions that target individual behaviour in an individual school domain. Many school environmental approaches to address childhood physical inactivity are targeted through policy change (Brownson et al., 2010). School-based physical activity policies include legislative or regulatory actions taken by a government agency that specify formal and informal rules or standards (Schmid, Pratt, & Witmer, 2006) to govern the amount of physical activity children should obtain during (physical education, recess, in-classroom activity breaks), and/or immediately before or after (active commuting to/from school, physical activity clubs and programs, intramural sports) school (Hatfield & Chomitz, 2015). Within a school context, policy can influence behaviour at many levels, including administration, teachers and children (Schmid, Pratt, & Witmer, 2006).

1.3 British Columbia's Daily Physical Activity Policy

Several provinces in Canada, including Alberta, Ontario and British Columbia, have adopted daily physical activity policies aimed at increasing children's physical activity specifically within schools (Olstad et al., 2015; Weatherson, Bradford, Berg & Sloboda, 2016). In BC, the Ministry of Education mandated a Daily Physical Activity (DPA) policy in 2008 (revised in 2011 and 2016[1]) stipulating all students from kindergarten (K) to grade 12 participate in physical activity (BC Ministry of Education [BCED], 2016a; BCED, 2016b). Students in grades 8 to 12 are responsible for recording 150 minutes of MVPA per week (in- or out- of school); however, elementary schools are responsible for providing at least 30 minutes of physical activity as part of the educational program for children in grades K to 7 on days with no physical education[1] (BCED, 2016a; BCED, 2016b). Physical activity requirements can be achieved through structured or free-play activities (endurance, strength, flexibility) occurring at school during instructional (i.e., PE, other class time) or non-instructional (i.e., recess, lunch or after school) time (BCED, 2016b). Although BC's DPA policy statement for elementary schools does not include specifications regarding physical activity intensity, the overall purpose of the policy is to help students achieve the Canadian Physical Activity Guidelines of 60 minutes of MVPA (BCED, 2016b). It is important to note, that while BC's DPA policy addresses physical activity behaviour, it does not specifically address sedentary behaviour, which could be reduced

[1] Over the course of the planning for and data collection of this research, the BC Ministry of Education revised the DPA policy statement multiple times. As such, there is no longer any division between PE and non-PE days. The DPA requirements of 30 minutes of physical activity are now required irrespective of school days with or without PE. We retained this separation for our analysis in Study 3 to explore whether days with PE are more effective at helping students achieve the guidelines. In addition, the policy originally stated that DPA may be offered in smaller time segments of ≥10 minutes (Olstad et al., 2015), however this is not stated on the most recently revised policy statement (BCED, 2016). Study 3 measures total intermittent MVPA over the course of the school day, irrespective of time segment length.

as a result of the policy. Most importantly, elementary schools have the autonomy to decide how to implement and fulfill DPA during the school day, which has implications on the delivery and impact of the policy. For this reason, elementary schools were chosen as the focus group for this research.

1.4 Importance of Policy Evaluation and Theory

Policy evaluation is the assessment of how a policy is being implemented and whether it is achieving its purpose or intent and is an important stage of the policy process (Brownson et al., 2010). Preliminary reviews suggest that school-based physical activity policies in general have the potential to increase children's physical activity in the short-term (Bassett et al., 2013; Lagarde & LeBlanc, 2010), yet their long-term impact on childhood overweight and obesity remains inconclusive (Williams et al., 2013). With respect to Canadian DPA policies, evaluation evidence is limited and more research is needed (Faulkner, Zeglen, Leatherdale, Manske, & Stone, 2014; Naylor & McKay, 2009). Implementation is the conversion of policy plans into action (DeGroff & Cargo, 2009) and implementation evaluation examines the progress and process of how this occurs (i.e., process) and measures the products resulting from the process (i.e., output; Taylor et al., 2010). For example, with respect to DPA policy implementation, process and output measures may include: the percentage of schools providing the minimum amount of time for daily physical activity, approaches employed by teachers to deliver DPA, and changes in the school-environment resulting from DPA policy implementation. Outcome evaluations measure the ultimate outcomes of action as a result of policy implementation; for example, change in knowledge, behaviour and health (Taylor et al., 2010). Within the context of the DPA policy, one example of an outcome measure is the percentage of students reaching moderate to vigorous physical activity levels during the school day (Taylor et al., 2010).

Evaluation is beneficial on many levels, as it can inform future policy development (or refinement) and warrant ongoing implementation, measure unintended consequences, enhance policy support and provide accountability to stakeholders (Taylor et al., 2010; Tjomsland, Wold, Krumsvik, & Samdal, 2015).

In order to improve the success of such policies, policies should be evaluated at the outset and on an ongoing basis (Ramanthan, Allison, Faulkner, & Dwyer, 2008). Unfortunately, as with other governmental health policies in schools (Williams et al., 2013), no monitoring mechanism was put in place prior to the DPA policy being mandated. Noted by researchers examining a similar DPA policy in Ontario, a lack of evaluation procedures from the outset of policy development is detrimental to tracking DPA policy implementation and ultimately its effectiveness (Robertson-Wilson & Lévesque, 2009; Stone, Faulkner, Zeglen-Hunt, & Bonne, 2012). Due to the variability in policy implementation in school settings, there has been an emphasis on measuring implementation (Saunders, Evans, & Joshi, 2005). Specifically, there is a need to understand the real-world constraints, or barriers, when implementing policy in school environments. Equally as important, implementation must be tied to outcomes to determine why a policy was or was not successful (Saunders et al., 2005). Examination of factors associated with implementing policies in real-world settings can occur with the use of behaviour change theories. Theoretical frameworks allow researchers to systematically and *comprehensively* evaluate influences on the targeted behaviour, and relate such influences to other literature. In turn, strategies or interventions to overcome these factors can then be developed based on the cumulative findings to help improve the impact these policies have on children's physical activity levels.

1.5 Lack of DPA Policy Evaluation

Although it has been a decade since the first DPA policy was mandated in Canada, evaluation of its implementation and effectiveness is surprisingly limited (Faulkner et al., 2014; Olstad et al., 2015). Alberta conducted a province-wide survey (Alberta Education, 2008), yet no evaluation monitoring system was established prior to DPA implementation in Ontario (Office of the Auditor General of Ontario, 2013; Allison et al., 2014; Brown & Elliot, 2015; Patton, 2012; Robertson-Wilson & Lévesque, 2009) or BC (Watts, Mâsse, & Naylor, 2014). To date, more DPA evaluation research has been conducted in Alberta and Ontario compared to BC. In BC, two studies have examined the implementation of DPA (Mâsse, Naiman, & Naylor, 2013; Watts et al., 2014); however, the effectiveness of the DPA policy within BC has not yet been examined. Therefore it is unknown if or how BC teachers implement the DPA policy during the school day and if this policy helps students achieve more physical activity and reduce sedentary time while at school. A provincial policy that has the potential to positively impact the health outcomes of so many BC children warrants further investigation as to its current implementation and effectiveness.

The overarching goals of this research was to contribute to the literature exploring the implementation of the DPA policy and provide the first examination of DPA policy effectiveness at achieving PA outcomes for children in BC. Overall, the objective of this thesis was to understand the factors that affect teacher's implementation of the DPA policy and understand how a teacher's implementation approach impacts the child's physical activity and sedentary behaviours while at school.

1.6 Research Purpose

There were three main purposes of this thesis. The *first purpose* was to summarize the existing DPA policy literature and conduct a theoretical examination of the barriers and facilitators to DPA implementation across Canada. A review of past literature provides the context by which to design an implementation and effectiveness study in BC and compare findings across provinces. The *second purpose* was to understand the DPA implementation process by BC teachers, including: i) factors that influence the provision of DPA opportunities, and ii) approaches used to implement the policy at school. This information was necessary to ascertain how the context influences the success or failure of the DPA policy and provide theoretically informed suggestions on how to improve implementation of the policy. Finally, the *third purpose* was to determine the effectiveness of the DPA policy at impacting children's MVPA levels and sedentary behaviour when teacher implementation consisted of provision of PA opportunities during instructional and non-instructional time combined versus only non-instructional time.

1.7 Overall Research Design: Multi, Mixed-Methods Approach

To address the first purpose, Study 1 (Chapter 2) of this thesis presents a scoping review of the existing DPA policy research and was conducted prior to Study 2 (Chapter 3) and Study 3 (Chapter 4) to inform the design of these subsequent studies. Study 2 and 3 were developed together and therefore represent a fixed design, whereby the methods were predetermined at the beginning of the research process. Together, these studies represent a natural experiment conducted over two interrelated phases in a multi-phase sequential design, using a combination of qualitative and quantitative methods (mixed methods; Creswell, 2012). Johnson, Onwuegbuzie and Turner (2007) provide a general definition of mixed methods research:

> Mixed methods research is the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration. (p.123)

Individually, qualitative and quantitative research paradigms assume differing philosophical (ontological, epistemological, axiological) and methodological perspectives, each with it's own strengths and limitations (Johnson et al., 2007). For example, a prominent strength of qualitative research is its focus on providing a deep understanding of the contexts and meaning of human experiences, whereas quantitative research provides breadth of knowledge through exploring relationships among measureable variables (Creswell, Klassen, Plano Clark, & Smith, 2011). A mixed methods approach can help to compensate for the constraints of one set of methods and lead to new insights (Albright, Gechter, & Kempe, 2013). Based on the philosophical tradition of pragmatism (Johnson et al., 2007), mixed research is often utilized in evaluation research, which seeks to answer practical questions or solve real-world problems. In this thesis, I sought to examine both the processes/experiences of DPA implementation by teachers along with the outcomes of DPA implementation on students' physical activity levels. Albright, Gechter and Kempe (2013) explain that the use of mixed methods in implementation research plays a critical role in understanding how the context influences the success or failure of an intervention. They describe the mixed methods research process:

> a common way of combining methods is to use quantitative data to study outcomes and qualitative data to study processes… Because qualitative work involves an inductive, subjective, contextual approach, it is particularly useful when there is a need to elicit the perspectives, values, and opinions of stakeholders, participants, or consumers in their own words. Qualitative approaches are also useful when seeking to understand why evidence-based practices were successfully or unsuccessfully implemented, or when seeking to identify strategies for facilitating implementation. In contrast, quantitative methods emphasize a deductive, objective, generalizing approach and are typically best

used in the measurement of intervention and/or implementation outcomes. (p. 401-402)

According to Reichardt and Cook (1979), researchers should embrace both qualitative and quantitative methodological paradigms:

> evaluations should be process-oriented as well as outcome oriented, exploratory as well as confirmatory. There is no reason for researchers to be constrained to either one of the traditional, though largely arbitrary, paradigms when they can have the best from both. (p.18-19)

For this thesis, I embraced a pragmatic perspective: prioritizing the research problem and question, using explicitly diverse approaches, valuing both objective and subjective knowledge, and employing "what works" (Morgan, 2007). Both the qualitative and quantitative components are essential to answering my research questions; therefore each component is given equal priority (i.e., equal status; Johnson et al., 2007).

In mixed methods studies, it is essential to collect and integrate quantitative and qualitative data rather than keeping them separate (Creswell et al., 2011). In this thesis, qualitative and quantitative methods were combined during data collection, analysis and interpretation. The rationale for mixing the qualitative and quantitative approaches was to enhance representation (i.e., the quality of data interpretation; Onwuegbuzie & Teddlie, 2003), including: triangulation (i.e., comparison of qualitative and quantitative results), complementarity (i.e., findings from one analysis type are used to enhance results from the other type), development (i.e., when data is collected sequentially so that the findings from the first analysis type are used to inform data collected and analyzed in other type), and expansion (i.e., the use of both analyses are used to expand the scope and focus of the study; Greene, Caracelli & Graham, 1989). Data for Studies 2 and 3 were collected and analyzed sequentially over two phases. In the first phase, interviews were conducted with elementary school teachers regarding

their implementation approaches and factors affecting their implementation of DPA through provision of physical activity opportunities during the instructional school day. In phase two, randomly selected children from the interviewed teachers classrooms wore accelerometers for one school week. Study 2 (Chapter 3) fulfills purpose 2i and consists of a theoretical analysis of the barriers and facilitators to teachers' implementation of DPA. Study 3 (Chapter 4) examines differences in children's physical activity and sedentary behaviour (purpose 3) by teacher-reported implementation approaches (purpose 2ii). While each phase could represent a standalone publishable study, data integration occurs in Study 3 (via connecting data approach) and in the general thesis conclusion (via merging data approach). Study 3 connects data by "analyzing one dataset, and then using the information to inform the subsequent data collection. In this way the integration occurs by connecting the analysis of results from the initial phase with the data collection from the second phase of research" (Creswell et al., 2011, p. 5). Merging data involves combining qualitative and quantitative results together in the discussion, and is achieved in the general thesis conclusion. It also occurred by transforming qualitative results into numerical form to compare to the quantitative dataset, which was done in Study 3.

1.8 Orientation to the Manuscript-Style Thesis

The reader will note several characteristics associated with a manuscript style thesis given it contains three submitted manuscripts. First, due to the connectedness of the studies yet independent publication, there is overlap in the general thesis introduction and in the introductions of each manuscript study. For example, the low physical activity prevalence statistics are cited across each study. To avoid unnecessary repetition, it was decided that the general thesis introduction be concise and only expand on sections that each manuscript did not

allow for due to manuscript length constrictions. Therefore, each manuscript provides the relevant background detail to set up rationale for that specific study's research purpose.

Second, some detail that might be observed in an unpublished thesis is not seen in a published manuscript because of journal restrictions on manuscript length. For example, Study 2 and 3 omit details from recruitment questionnaire due to journal restrictions and Study 3 omits details regarding raw class accelerometer data. To compensate, an appendix of additional information for Study 2 and 3 is provided (see Appendix A to M).

Third, there is a minor inconsistency in referencing style between the overall thesis and manuscripts due to differential requirements of the University and publishing journals. The overall thesis used American Psychological Association (APA) reference formatting, whereas all three manuscripts used BioMed Central formatting with consecutive numerical in-text citations. The most prominent difference between the two is seen in the reference list, where the full journal title is cited in APA formatting and Index Medicus/MEDLINE journal abbreviations are used in BioMed Central reference style. To retain the original structure of the papers, the manuscripts referencing style was not modified. The references for each study are presented immediately after each study. The references for the overall introduction and conclusion are presented at the end of the thesis.

Fourth, and finally, a general conclusion will integrate the findings and address their collective contribution to the school-based physical activity policy literature.

Chapter 2: Study 1 – A Theoretical Analysis of the Barriers and Facilitators to the Implementation of School-Based Physical Activity Policies in Canada: A Mixed Methods Scoping Review[2]

2.1 Background

Like most children and youth worldwide [1], Canadian children are not meeting the national physical activity guidelines for optimal health [2, 3, 4]. To address this problem, the World Health Organization recommends that schools develop policies to increase physical activity among children [5]. In an attempt to help children meet the national recommendations of 60 minutes of moderate-to-vigorous physical activity (MVPA), three Canadian provinces have adopted Daily Physical Activity (DPA) policies aimed to increase children's physical activity levels specifically during the school day [6, 7, 8]. Although the specific DPA policy requirements for each province varies slightly, they are comparable in that they require elementary schools (and thus teachers, principals and/or administration) to provide a specific amount of time each day for children to be active during instructional hours of the school day. For example, the Ministry of Education in Ontario mandated their DPA policy in 2005, requiring elementary schools to provide at least 20 minutes of sustained MVPA as part of the instructional school day for children in grades one to eight [8]. Similar DPA policies were authorized in Alberta and British Columbia in 2005 and 2008, respectively, with the requirement to provide activities that vary in form and intensity for 30 minutes during the school day [6, 7]. Although

[2]This manuscript has been published (citation follows). The reference section and additional files for this manuscript are included at the end of this chapter.

Weatherson, K.A., Gainforth, H.L., & Jung, M.E. (published March 27, 2017). A theoretical analysis of the barriers and facilitators to the implementation of school-based physical activity policies in Canada: A mixed methods scoping review. *Implementation Science.*

DPA policies ultimately aim to change and have an effect on students' physical activity levels at school, within the context of elementary schools, the implementation of DPA policies require behaviour change of the teacher to provide opportunities for children to be active, and the approaches they choose to provide these opportunities is left at their personal or school's discretion. In this way, the DPA policies potentially affect two different, yet interrelated behaviours (the provision by teachers and the physical activity of students). Therefore, if DPA policies are implemented as intended, teachers, principals, and/or administration will change their provision/implementation behaviours and students will change their physical activity behaviours.

While there are many examples of policies being adopted to promote the physical activity of children [9, 10], "the adoption of policies is not sufficient to promote greater physical activity: policies are not self-implementing" (p.280) [11]. Implementation is the conversion of policy plans into action [12] and implementation evaluation examines the progress and process of how this occurs and measures the products resulting from the process [13]. There are many individual, environmental and social-cultural factors that influence the successful implementation of policies at a local level. This is especially true of schools, which are "dynamic, complex, multi-level systems with numerous factors that can influence implementation" (p.274) [14] and the quality of implementation can affect the outcomes of the policy or program [15]. Therefore, studying only the adoption of policies while ignoring the context in which they are implemented is detrimental to understanding *how* and *why* policies are or are not successful. A holistic approach that considers the complex interaction of these factors must be taken into account when considering how physical activity policies are implemented in

various school-settings.

Although it has been a decade since the first DPA policy was mandated in Canada, evaluation of its implementation and effectiveness is surprisingly limited [16, 17]. Provincial school policies that have the potential to positively impact the health outcomes of so many Canadian children warrant further investigation as to their current implementation and effectiveness. A recently published review examining the adoption, diffusion, implementation and impact of DPA policies across Canada rated the strength of each province's policy based on the language used, specific time and intensity requirements and the inclusion of mechanisms for implementation and monitoring [17]. This review highlighted that the implementation of these policies across Canada is inconsistent and suboptimal. Additionally, only one study in BC [18] and two studies in Ontario [19, 20] have examined the effectiveness of DPA policy implementation at increasing children's PA levels at school, with mixed results. It should be noted, however, that the BC evaluation of DPA examined only the impact of DPA on provision of physical education minutes per week, not on overall physical activity levels at school [18]. These mixed findings further highlight the need to examine the factors that prevent implementation in order to understand why the policy is not having a positive impact on children's PA levels at school. While the authors of this review thoroughly examined how each policy was conceptualized and adopted by each province, they did not use theoretical principles to review the evaluation pertaining to the implementation and impact of these policies on students' physical activity at school, important components of understanding the policy process [21]. Additionally, of the articles they included in their review, few of the authors reported explicit use of behaviour change theory to guide their original research or analyze the factors

affecting the implementation process. Theory is valuable for understanding how a policy is put into practice (i.e., implementation) and in identifying the barriers (i.e., factors preventing implementation) and the facilitators (i.e., factors enhancing implementation) that influence policy implementation, in order to explain the impact these policies have on children's physical activity levels. There are many factors associated with implementing interventions and policies in real-world settings, which requires behaviour change at an individual, organizational or community level [22]. The implementation of the DPA policy during the school day requires behaviour change of the teacher, principals and/or administration, and thus it is important to examine perceived barriers to implementation from this perspective. While identifying barriers to implementation is a common area of inquiry in implementation research, theory is often not used to guide our understanding of these factors [23], which if addressed would be able to increase systematic uptake and success of these policies. The advantage of conducting a theory-based analysis of the barriers and facilitators affecting the implementation of school-based physical activity policies by teachers is that it provides a framework for comprehensively understanding the relationship between these factors and the mechanisms by which they affect teachers' behaviour. Understanding these connections from a theoretical perspective better helps inform and guide researchers, policy makers and individuals responsible for delivering such policies on how to develop evidence-based strategies to improve uptake of the policy into practice. Simply identifying barriers that are not linked to theoretical constructs does not provide a strong foundation for intervention development.

One such framework that can allow us to apply theory and comprehensively identify the factors that need to be addressed is the Theoretical Domains Framework (TDF) [24, 25]. The TDF is a suitable framework for retrospectively examining barriers and facilitators. It accounts

for the overlapping constructs that exist across behaviour change theories and provides categories called domains by which to more broadly capture the potential range of factors that influence implementation outcomes, thus allowing researchers to better understand policy implementation [25, 26]. It also provides a common language for researchers to classify barriers and facilitators to implementation. The 14 TDF domains include: knowledge; skills; memory, attention and decision processes; behavioural regulation; social/professional role and identity; beliefs about capabilities; optimism; beliefs about consequences; intentions; goals; reinforcement; emotion; environmental context and resources; and social influences [22]. The TDF has been used in several reviews to understand barriers and facilitators to a wide variety of behaviours (e.g., patients' exercise behaviour, healthcare professionals' behaviours in relation to pregnancy weight management) [27, 28]. An examination of the barriers and facilitators to DPA implementation by DPA providers (i.e., teachers, principals and/or administration) using the TDF will provide a list of the potential modifiable factors to target and allow researchers to create theoretically informed interventions to improve the implementation and effectiveness of this school-based physical activity policy in the future.

2.1.1 Purpose

The aim of this review was to broadly understand the implementation and effectiveness of the DPA policy in Canadian elementary schools. Specifically, we aimed to examine: 1) the implementation status of DPA in Canada, 2) the implementation approaches used to deliver the DPA policy during the school day, 3) the barriers and facilitators to DPA policy implementation, and 4) the effectiveness of DPA policy implementation at increasing the physical activity of children at school.

2.2 Method

2.2.1 Approach

Due to the variety of methods used across a small number of existing evaluations, a systematic review and meta-analysis were not possible. Instead, this mixed methods scoping review, guided by the Arksey and O'Malley framework [29], provides a systematic description and synthesis of data. Scoping reviews are appropriate for summarizing broad, understudied areas and identifying gaps in the literature [29]. In addition, the Theoretical Domain Framework was used to code barriers and facilitators to DPA implementation. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria guided reporting of the methods and findings (see Additional file 2.1) [30]. A protocol for this review was not registered.

2.2.2 Search and Screening

To retrieve research articles and governmental reports on policy evaluation of DPA in Ontario, Alberta and British Columbia, two databases (ERIC, CINAHL) and one search engine (Google Scholar, to identify gray literature) and respective provincial government/education websites were searched in February 2015 for the time period 2005-2015. The same search was conducted again in May 2016 to retrieve additional articles published after the original search. One author executed the searches in consultation with a librarian. The search query was tailored to the specific requirements of each database and broad search terms included: *daily physical activity* OR *physical activity* OR *exercise* AND *polic** AND *school*. Additional terms were used in the Advanced search option of Google Scholar, to find articles with all of the words: school AND polic* AND Canada, and with at least one of the words: *daily physical activity* OR *physical activity* OR *exercise* AND *qualitative* OR *quantitative.* An *a priori* decision was made

to screen only the first 100 hits (as sorted by relevance by Google Scholar) after considering the time required to screen each hit and because it was believed that further screening was unlikely to yield many more relevant articles. Finally, reference lists of identified articles were examined to retrieve additional eligible articles. One author screened titles and abstracts against eligibility criteria and full texts were retrieved in situations where relevance was uncertain. Each eligible article was read in its entirety to identify studies that examined the barriers and facilitators to DPA implementation. The screening process to obtain the eligible studies is illustrated in Figure 2.1. Phase 1 included the search for eligible studies for the overall review and phase 2 included reviewing the implementation articles for the examination of barriers and/or facilitators.

2.2.3 Eligibility Criteria

Included studies were those that examined any aspect of the implementation or impact of DPA in Canada using qualitative and/or quantitative methods. Government reports were also included in the review. Inclusion criteria for articles and reports were: (i) articles written in English, (ii) publication after 2005 (after first provincial policy was mandated), (iii) involved some aspect of DPA policy evaluation (implementation or impact), (iv) applicable to elementary school setting (children aged 5-12 years), and (v) primary research papers. Articles were excluded if they applied only to a secondary school setting (youth aged 13-18 years), as both Alberta and Ontario's DPA policies do not apply to these students. Unless published, dissertations were not included in this review. Articles that only addressed participants' perspectives or opinions of PA outcomes and did not include formal measurement of DPA (either subjective or objective; i.e., survey, interview, pedometer, etc.) were considered implementation articles (not effectiveness). To answer the third aim of this study,

implementation articles were examined for the presence of barriers and facilitators, operationalized as any factor, characteristic, view or belief that either impedes or enables implementation of the DPA policy. For this analysis, eligible articles included those that examined barriers and facilitators from the perspective of teachers, principals and/or administration.

2.2.4 Data Extraction

The first author extracted the following data from each article: (1) study type and design, (2) participants, (3) methods used to assess implementation and/or PA outcomes, and (4) major findings (process and/or outcome results). For the purposes of study type classification, only student self-reported or objectively measured physical activity was considered an impact measure and classified as an 'effectiveness' article. If an article asked teachers, principals and/or administration to report on children's physical activity (based on their observation), this study was classified as an 'implementation' article. If measured, DPA implementation status (i.e., degree to which DPA was delivered) and approaches used to implement DPA (i.e., methods of DPA delivery) were extracted by the same researcher. Additional information was extracted from each article examining the implementation barriers and/or facilitators, including: (1) data collection method, and (2) behaviour change theory used, if applicable. Barrier and facilitator extraction was performed by one researcher, with double extraction occurring across 33% (n = 3) of the articles by a research assistant. To identify barriers and facilitators, each article was read in its entirety by both researchers. We distinguished between a barrier and facilitator based on how the authors of each article reported and classified the factor influencing DPA policy implementation. If the authors did not provide this distinction, we used our operationalized definition stated previously. Once identified, each researcher transferred the factor to an excel

spreadsheet. For qualitative studies, the barrier/facilitator was recorded in its original format unless only reported by authors in a synthesized format (e.g., according to a themed code). For quantitative studies, individual barriers/facilitators were extracted if ≥50% of respondents agreed that the factor influenced implementation. In other words, a factor was not extracted if >50% of respondents disagreed that the barrier/facilitator was significant. Choosing to extract the barriers and facilitators that were viewed by the majority of respondents as being significant influences to policy implementation allows researchers to provide recommendations for and develop interventions that target these pertinent factors in the future and are hopefully relevant across multiple school contexts. For questionnaire measures with an intermediate category (i.e., likert-scale questions), the barrier/facilitator was extracted if at least 50% of respondents agreed with the intermediate category (or agreed more strongly; see more extraction details in the comments column of Table 2.3). If a quantitative study included open-ended questions about implementation barriers or facilitators, the responses were extracted irrespective of how many respondents agreed they were present. Extracted factors from each coder's excel spreadsheet were compared to assess extraction agreement across the three studies.

2.2.5 Quality Assessment

Although not a requirement in Arksey and O'Malley's [29] scoping review framework, it has been suggested by others to include an assessment of methodological quality in included studies [31]. Due to the lack of validated quality assessment tools for process evaluations, the adapted version of the criteria described by Naylor and colleagues [32] and originally adapted from Wierenga and colleagues [33] was used (see items and evaluation criteria in Additional file 2.2). In accordance with Naylor and colleagues [32] past work, items were scored as positive, negative or not applicable and studies were classified as strong (>75% positive), moderate (50-

75%) or weak (<50%). When an item was not applicable, that item was excluded from the mean score of that study's rating. One reviewer conducted quality assessments for all implementation articles, with a second rater assessing 33% (n = 4) of the articles. Quality assessment agreement was based on overall global ratings not on individual items. For the two studies examining DPA policy's effectiveness on children's physical activity [19, 20], the validated quality assessment tool for quantitative studies developed by the Effective Public Health Practice Project (EPHPP) [34] was used (see items and evaluation criteria in Additional file 2.3). The EPHPP quality assessment tool assigns a strong, moderate or weak rating to six study components to provide a global quality rating. Strong studies have four or more strong components and no weak components. Moderate studies have fewer than four strong ratings and/or only one weak component. Weak studies have two or more weak components. Only one reviewer conducted quality assessments for these articles.

2.2.6 Data Synthesis / Analysis

Implementation status and approaches and physical activity outcomes across each eligible study were summarized descriptively. The TDF was used to code the implementation barriers and facilitators reported by teachers, principals and administration across the studies in order to identify what needs to change for behaviour/implementation to change.

Reliability of Method. Agreement of barrier and facilitator extraction by coders was assessed by percent agreement. To analyze the factors that influenced the implementation of DPA across studies, two researchers independently coded barriers and facilitators to the TDF domains in seven rounds. For each round, a percentage of the total extracted list of barriers and facilitators were randomly selected (across all papers). In the first round, the theoretical definitions of each TDF domain were used as a framework to guide coding. Coders met to

discuss discrepancies after the first round (and every round thereafter) and a coding manual was refined to the context of our research topic for subsequent coding rounds (see 3rd column in Additional file 2.4). Ongoing discussion and refinement between rounds ensured that recoding previous items was not necessary. In the first round, 9.85% of the total identified barriers and facilitators (*n* = 20) were coded using the TDF domain and definitions [24] (see Additional file 2.4). In rounds 2 and 3, an additional 11.8% (*n* = 24) and 12.8% (*n* = 26) was coded, respectively. In round 4, an additional 19.7% (*n* = 40) was coded. In round 5, 14.8% (*n* = 30) more were coded and in round 6, 16.3% (*n* = 33) was coded. In round 7, the last 14.8% (*n* = 30) was coded. Where coding varied, consensus was achieved through discussion after each round. Percent agreements, Cohen's Kappa statistic [35] and prevalence adjusted bias adjusted Kappa statistic (i.e., PABAK) [36] were used to show agreement between coders for new items coded at each round. PABAK was used to account for the high prevalence of not assigning more than one domain to each barrier. Inter-coder agreement values of 0.60-0.79 indicate "substantial" reliability and those above 0.80 are "outstanding" [37]. Finally, main themes from barrier/facilitator coding were identified and illustrative comments for each theme were selected.

2.3 Results

2.3.1 Characteristics of eligible studies

Selection of eligible studies is summarized in Figure 2.1. The search resulted in 66 articles being retrieved and 38 being excluded for not meeting the eligibility criteria. Overall, a total of 15 articles and reports met the eligibility criteria for the current review [18, 19, 20, 38-49], ten of which examined barriers and facilitators to implementation [38, 40, 41, 43-49]. Of the 15 studies that met the inclusion criteria, 11 articles evaluated the Ontario DPA policy [19, 20, 38-46], and 2 articles were from both Alberta [47, 48] and British Columbia [18, 49]. Table 2.1

summarizes each study based on province, evaluation type, methods and data used, participants, evaluation indicators and main findings. There were an equal number of quantitative (n = 6), qualitative (n = 5) and mixed methods (n = 4) studies included in this review. The majority of the studies evaluated implementation (n = 13) and two studies evaluated a combination of implementation by teachers and effectiveness on student's physical activity levels.

Figure 2.1. Flow chart of search results and barrier/facilitator identification

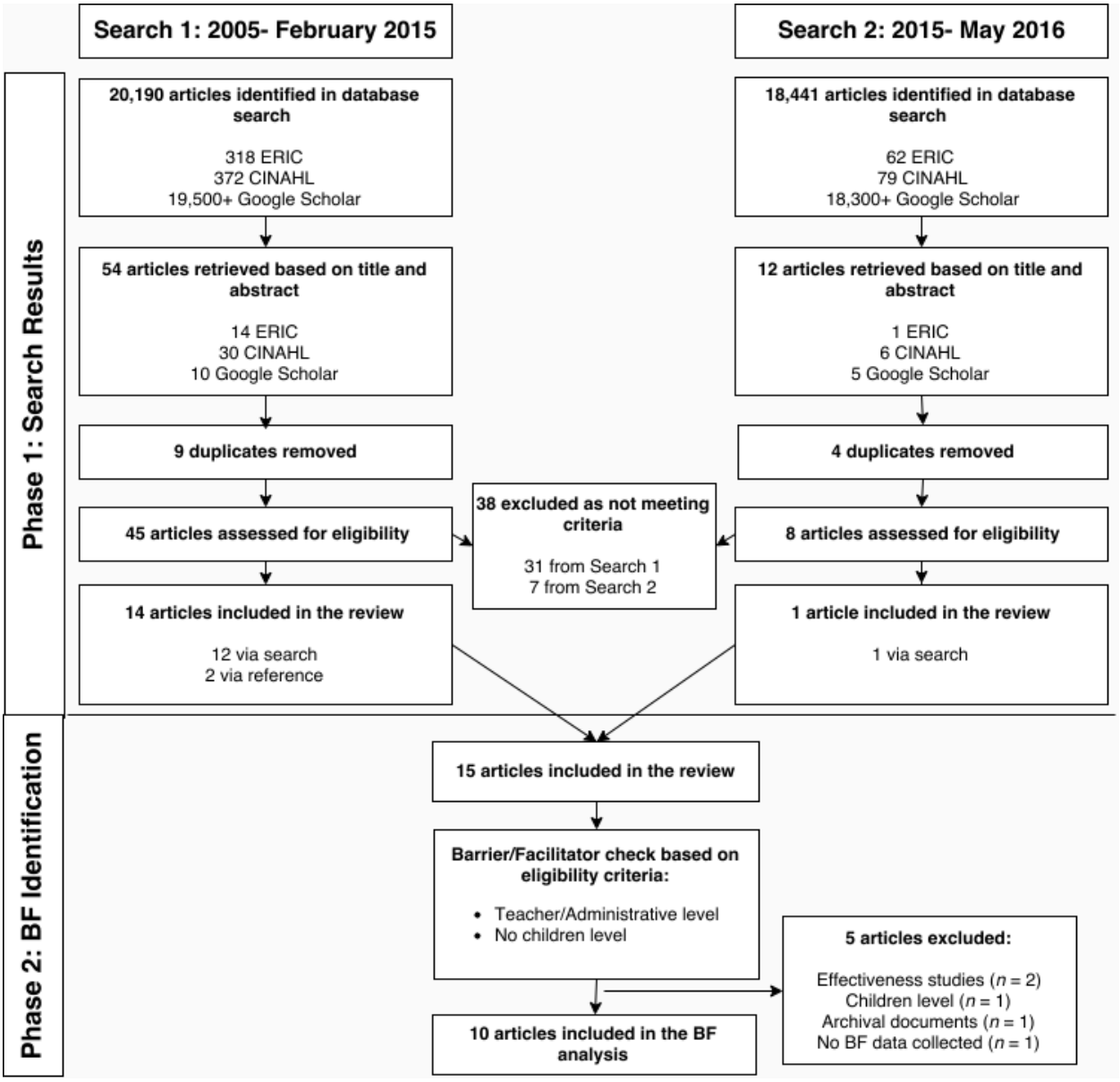

Table 2.1. Summaries of Daily Physical Activity Policy Evaluations in Canada

Author, year	Province	Evaluation type	Methods	Data source(s)	Study participants (*n*=sample size)	Evaluation indicators/ questions	Main findings related to DPA
Patton, 2012	ON	Implement	QUANT	Survey	Teachers (*n*=145)	% implementation, implementation approaches, teacher's perspectives (supports and barriers, attitudes)	45% often or always conduct DPA on days with no PE; 85% report sufficient resources and 89% report sufficient knowledge; 46% think DPA should be more structured; 65% reported lack of monitoring; 60% support DPA
Patton et al., 2014	ON	Implement	QUANT	Survey	Students (*n*=146)	Implementation approaches, barriers, attitudes	46% reported DPA everyday there is not PE; barriers: student disruption, withholding DPA as punishment; majority of students agree that there is enough space/equipment/time to do DPA everyday and majority enjoy it
AGO, 2013	ON	Implement	MIXED	Survey, interviews, document review	School boards (teachers and principals) (*n*=unknown)	Procedures for implementing, monitoring and measurement and reporting of DPA in schools	Neither the Ministry or School boards are monitoring implementation; Majority of principals reported students not getting DPA; Barriers: lack of time and space, focus on literacy
Strampel et al., 2014	ON	Implement	MIXED	Survey (with open-ended questions)	Teachers (*n*=137)	Barriers and possible solutions to DPA implementation	Barriers: lack of time, resources, space and staff and student buy-in; Possible solutions: new games with minimal equipment, more indoor DPA activities, better infrastructure, more resources, whole-school DPA approach, student leaders/DPA role models, school-community links for DPA

Table 2.1. Summaries of Daily Physical Activity Policy Evaluations in Canada

Robertson-Wilson & Lévesque, 2009	ON	Implement	QUAL	Archival documents	N/A	Framework used to examine implementation approaches and challenges	DPA policy accounts for several factors (allocation of resources, task specification) important for implementation but not all (sustainability of resources, policy value, evaluation plans)
Brown & Elliott, 2015	ON	Implement	QUAL	Semi-structured interviews	Teachers (*n*=14) and principals (*n*=5)	DPA implementation approaches, facilitators, barriers, perceived outcomes and suggestions for change	Approaches: multiple breaks, student-led activities, integration into other subjects; Facilitators: staff support, available resources, training sessions; Barriers: lack of time, space, equipment, training, student motivation and monitoring; Outcomes: increased focus, enjoyment, classroom environment; Suggestions: whole-community approach, more space, resources and monitoring
Rickwood, 2015	ON	Implement	QUAL	Semi-structured interviews	Teachers (*n*=5) and school administrators (*n*=4)	Perceived barriers, association between beliefs about DPA policy and student PA levels	Barriers: diminishing priority of DPA, used as a behaviour management strategy, lack of student motivation
Allison et al., 2014	ON	Implement	QUAL	Semi-structured group and individual interviews	Central players in development and implementation of DPA (*n*=10)	Factors influencing development and implementation, roles of key players, barriers and current status of DPA	Issues of flexibility and accountability; Several relationships to assist with implementation; Barriers of tight timeline, lack of support, insufficient training, lack of facilities, space and equipment, poor weather, increased teacher burden, lack of accountability; Inconsistent implementation and lack of evaluation plan

Table 2.1. Summaries of Daily Physical Activity Policy Evaluations in Canada

Gilmore & Donohoe, 2016	ON	Implement	QUANT	Survey	Teachers (*n*=136)	Implementation status; Perceived competence, motivation and skills to deliver DPA	46% of teachers reported that DPA is not being delivered; Majority of teachers lack competence, motivation and skills to deliver DPA
Stone et al., 2012	ON	Combination	QUANT	Accelerometer and classroom schedules	Students (*n*=856)	Total PA, frequency of DPA schedule and quality, number and duration of sustained bouts of MVPA (≥5 min), BMI	Less than 50% get DPA every day, but for those that do they are more active, more likely to meet guidelines and less likely to be overweight; No child engaged in sustained MVPA for ≥20 mins
Hobin et al., 2010	ON	Combination	QUANT	Survey	Students (*n*=2379) and school administrators (*n*=30)	Student-level (sex, grade, #PE classes/wk, MVPA minutes) and school-level (intramurals and interschool programs, DPA implementation model) characteristics	70% of schools offered DPA only on days without PE; Student PA levels were associated with PE frequency but not DPA implementation model
Kennedy et al., 2010	AB	Implement	MIXED	Interview or survey	Principals/ vice-principals (*n*=55) and PE teachers (*n*=7)	DPA knowledge, % implementation, approaches, barriers	100% principals and teachers reported full implementation; 80% of schools provided daily PE
Alberta Education, 2008	AB	Implement	MIXED	Survey	Principals (*n*=387) and teachers (*n*=638)	Resources and supports for DPA, PE, DPA activities, attitudes, challenges, monitoring status	Positive perceptions of DPA, higher for principals; Multiple approaches for implementation and challenges (scheduling, lack of facilities/space); 60% of principals monitor DPA
Watts et al., 2014*	BC	Implement	QUANT	Survey	Principals (*n*=351)	Environment changes; minutes of PE per week and delivery method of PE	≥150 min PE/week increased from 34.1% to 48.1% before and after implementation

Table 2.1. Summaries of Daily Physical Activity Policy Evaluations in Canada

Mâsse et al., 2013	BC	Implement	QUAL	Semi-structured Interviews	Principals (*n*=17) and teachers (*n*=33)	Perceived implementation, styles/change, factors that impeded or facilitated implementation of DPA	Perceived implementation varies between principals and teachers; prescriptive vs. non-prescriptive approach; major themes: relative advantage, compatibility, complexity, observability, facilitators (contextual factors)

ON, Ontario; AB, Alberta; BC, British Columbia; Implement, implementation evaluation; QUANT, quantitative; QUAL, qualitative; MIXED, mixed methods, study used both quantitative and qualitative measures; Combination evaluation type means study/report examined some aspect of implementation process and policy effectiveness; AGO, Office of the Auditor General of Ontario; PE, physical education; MVPA, moderate-to-vigorous physical activity; BMI, body mass index

*Study examined nutritional policy in middle and high school, only relevant data from grade 6 and DPA examined

2.3.2 Study Quality

Due to nature of a scoping review and the limited research available, articles were not excluded based on their quality rating (see Additional file 2.5 and 2.6). Both raters were in complete agreement of overall global ratings for process evaluations. While not excluded from the review, we were not able to assess the quality of the Auditor General's Office report [40] due to poor reporting. Specifically, there was a lack of detail on the methods employed and interpretation of the results. Of the remaining studies evaluating the implementation of DPA, 8 studies received moderate process scores [18, 42-45, 47-49] and 4 studies received weak process scores [38, 39, 41, 46]. Based on the process measures quality assessment criteria, no studies received strong process scores. This was most likely due to the lack of multiple data collection methods and the inability to measure data on multiple occasions. Only one study managed to include measurements before the DPA policy was implemented to measure the change in the school environment [18]. No studies measured policy outcomes related to implementation dose or quality (item P8). Based on the EPHPP quality assessment tool, the two effectiveness articles received weak global ratings, due to poor reporting because secondary data was presented (original articles were retrieved to assess methods) [50, 51]. Of note is that the tool is not specific to observational studies, so some items were not applicable.

2.3.3 Barrier and Facilitator Extraction and Coding Reliability

Ten studies that reported factors that influence the implementation of DPA were included (see Figure 2.1). The two independent coders extracted a total of 76 barriers/facilitators from three randomly selected articles and percent agreement for barrier and facilitator extraction was 75.0%. Across each barrier and facilitator coding rounds, the average inter-coder agreement was

outstanding. The initial coding in round 1 showed substantial agreement levels, but reliability improved following refinement of the coding manual (see Table 2.2).

Table 2.2. Inter-coder agreement statistics including percent agreement, Kappa and PABAK and the number of observations used during each coding round

Round	% total (*n* observations)	Mean percent positive agreement (*n* observations*)	Mean Kappa (±SD)	Mean PABAK (±SD)
Round 1	9.85 (20)	70.0 (20)	0.66 ± 0.50	0.90 ± 0.15
Round 2	11.8 (24)	88.5 (26)	0.90 ± 0.25	0.97 ± 0.08
Round 3	12.8 (26)	71.0 (31)	0.79 ± 0.41	0.94 ± 0.12
Round 4	19.7 (40)	76.2 (42)	0.74 ± 0.44	0.92 ± 0.12
Round 5	14.8 (30)	84.2 (38)	0.85 ± 0.35	0.94 ± 0.12
Round 6	16.3 (33)	77.5 (40)	0.83 ± 0.34	0.94 ± 0.11
Round 7	14.8 (30)	84.8 (33)	0.90 ± 0.29	0.97 ± 0.09

Kappa, Cohen's Kappa statistic [35]; PABAK, prevalence adjusted bias adjusted Kappa statistic [36]
*Some barriers were coded under multiple domains if applicable. Mean percent was calculated based on each code the BF was given.

2.3.4 Implementation Status

While one study reported 100% successful implementation by principals and teachers in a sample of Calgary elementary schools [47], most studies revealed that schools are not meeting implementation requirements. In their DPA study in Ontario, Stone and colleagues [20] categorized schools on a continuum according to implementation schedule: according to parents, 16% of students were occasionally (1-2 days per week), 34% of students were often (3-4 days per week) and 49% of students were always (5 days per week) given opportunities to be active each day for 20 minutes. In one school district in Ontario, only 45% of teachers and 46% of students reported always or often doing DPA on days with no physical education [38, 39]. In BC, Watts and colleagues [18] found that 65% of the schools they surveyed obtained full

implementation of DPA, while another study revealed that principals perceived greater implementation (90%) compared to teachers (43%) [49].

2.3.5 Implementation Approaches

Implementation approaches used by DPA deliverers to fulfill DPA requirements included many different approaches. In BC, Mâsse, Naiman, and Naylor [49] categorized implementation style taken by schools as either prescriptive or non-prescriptive. Prescriptive approaches require all children to participate during instructional time while non-prescriptive approaches provide children with more opportunities to be active during non-instructional time. The majority of elementary schools across each province adopted a prescriptive approach by increasing physical education classes during the week [18, 43, 48] or scheduling DPA activity class into the timetable [43, 47-49]. Ontario schools used some creative methods to deliver DPA during instructional time, including integrating DPA into other curriculum subjects, taking multiple smaller breaks throughout the day and allowing older students to lead DPA activities for younger classes [43]. Non-prescriptive approaches included providing more opportunities and access to facilities at recess and lunch breaks, without providing additional times to be active during instructional time [40, 47-49]. For example, in Alberta, 57% of schools reported increasing resources through the purchasing of equipment for gym and recess [48].

2.3.6 Identified Barriers and Facilitators

A total of 203 barriers/facilitators were extracted across the ten studies. Table 2.3 outlines the number of barriers/facilitators that were identified across DPA studies based on the TDF domains. Some of these barriers were coded under multiple domains, resulting in a total of 230 coded barriers/facilitators. The most commonly coded TDF domains were *Environmental context and resources (ECR*; *n* = 86; 37.4%), *Beliefs about consequences* (*n* = 41; 17.8%) and *Social*

influences (*n* = 36; 15.7%). No barriers/facilitators were coded in *Memory, attention and decision processes*, *Goals*, or *Optimism* domains. Only four of the ten articles that examined implementation used theory to guide the study. Identified themes from the TDF domains are listed in Additional file 2.7.

Table 2.3. TDF identified barriers and facilitators of DPA

Paper (author, date)	Province	Participants	Method	Scale	Theory	Total BFs Identified (*n*)	TDF Barriers (*n*)	Comments
Mâsse et al., 2013	BC	Principals and teachers	Interviews	N/A	DOI	24	ECR (9) Beliefs about consequences (4) SPRI (3) Social Influences (2) Skills (2) Beliefs about capabilities (2) Knowledge (2)	Theory was used to arrange study findings, but did not guide interview.
Kennedy et al., 2010	AB	Principals, vice-principals and PE teachers	Survey	Check all that apply	N/A	12	ECR (8) Social Influences (4) Skills (1) Knowledge (1)	The survey contained preset answers; participants were allowed to give more than one answer. Frequencies (%) were reported and factors were extracted if at least 50% of the respondents checked that the barrier was present.
Strampel et al., 2014	ON	Teachers	Survey	Likert-scale (1=strongly disagree to 5=strongly agree)	N/A	13	ECR (8) Social Influences (3) Beliefs about capabilities (1) SPRI (1) Skills (1) Knowledge (1)	Frequencies, means and standard deviations were reported. Extraction and coding was based off frequencies. The middle anchor was 'Neither agree nor disagree' and any responses for this option were not included in determining if the factor was extracted. Some items were reverse scored and therefore, these were accounted for in item extraction. All open-ended responses were extracted.

Table 2.3. TDF identified barriers and facilitators of DPA

Patton, 2012	ON	Teachers	Survey	Likert-scale (1=never to 5=always)	N/A	14	Beliefs about consequences (6) ECR (4) Social Influences (2) Emotion (1) Reinforcement (1) Intentions (1)	Only extracted barriers that at least 50% of respondents believed sometimes, often, or always influenced delivery of DPA.
Allison et al., 2014	ON	Key Informants (involved in initial development and implementation of DPA)	Interviews	N/A	N/A	24	ECR (13) Beliefs about consequences (3) Skills (3) Knowledge (3) Reinforcement (3) SPRI (2) Social Influences (2) Intentions (1) Beliefs about capabilities (1)	
Brown & Elliot, 2015	ON	Teachers and principals	Interviews	N/A	SET and ANGELO	61	ECR (22) Beliefs about consequences (13) Social Influences (13) Skills (6) Reinforcement (5) Intentions (3) Beliefs about capabilities (3) Knowledge (3) SPRI (1) Behavioural Regulation (1)	

Table 2.3. TDF identified barriers and facilitators of DPA

Rickwood, 2015	ON	Teachers and administrators	Interviews	N/A	CST	15	ECR (5) Beliefs about consequences (4) Social Influences (3) Intentions (1) Beliefs about capabilities (1) SPRI (1)	Participants discussed barriers more in relation to PE, coaching and overall general PA; not always DPA-specific. However, DPA policies do include PE as a method to meet DPA guidelines, and therefore all reported barriers and facilitators were extracted.
Alberta Education, 2008	AB	Principals and teachers*	Survey	Likert-scale (1=strongly agree to 5=strongly disagree)	N/A	33	ECR (13) Beliefs about consequences (11) Social Influences (7) Beliefs about capabilities (2) Skills (1) Knowledge (2) SPRI (1)	Only extracted barriers that received at least 50% agreement (somewhat agree, strongly agree). The middle anchor was 'Neither agree nor disagree' and any responses for this option were not included in determining if the factor was extracted. *Principals reported less challenges associated with DPA implementation and perceived more positive outcomes than teachers. Despite this difference, the same extraction criteria applied irrespective of whether it was the teachers or principals agreeing/disagreeing that the factor was present.
Auditor General's Office, 2013	ON	School boards (Principals and teachers)	Surveys, interviews, document review	Not reported	N/A	3	ECR (3)	Survey question type was not reported. Descriptive results were presented on the most influential barriers. These factors were extracted.

Table 2.3. TDF identified barriers and facilitators of DPA

Gilmore & Donohoe, 2016	ON	Teachers	Survey	Likert-scale (7 pt scale from strongly disagree to strongly agree; anchors not provided)	FMST	4	Skills (2) ECR (1) Knowledge (1) Beliefs about capabilities (1) Intentions (1)	Only extracted barriers that received at least 50% agreement (agree, strongly agree). The middle anchor was 'Neither agree nor disagree' and any responses for this option were not included in determining if the factor was extracted.

BC, British Columbia; AB, Alberta; ON, Ontario; PE, physical education; DPA, Daily Physical Activity Policy; PA, physical activity; DOI, Diffusions of Innovations; SET, Social Ecological Theory; ANGELO, Analysis Grid for Environments Linked to Obesity Framework; CST, Cultural Systems Theory; FMST, Ford's Motivation Systems Theory; TDF, Theoretical Domains Framework; ECR, Environmental context and resources; SPRI, Social/professional role and identity

2.3.7 Effectiveness of DPA Policy Implementation on Children's Physical Activity

Only two of the 15 articles examined the impact of DPA on student's physical activity behaviour [18, 19]. Hobin and colleagues [19] examined associations between student self-reported MVPA and schools' DPA implementation model and found that student physical activity was associated with PE frequency per week but not the DPA implementation model (i.e., DPA only on days without PE, in addition to daily PE, or as part of daily PE). Stone and colleagues [20] used accelerometers and classroom schedules to compare total physical activity and sustained bouts of MVPA to frequency of DPA schedule. They found that less than 50% of students received DPA every day and no child engaged in sustained MVPA for 20 minutes as required by the DPA guidelines. However, for children who did receive DPA every day, they were more active overall, more likely to meet PA guidelines and less likely to be overweight compared to students who did not receive DPA.

2.4 Discussion

With the limited research examining the DPA policy in Canada, the current status and approaches used to implement DPA and the impact on student's physical activity levels is not well understood; however, this review revealed that DPA deliverers (i.e., teachers, principals, administration) often report many barriers to DPA implementation, most of which relate to the *Environmental context and resources* (i.e., lack of training, time and resources), *Beliefs about consequences* (i.e., burden on teacher, classroom influences) and *Social influences* (i.e., lack of student/parent interest) domains of the TDF. Understanding these implementation barriers from a theoretical perspective is key to creating solutions to overcoming them in the future. Our review adds this theoretical analysis to the existing literature and is relevant to other studies examining

the implementation of school-based interventions and polices that commonly report similar barriers and facilitators to uptake [32].

2.4.1 Barriers and Facilitators and Theoretically Informed Solutions to DPA Implementation

Nearly all implementation evaluations reviewed for this article examined staff member's perspectives regarding the barriers and facilitators to DPA policy implementation. Common themes emerged irrespective of province, context/scheduling requirement (i.e., instructional or non-instructional) or data collection methodology (i.e., quantitative or qualitative) and the majority of barriers reported by teachers and principals related to the TDF theoretical domains of *ECR, Social influences* and *Beliefs about consequences*. These implementation barriers experienced by DPA deliverers are similar to those reported by others implementing similar school-based PA policies [52-56], highlighting that school policy implementers experience similar barriers and challenges when implementing PA initiatives in a school context.

A primary strength of this study as compared to previous reviews is that in using a theoretical framework to understand policy implementation, researchers can develop theoretically informed solutions to the identified barriers and design interventions that can better target these problems in the future [57]. A TDF analysis provides the behavioural diagnosis of what needs to change in a specific context in order for a target behaviour to occur and can be linked to intervention functions and techniques to change behaviour through guidance of the Behaviour Change Wheel framework (BCW) [22]. This review highlights the need to create interventions that target barriers relating to the 1) *ECR*, 2) *Beliefs about consequences* and 3) *Social Influences* domains. Intervention functions that have been linked to these domains include: 1) Training, Restriction, Environmental restructuring and Enablement; 2) Education,

Persuasion, and Modelling, and 3) Restriction, Environmental restructuring, Modelling and Enablement, respectively [22]. Therefore, DPA implementation may improve if some or all of these intervention functions are directed at the DPA deliverers through interventions. For example, one strategy to overcome the commonly reported barrier of lack of training (coded in the TDF domains *ECR, Skills* and *Knowledge*) would be for Ministries of Education and/or school boards to provide additional and ongoing training to teachers on how to conduct DPA during the instructional and non-instructional school day. Similarly, to target teachers' perception of a lack of time (i.e., *ECR*) and minimize the burden that they feel about fitting DPA in during the busy school day (i.e., *Beliefs about consequences*), school boards can emphasize how DPA positively benefits children's focus and concentration (i.e., education) or require that DPA is a part of the overall curriculum and monitor it more readily (i.e., environmental restructuring). Focusing specifically on teacher's reported implementation barriers and perceptions will assist with policy implementation, considering that they express less support, perceive less effectiveness of and report more barriers for DPA implementation than principals [38, 43, 48].

2.4.2 Low Adoption of DPA Implementation

The level of perceived implementation adoption is inconsistent across the three provinces. Overall, it appears that only about half of the elementary schools studied are meeting their respective DPA time requirement, as self-reported by teachers and principals. However "[the] self-reported findings may reflect what is scheduled versus actual policy implementation" (p.S75) as made evident by direct observations in a school-based PA policy evaluation in Alabama [58]. Moreover, scheduling DPA into the school day provides children with the *opportunity* to be active, but does not guarantee that students are active during this time.

2.4.3 Implementation Approaches

Implementation approaches across Canada have varied, with the majority of schools adopting prescriptive (e.g., additional PE and scheduling DPA into timetable, integrating DPA into other curriculum subjects, taking multiple smaller breaks throughout the day) approaches, and some schools using non-prescriptive (e.g., intramurals, lunch hour games and open access to facilities and equipment) approaches (defined by Mâsse and colleagues [49]). Non-prescriptive approaches would allow schools and teachers to take a more 'hands-off' approach and possibly minimize the two major perceived barriers relating to *ECR*, including of a lack of time in schedule [38, 40, 41, 43, 47-49] and conflicting with other curricular demands [38, 40, 41, 43, 45, 49]. Unfortunately, the implementation delivery methods currently used are not linked to PA outcomes, and as such, it is unknown how effective these specific approaches are at increasing children's physical activity levels at school. A more specific examination of the behaviour change techniques [59] that teachers, principals and administrative staff use to deliver DPA would be beneficial for linking implementation approaches to identified barriers, and ultimately PA outcomes.

2.4.4 Future Research

There is an obvious need for future evaluation to examine DPA policy implementation and effectiveness across all three provinces. Few studies have evaluated the effectiveness of the various DPA implementation approaches employed by elementary schools on student's PA levels. To understand the impact of these policies, further research that uses objective measures of PA in children is needed. Even though DPA policy implementation barriers and facilitators have been examined in depth, it is unclear whether or not these findings have been utilized to change implementation practices. In particular, it is unclear if and what strategies have been

provided to or used by schools to overcome barriers and facilitate implementation of the policy. In order for the DPA policy to meet prescribed outcomes, it is essential that current evaluation research findings be translated into usable forms to allow for schools to adopt implementation procedures according to research-based evidence. The use of the TDF to analyze barriers and facilitators to implementation assists with this process for future research interventions.

2.4.5 Strengths and Limitations

While the strength of this review is the utilization of a theoretical framework to categorize the factors that influence the implementation of the DPA policy across three Canadian provinces, it is important to recognize its limitations. A limited number of databases were searched and therefore our search for articles was not exhaustive. It is possible that the search terms did not result in the complete retrieval of DPA policy articles in this context. The exclusion of dissertation data may also have limited relevant research from this review. Future research should consider a formal systematic review that includes similar DPA policies from international jurisdictions to provide more comprehensive and generalizable findings.

Only one author screened articles for eligibility and extracted data from all studies. Of the studies that were included, it is difficult to compare findings and therefore draw conclusions from this review, due to the nature of heterogeneity in policy implementation and evaluation. Barriers and facilitators were not always explicitly discussed and the authors did not have access to the raw data from each eligible article. Therefore only barriers and facilitators that were reported by the original authors could be extracted and coded and findings may not encompass the full range of factors that influence DPA implementation. Given the heterogeneity of reporting barriers and facilitators across studies, we found it useful to code the barriers and facilitators in

rounds, using the TDF domain definitions. After each round, consensus discussion allowed us to refine the coding manual to the context of the research topic and this strengthened our agreement.

Our parameters for barrier and facilitator extraction excluded factors that may have a significant role on implementation. Even if most respondents did not agree that a barrier or facilitator influenced implementation, it still represents a factor that should be considered in tailoring interventions. However, while some factors may not have been extracted from one study, they may have been extracted from other studies and therefore were still captured in our findings. In the future, it would be helpful for authors to use consistent methods for measuring and reporting barriers and facilitators (e.g., using a theoretical framework like the TDF). Finally, the level at which the barrier/facilitator was being discussed in the original research was not always clear (i.e., does the factor affect the teacher implementing DPA or the student engaging in physical activity?). The use of the TDF allowed us to accomplish this by categorizing the barriers/facilitators according to the DPA deliverer (i.e., teacher, principal, administration); however, it is possible that the level at which the barrier/facilitator was working was incorrectly interpreted by the researchers.

Overall, the research evaluating the Daily Physical Activity policies in Ontario, Alberta and British Columbia has many shortcomings. Of particular concern is the lack of evaluation in British Columbia and Alberta. While the majority of studies have examined the process of DPA policy implementation in elementary schools, a lack of implementation adoption undermines future evaluation of the policy's effectiveness on student PA levels. Only when schools report greater adherence to implementation, will there be value in measuring the policy's effectiveness. Also, "[b]ecause policy and program implementation are evolving processes that typically entail

extensive adaptation, evaluation efforts must continue to attend to process issues" (p. 56) [12]. Important process issues include addressing the barriers to implementation. While research evidence is limited and the use of theory to guide our understanding of policy evaluation has been scarcely utilized, this review provides a theoretical lens in which to understand the barriers and facilitators to DPA policy implementation. It is our hope that this analysis will assist researchers in creating interventions to overcome implementation barriers and more successfully fulfill policy guidelines to be able to evaluate the effectiveness of these policies on student's PA levels in the future.

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and material

All data generated or analyzed during this study are included in this published article (and its supplementary information files).

Additional files

Additional file 2.1: PRISMA Checklist. Completed PRISMA checklist indicating page number in manuscript of relevant content.

Additional file 2.2: Process measures quality assessment. Quality assessment criteria for process evaluations, adapted from Wierenga and colleagues [33].

Additional file 2.3: Impact measures quality assessment. Quality assessment criteria for effectiveness evaluations, adapted from Thomas and colleagues [34].

Additional file 2.4: TDF coding manual. TDF domains and definitions used to code barriers and facilitators.

Additional file 2.5: Quality assessment of implementation studies. Quality ratings for each implementation study using Wierenga and colleagues [33] quality assessment criteria.

Additional file 2.6: Quality assessment of effectiveness studies. Quality ratings for each effectiveness study using Thomas and colleagues [34] quality assessment criteria.

Additional file 2.7: Themed barriers and facilitators to DPA implementation by theoretical domain. Identified themes to implementation barriers and facilitators arranged by TDF domains.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

The first author envisioned and planned the study and collected the data. The first and second authors analyzed the data. The first author drafted the manuscript and all authors read and approved the final manuscript.

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2.6 Additional files for Study 1

Additional file 2.1. PRISMA Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2-3
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	4-7
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	7
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	8
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	9
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	8-9
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	8-9

Additional file 2.1. PRISMA Checklist

Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	8-9
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	11, Suppl 2, 3
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	9-12
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	11-12
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	n/a
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	11-12
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	13, Fig 1
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	13, Table 1
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	13-14, Suppl 5,6
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	Table 1, Table 3
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	14-16

Additional file 2.1. PRISMA Checklist

RESULTS			
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	n/a
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	15, Suppl 7
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	16-19
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	16-19
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	19-20
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	18-20
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	n/a

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

Additional File 2.2. Process measures quality assessment*

Item	Evaluation Criteria
P1) Level of evaluation	Positive if implementation was evaluated on 2 or more levels (e.g., student/family, teacher)
P2) Definition of process variables	Positive if process variables were adequately described
P3) Process variables	Positive if four or more process variables were reported
P4) Data collection	Positive if two or more techniques were used (i.e., triangulation)
P5) Timing of data collection	Positive if process variables were measured on multiple occasions (e.g., pre, during and/or post implementation)
P6) Quantitative process variables	Positive if quantitative process outcomes were assessed using methods of acceptable quality
P7) Qualitative process variables	Positive if qualitative study design was adequately described (e.g., participant selection, setting, data collection)
P8) Outcome related to implementation	Positive if outcomes were evaluated in the context of implementation dose/quality

*Process measures quality assessment adapted from Wierenga et al., 2013

Additional File 2.3. Impact measures quality assessment *

Item	Evaluation Criteria
Selection bias	Are the individuals selected to participate in the study likely to be representative of the target population? What percentage of selected individuals agreed to participate?
Study design	Was the study described as randomized? If yes, was the method of randomization described? If yes, was the method appropriate?
Confounders	Were there important differences between groups prior to the intervention? If yes, indicate the percentage of relevant confounders that were controlled either in the design (e.g., stratification, matching) or analysis.
Blinding	Was (were) the outcome assessor(s) aware of the intervention or exposure status of participants? Were the study participants aware of the research question?
Data collection methods	Were data collection tools shown to be valid? Were data collection tools shown to be reliable?
Withdrawals and dropouts	Were withdrawals and dropouts reported in terms of numbers and/or reasons per group? Indicate the percentage of participants completing the study

*Quantitative quality assessment performed using the quality assessment tool for quantitative studies developed by the Effective Public Health Practice Project (EPHPP; Thomas et al., 2004)

Additional File 2.4. TDF coding manual

TDF Domain	Definition	Notes (Themes)
Skills (physical, cognitive and interpersonal)	An ability or proficiency acquired through practice	• Lack of training*
Knowledge	An awareness of the existence of something	• Lack of training*
Memory, attention and decision Processes	The ability to retain information, focus selectively on aspects of the environment and choose between two or more alternatives	
Behavioural regulation	Anything aimed at managing or changing objectively observed or measured actions	
Social/professional role and identity (SPRI)	A coherent set of behaviours and displayed personal qualities of an individual in a social or work setting	
Beliefs about capabilities	Acceptance of the truth, reality, or validity about an ability, talent, or facility that a person can put to constructive use	
Optimism	The confidence that things will happen for the best or that desired goals will be attained	
Beliefs about consequences	Acceptance of the truth, reality, or validity about outcomes of a behaviour in a given situation	• Child enjoyment/fun • Impact on child learning
Intentions	A conscious decision to perform a behaviour or a resolve to act in a certain way	• Priority at individual level
Goals	Mental representations of outcomes or end states that an individual wants to achieve	
Reinforcement	Increasing the probability of a response by arranging a dependent relationship, or contingency, between the response and a given stimulus	

Additional File 2.4. TDF coding manual

Emotion	A complex reaction pattern, involving experiential, behavioural, and physiological elements, by which the individual attempts to deal with a personally significant matter or event	• Personal fun/enjoyment
Social influences	Those interpersonal processes that can cause individuals to change their thoughts, feelings, or behaviours	• Supportive others • Mentorship • Priority at group level • Generic support (no resources specified)

Coding manual based on definitions provided in Cane, O'Connor & Michie (2012). TDF, Theoretical Domains Framework

*A general lack of training was always coded under Skills AND Knowledge AND ECR.

Additional File 2.5. Quality assessment of implementation studies*

	Process measures quality assessment*								
	P1	P2	P3	P4	P5	P6	P7	P8	Global process rating
Kennedy et al., 2010	+	+	+	−	−	−	N/A	N/A	Moderate
Robertson-Wilson & Lévesque, 2009	−	+	+	−	−	N/A	+	N/A	Moderate
Strampel et al., 2014	−	+	−	+	−	−	−	N/A	Weak
Patton, 2012	−	+	+	−	−	−	N/A	N/A	Weak
Patton et al., 2014	−	−	−	−	−	−	N/A	N/A	Weak
Allison et al., 2014	+	+	+	−	−	N/A	+	N/A	Moderate
Brown & Elliot, 2015	+	+	+	−	−	N/A	+	N/A	Moderate
Rickwood, 2015	+	−	+	−	−	N/A	+	N/A	Moderate
Gilmore & Donohoe, 2016	−	−	+	−	−	−	N/A	N/A	Weak
Alberta Education, 2008	+	+	+	−	−	+	N/A	N/A	Moderate
Mâsse et al., 2013	+	+	+	−	−	N/A	+	N/A	Moderate
Watts et al., 2014	−	+	+	−	+	+	N/A	N/A	Moderate

*Process measures quality assessment adapted from Wierenga et al (2013). See Additional file 2 for definitions of P1-P8

Additional File 2.6. Quality assessment ratings for effectiveness studies

	Quantitative quality assessment*						
	Selection bias	Study design	Confounders	Blinding	Data collection methods	Withdrawals/ dropouts	Global quantitative rating
Stone et al., 2012[a]	Moderate	Weak	N/A	Weak	Strong	Weak	Weak
Hobin et al., 2010[b]	Weak	Weak	N/A	Weak	Moderate	N/A	Weak

*Quantitative quality assessment performed using the quality assessment tool for quantitative studies developed by the Effective Public Health Practice Project (EPHPP; Thomas et al., 2004). See Additional file 3 for questions related to each component

[a] Components reported in original study by Stone, Faulkner, & Buliung (2013)

[b] Components reported in original study by Leatherdale, Manske, Faulkner, Arbour, & Bredin (2010)

Additional File 2.7. Themed barriers and facilitators to DPA implementation by theoretical domain

TDF Domain[a]	Theme - Barriers	Theme - Facilitators
Skills	• Lack skills and experience in physical activity delivery • Lack of training[b]	• Training opportunities
Knowledge	• Lack of training[b] • Lack of direction in policy guidelines (i.e., uncertainty about what qualifies)	• Teacher experience, knowledge and comfort in physical activity delivery
Behavioural regulation		• Putting DPA in schedule
Social/professional role and identity (SPRI)	• Belief that DPA should be a shared responsibility (of school, parent and student)	• Policy compatible with school and teacher priorities
Beliefs about capabilities	• Difficulty in fitting DPA into curriculum • Teacher uncomfortable conducting DPA	
Beliefs about consequences	• Burden on teacher (i.e., increased workload, responsibility, stress) • Classroom influences (i.e., noise, disruption, time away from other subjects) • Safety issues	• Student influences (i.e., child enjoyment/fun, leadership opportunities) • Impact on child learning (i.e., increased focus and attention) • Classroom influences (i.e., improves overall environment)
Intentions	• No motivation of teachers • Diminishing priority (compared to other subjects)	• Priority of schools and teachers • Teachers' values (i.e., physical activity is important)
Reinforcement	• Lack of monitoring/accountability	
Emotion		• Personal fun/enjoyment

Additional File 2.7. Themed barriers and facilitators to DPA implementation by theoretical domain

Environmental context and resources (ECR)	• Lack of training[b] • Lack of time in schedule • Competing academic curricular demands • Lack of resources (i.e., space/facilities, equipment) • Inclement weather • Unclear policy guidelines	• Adequate indoor and outdoor facility space • Provincially-made available resources and ideas • Access to a PE specialist
Social influences	• Lack of student/parent interest • Negative student outlook on physical activity	• Leadership and support from staff, administration and other school champions

TDF, Theoretical Domains Framework; PE, physical education

[a]No BFs were coded to *Memory, attention and decision processes*, *Goals*, or *Optimism* domains

[b]A general lack of training was always coded under Skills AND Knowledge AND ECR.

Chapter 3: Study 2 – Barriers and Facilitators to the Implementation of a School-Based Physical Activity Policy in Canada: Application of the Theoretical Domains Framework[3]

3.1 Background

Levels of physical activity are assiduously low among children and youth in Canada [1] and worldwide [2], and have in part contributed to the increased rates of childhood overweight and obesity and associated chronic diseases [3,4]. Establishing healthy lifestyle behaviours, like physical activity, is imperative during childhood, as these behaviours can extend across the life span [5] and have long-term health implications. Consequently, public health governing bodies have prioritized strategies and interventions to combat children's physical inactivity and obesity crisis globally [6,7] and within Canada [8]. In Canada, schools are often the target of such initiatives as they represent an environment through which to reach a large and diverse population of youth, who spend a majority of their waking time in school [9,10].

Several provinces in Canada have adopted daily physical activity policies aimed at increasing children's physical activity specifically during the school day [11-13]. In British Columbia, the Ministry of Education mandated a Daily Physical Activity (DPA) policy in 2008 (revised in 2011) requiring elementary schools to provide at least 30 minutes of DPA as part of the educational program for children in grades Kindergarten to seven [11]. Specifically, the DPA policy requires elementary students to achieve 30 minutes of physical activity at school on days

[3]This manuscript has been submitted (citation follows). The reference section and additional files for this manuscript are included at the end of this chapter.

Weatherson, K.A., McKay, R., Gainforth, H.L., & Jung, M.E. (submitted March 15, 2017). Barriers and facilitators to the implementation of a school-based physical activity policy in Canada: Application of the Theoretical Domains Framework. *BMC Public Health.*

with no physical education[a]. This requirement can be achieved during instructional (i.e. within-class) or non-instructional (i.e. recess or lunch break) time.

In order to improve the success of such policies, it is advised that policy evaluation occur at the outset and continues on an ongoing basis [14]; however, minimal research has examined the process of how policy plans are translated into practice (i.e., implementation) and there is currently no research examining the effectiveness of the DPA policy in BC schools [15]. Central to understanding the implementation process is a comprehensive and theoretical examination of the numerous factors that can impede (i.e., barriers) or enhance (i.e., facilitators) the successful implementation of physical activity policies at a local school-level. While some research has identified barriers and facilitators to DPA implementation in Canada [16-20], theory is often not used to guide our understanding of these factors [21]. Behaviour change theories postulate the psychological and environmental constructs that affect behaviour by specifying mechanisms of change. Within the school context, utilizing a theoretical approach allows researchers to systematically identify the potentially malleable factors affecting teacher's implementation of the policy and to prioritize and develop strategies through which to target these key factors to improve policy practice and achieve desired outcomes. For this reason, this study aims to move beyond the simple identification of barriers and facilitators to DPA policy implementation (which has been exhausted in previous research) by descriptively linking these factors to pathways of behaviour change in order to enhance implementation practices [22].

The Theoretical Domains Framework (TDF), developed and validated by Michie and colleagues [23,24], accounts for the overlapping constructs that exist across behaviour change theories. Specifically, the TDF provides 14 categories, called domains, by which to broadly categorize the potential range of factors that influence implementation outcomes, including:

knowledge; skills; memory, attention and decision processes; behavioural regulation; social/professional role and identity; beliefs about capabilities; optimism; beliefs about consequences; intentions; goals; reinforcement; emotion; environmental context and resources; and social influences [25]. As such, the TDF provides a comprehensive method to identify and classify the factors that need to be addressed to enhance implementation [23,24] and is linked to the Behaviour Change Wheel framework [25] to guide researchers in the selection of theory, intervention functions and behaviour change techniques for intervention design and delivery.

3.1.1 Purpose

The purpose of this study was to use the Theoretical Domains Framework to understand teachers' barriers and facilitators to the implementation of the Daily Physical Activity policy in one school district in British Columbia. Additionally, barriers and facilitators were examined and compared according to how the teacher implemented the DPA policy during the school day (provision of DPA during instructional time or only non-instructional time).

3.2 Method

3.2.1 Overall Design

This study used short surveys and semi-structured interviews to explore the factors (i.e., barriers and facilitators) associated with the implementation of the Daily Physical Activity policy by elementary school teachers in one school district in British Columbia. A content analysis was conducted using the TDF and overarching themes were identified within each domain. Ethical approval was obtained from the Canadian University's Behavioural Research Ethics Board for research involving humans, and the respective school district.

3.2.2 Framework

The researchers used the TDF to construct the semi-structured interview guide [see Additional file 3.1], which was further refined after piloting the interview with two elementary school teachers. The TDF was then used to identify and categorize the implementation barriers and facilitators and explore emergent themes by domain.

3.2.3 Sample Selection and Recruitment

One school district from British Columbia representing over 30 public elementary schools was approached to participate in this study. Principals of all elementary schools were emailed an information letter to request time to present the study to their intermediate teachers. Teachers were eligible to participate if they were grades 4, 5 or 6 certified school teachers in publicly funded elementary schools with at least one year of experience teaching at an elementary school level, and were currently teaching in the 2015-2016 school year. In total, principals from 13 elementary schools (42% response rate) provided approval for their teachers to participate, with 33 (of 40) teachers from 11 of these schools (83% response rate) providing written consent to complete a survey and potentially participate in the interview. The short survey consisted of questions relating to the teacher's DPA implementation approaches and basic demographic information. Maximum variation sampling [26] was used to recruit teachers to be interviewed to ensure representation across teacher-reported implementation approaches, which continued until data saturation was reached [27].

3.2.4 Data Collection

KW conducted twelve semi-structured interviews with 13 teachers between February and April 2016, at a time and location convenient to each teacher. All interviews were conducted individually except for one interview, which included two grade 6 teachers from one school. The

latter was done because these teachers share a formal platooning schedule (i.e., complete curriculum together within two classrooms), thus reporting the same DPA implementation approach. Each interview was between 31 and 64 minutes in duration (M = 52.25, SD = 9.65) and consisted of a broad open-ended question (i.e., "Are there any factors that affect if or how you implement DPA in your classroom during class time? If so, what?") to elicit perceived barriers and facilitators impacting the implementation of the DPA policy by teachers. Probing questions were used to clarify domain-specific content if the participant had mentioned factors that appeared to fit within a certain domain (i.e., if the participant mentioned the influence of other teachers, the interviewer asked, "Are other teachers in your school implementing DPA?" to probe on *Social influences*, see Interview guide in Additional file 3.1 for more information). If the participant did not mention a factor related to a specific domain, they were not asked the relevant domain-specific probing question. This approach was done to minimize leading questions. Field notes were taken by the interviewer during the interview to ensure each relevant domain was discussed further. Verbal consent was obtained from each participant to audio-record the interview and participants received a monetary reimbursement ($20) for their participation.

3.2.5 Data Extraction and Analysis

Digital recordings were transcribed verbatim directly into NVivo Version 11 [28] by KW and two research assistants. Interview transcripts were checked for accuracy by the interviewer. We employed a deductive and inductive analytical approach in a two-stage process whereby extracted barriers and facilitators were 1) deductively coded using pre-existing domains (content analysis based on TDF), and 2) analyzed for emergent themes within each domain. This analysis procedure was chosen because it provides a simple method for summarizing findings in the

context of focused evaluation questions, while allowing exploration of unanticipated factors associated with implementation, and is commonly used in health research [29,30] and TDF analyses [31-33].

All transcripts underwent a minimum of three readings by at least one coder: first for familiarization with overall content, second to extract barriers and facilitators, and third to categorize according to TDF domain. To ensure the trustworthiness of the data extraction and coding, a second coder extracted and coded 33% (n = 4) of interview transcripts and any discrepancies between the two were discussed until a consensus was reached. All data was coded in Excel. Data extraction and coding are described in more detail below.

3.2.6 Barrier and Facilitator Extraction

Barrier and facilitator extraction was performed by KW, with double extraction occurring across 33% (n = 4) of the transcripts by RM. Coders read through each interview transcript line-by-line, highlighting and coding the text to 'Barrier' or 'Facilitator' nodes (containers), operationalized as any factor, characteristic, view or belief that either impeded or enabled implementation of DPA by teachers during the instructional school day, respectively. Barriers and facilitators were extracted if the teacher being interviewed commented that the factor affected their own personal implementation of DPA or if they thought it affected other teachers' implementation of DPA (i.e., shadowed data). Hypothetical barriers and facilitators, characterized as a factor that the teacher perceived (versus experienced/encountered) to be a potential barrier or facilitator to them or other teachers, were not extracted (e.g., belief that specific resources or support would be helpful for implementation without past experience with these resources/support). If a teacher discussed the same barrier/facilitator at different times within the interview, the factor was counted as separate items. Therefore, the total (count and

percent) coded to each TDF domain represents the proportion of interview time spent discussing these factors within each domain. Discrepancies in extraction were discussed until a consensus was reached. Agreed upon barriers and facilitators were transferred to an Excel spreadsheet for TDF coding.

3.2.7 Barrier and Facilitator Coding

To analyze the extracted factors that influenced the implementation of DPA, two researchers independently coded barriers and facilitators from each interview over twelve rounds (each interview was a new round), with the order of each round being selected at random. As we were attempting to understand barriers and facilitators within the school context (and not test the reliability of the TDF), researchers coded in rounds and met to discuss discrepancies after each round. In the first round, identified barriers and facilitators were coded using the TDF domain and definitions as a coding framework (see Additional file 3.2) [25]. Where coding varied, consensus was achieved through discussion and the coding manual was refined for subsequent coding rounds to facilitate consistency of TDF coding (see 3rd column in Additional file 3.2). In the case of particularly challenging exerts, expertise was sought from an expert coder who is knowledgeable and experienced in application of the TDF. Coders also made notes and comments on the overall meaning of each exert during each coding round and responses were compared across teacher-reported implementation approach type. The first coder identified main themes from each domain and exemplary quotations for each theme were selected, consistently cross-checking themes to original transcripts. Negative cases were highlighted and used to refine themes that accounted for the majority of cases. To ensure that interpretations were supported by the data (i.e., confirmation), the themes were presented to the second coder and to an additional researcher who was not part of the data collection, extraction and coding for feedback.

3.2.8 Reliability

Percent agreement was used to show agreement on barrier and facilitator extraction. Percent agreements, Cohen's Kappa statistic [34] and prevalence adjusted bias adjusted Kappa statistic (i.e., PABAK) [35] were used to show agreement between coders on categorizing the barriers and facilitators by TDF domain, for new items coded at each round as well as for the overall total. PABAK was used to account for the high prevalence of not assigning more than one domain to each barrier. Inter-coder agreement values of 0.60-0.79 indicate "substantial" reliability and those above 0.80 are "outstanding" [36].

3.3 Results

3.3.1 Characteristics of Participants

In total, twelve interviews were conducted with thirteen teachers (4 male, 9 female), who were aged 30 – 60 years (M = 44.69, SD = 10.33) and varied in teaching experience from 5 to 34 years (M = 15.69, SD = 9.31). Of those teachers who were interviewed, one teacher taught grade 4, three teachers taught grade 4/5, two teachers taught grade 5, five teachers taught grade 5/6 and two teachers taught grade 6. Ten teachers reported implementing DPA by providing additional opportunities to be active during instructional time (instructional implementers), while three teachers were classified as non-instructional implementers because they relied on students being active during non-instructional lunch and recess breaks.

3.3.2 Barrier and Facilitator Extraction and Coding Reliability

The two independent coders extracted a total of 343 barriers/facilitators from four randomly selected interviews and percent agreement across all extraction rounds was 86.3% (see Additional file 3.3). A total of 900 factors (417 barriers, 483 facilitators) were extracted across the twelve interviews. Upon coding, 68 (26 barriers, 42 facilitators) factors were deemed

ineligible (due to being hypothetical or not affecting the targeted behaviour) and removed from the data set (see Additional file 3.4), leaving a total of 832 items. All items were coded into at least one of the fourteen TDF domains or an '*Other*' category (for items that did not clearly fit into a pre-defined domain). Some items were coded to multiple TDF domains, resulting in a total of 1422 observations. Across all barrier and facilitator coding rounds, the average inter-coder agreement was outstanding (Percent agreement = 59.7%; Kappa = 0.73 ± 0.37; PABAK = 0.91 ± 0.13). Overall reliability improved following refinement of the coding manual (see Additional file 3.5) and consensus of final codes was reached through discussion, resulting in 1141 final barrier and facilitator codes.

3.3.3 Implementation Barriers and Facilitators

Table 3.1 outlines the number (total count and percent) of barriers/facilitators that were identified across each TDF domain by implementation approach group. Accordingly, the most commonly coded TDF domains accounting for 75% of the total were *Environmental context and resources* (*ECR*; *n* = 250; 21.9%), *Beliefs about consequences* (*n* = 225; 19.7%), *Social influences* (*n* = 193; 16.9%), *Knowledge* (*n* = 100; 8.8%), and *Intentions* (*n* = 88; 7.7%). Only two items were classified as *Other* (or uncodable), due to a lack of specificity. Across all participants, more facilitators than barriers were discussed in relation to *Knowledge*, *Behavioural regulation*, *Beliefs about consequences*, *Goals*, and *Social influences* domains. Barriers and facilitators were equally discussed in *Beliefs about capabilities, Optimism,* and *Intentions* domains. Non-instructional implementers discussed rarely or not at all factors related to *Memory, attention and decision processes, Behavioural regulation,* and *Goals*. These differences are explored more descriptively in the next section. Table 3.2 reports the main themes identified in each theoretical domain and Table 3.3 provides illustrative quotations by domain themes.

Table 3.1. Barriers and facilitators by TDF domain and implementation approach

	Instructional (*n* = 10)		**Non-instructional (*n* = 3)**		**Total (*n* = 13)**	
TDF Domain	***n* barriers**	***n* facilitators**	***n* barriers**	***n* facilitators**	***n* total[1]**	**% total[1]**
Skills	12	31	2	4	49	4.3
Knowledge	38	51	6	5	100	8.8
Memory, attention and decision processes	7	3	1	0	11	0.01
Behavioural regulation	0	8	0	0	8	0.007
Social/professional role and identity	7	25	2	4	38	3.3
Beliefs about capabilities	25	26	8	5	64	5.6
Optimism	15	11	3	3	32	2.8
Beliefs about consequences	61	147	9	8	225	19.7
Intentions	34	41	8	5	88	7.7
Goals	1	20	1	0	22	1.9
Reinforcement	22	4	4	2	32	2.8
Emotion	13	10	4	0	27	2.4
Environmental context and resources	133	69	33	15	250	21.9
Social influences	61	111	8	13	193	16.9
Other	2	0	0	0	2	0.002
Total	**431**	**557**	**89**	**64**	**1141**	**100**

TDF, Theoretical Domains Framework

[1] The total (*n* and %) coded to each TDF domain represents the proportion of interview time across the sample spent discussing barriers and facilitators within each domain

Table 3.2. Emergent themes by theoretical domain

TDF Domain	**Barrier Themes**	**Facilitator Themes**
Skills	• Initial DPA-specific training was good but insufficient/inappropriate over time[1]*	• Previous training and experience is helpful
Knowledge	• DPA is not our expertise • Unaware of DPA policy requirements	
Memory, attention and decision processes	• Forgetting about DPA	• I don't think about it, it's a routine

Table 3.2. Emergent themes by theoretical domain

Behavioural regulation		• Writing it down (on timetable, board) helps us remember
Social/professional role and identity	• It's not my job/responsibility	• It's my professional obligation • It's important to me because I'm active
Beliefs about capabilities	• It's difficult to motivate students • DPA delivery depends on confidence and comfort-level*	• It's easy to implement
Optimism	• Optimism depends on student's motivation to be active	
Beliefs about consequences	• Takes time out of schedule • Requires extra planning and set up time • No impact on PA levels versus increases PA levels of those who need it most* • Student boredom	• Heightens awareness of physical activity importance (for student and teacher) • Student enjoyment is activity dependent • It's a mental break (for student and teacher) • It improves students' attention and focus which improves the learning environment
Intentions	• Teachers' priorities and interests differ* • DPA is dropped for other subjects (contingent intentions)	
Goals		• Planning for and scheduling DPA into the timetable
Reinforcement	• Lack of monitoring	
Emotion	• It's frustrating • I'm worried that students will get hurt • It's a joke	• I enjoy it too

Table 3.2. Emergent themes by theoretical domain

Environmental context and resources	• Lack of time due to curricular demands and schedule interruptions • Resources (ideas or equipment) and administration or training workshops are helpful/sufficient versus not age-appropriate/insufficient* • Teachers' autonomy is decreased versus supported* • There are space constraints • It depends on the weather* • It is harder at an intermediate level[2]	
Social influences	• The school system prioritizes academics versus they prioritize DPA* • I implement DPA just like other teachers* • Students don't participate and you can't force them to move	• A champion teacher who shares resources is helpful • Students cue teachers verbally and non-verbally

*These themes fit under barriers and facilitators

[1] This theme was also coded to *Knowledge* and *ECR*

[2] This theme was also coded to *Social influences*

Table 3.3. Exemplary quotes or explanations for the themes

Theoretical Domain	**Sample quotes/explanations by theme**
Skills	**Initial DPA-specific training was good but insufficient/inappropriate over time** "When this all first came into play, we did ActionSchools. So that was our day. We had a specialist come. We tried out a bunch of the games. We opened up the bins. We looked at what kind of resources there were. And then we did some kind of team building, brain storming, 'what could this look like in your classroom?' It was a great day. Um that was the only support that we were given." (Implementer 7) **Previous training and experience is helpful** "I would say I do [have the necessary skills] because I did my entire undergrad in Human Kinetics, in Exercise Science. And obviously when I went through that program, we did do a lot - I don't want to say a lot - but we did do some PE-related courses. So, did I take a soccer course, a basketball- I took all that stuff and obviously learnt about the benefits of it all. But I think just with my background in it, I am probably more well equipped as a teacher umm to just - I can seriously just take my kids out and wing a game and I just know how to do it because I've done it so many times." (Implementer 3)
Knowledge	**DPA is not our expertise** " 'Cause we tend to teach what we know. And PE and daily physical activity kind of sit- not with all teachers, but on the backburner of what we know really well." (Implementer 10) **Unaware of DPA policy requirements** - Although all teachers knew about the DPA policy, very few had *Knowledge* of the specific requirements relating to duration (i.e., minutes), intensity (i.e., MVPA), type (i.e., aerobic, strength, flexibility), and time of day (i.e., during instructional and non-instructional). "I think teachers don't know enough about it-- I don't know enough about it, and I'm pretty savvy in that area. But I couldn't- I couldn't tell you that I've actually viewed that document myself. And that's wrong." (Implementer 7)
Memory, attention and decision processes	**Forgetting about DPA** - Overall, almost all teachers discussed not remembering or forgetting to implement DPA during the school day. **I don't think about it, it's a routine** "I think initially when we first started it, I was very conscientious about that but now I think I don't really think about it, we just kinda, incorporate it." (Implementer 5) "I want to say it's just routine. Like I write out a day plan every single day. And every single day I just write it in there. And actually, I plan the blocks I have before and I plan the blocks after for that umm it's -- and I

Table 3.3. Exemplary quotes or explanations for the themes

Memory, attention and decision processes	know it's not a specific time in here. But- and in my mind I'm always like it's 15 minutes. But it's not. It turns into 20-25 minutes pretty much every day. But I plan accordingly. And it's a routine, it's something we do every day." (Implementer 3)
Behavioural regulation	**Writing it down (on timetable, board) helps us remember** – Teachers who implemented DPA regularly discussed the importance of writing it on their timetable or the board in order to remind themselves to conduct DPA. "I do that [schedule it in] because that's just - well, that shows my thinking and it's my plan. And then ugh, it reminds me to do it, or that kind of thing. Umm, and then I also put it on the board, right? Because every day the agendas up." (Implementer 5)
Social/professional role and identity	**It's not my job/responsibility** "We are - I felt my job is an educator and we seem to be taking on a lot of society's jobs. Family's jobs. And I thought, you know, I'm kind of up to here with the responsibility for every little thing. That was my - definitely my first thought." (Non-implementer 1) "I mean, at first I was sort of like, 'well, we're doing parental jobs now? Like is it not the parent's job to ensure that their child is...' And I still think that. I think it's up to a parent to make sure they're providing their kid with opportunities at home. Umm I do believe that. And if there's a day that we don't do DPA and the kids complain, I'm like 'well run home. What do you do when you go home? Play with your video game?' You know? So I don't really feel too bad if we don't get to it or if it's a day where it's only 15 minutes. Umm so I do think there is a responsibility in the home to ensure that your child is getting some exercise, for sure. Ya." (Implementer 5) **It's my professional obligation** "For me, as with anything else on my report card, like I have to know that I covered it, that they did it and that I evaluated it appropriately. I have to know that as an educator myself. That's a professional standard that I hold myself." (Implementer 7) **It's important to me because I'm active** "I'm interested in maintaining a good physical health in my own life, it just plays into my teaching because of my identity." (Implementer 10) "But like, I'm passionate about sports. I've done sports my whole life and I'm always coaching. Like I'm the coach here…and I probably do our DPA more consistently than others." (Implementer 1)
Beliefs about capabilities	**DPA delivery depends on confidence** "I think some of them might feel that, I mean, if they don't exercise, or they don't, they're not knowledgeable about healthy habits in their own life- 'cause lots of

Table 3.3. Exemplary quotes or explanations for the themes

Beliefs about capabilities	people aren't knowledgeable- that they wouldn't want to model it anyways in school. So those would probably be the teachers- Not that they wouldn't do it, but they would put on DVDs or you know, play games or something like that. Um, I don't know why they wouldn't be confident. I think that would probably be my biggest thing. It's when... even in other subjects, if I'm not confident in teaching - French is another one - um, that somebody might not be confident in, that they wouldn't spend a lot of time on French." (Implementer 10) **and comfort-level** "Like, if you ask that question maybe for someone else who didn't feel as comfortable teaching physical activity, PE, they tend to not do as much." (Implementer 1) **It's difficult to motivate students** - Teachers discussed that it was not the provision of DPA opportunities that was necessarily difficult, but the motivation of children who were not motivated to be active. "Do I wish I could find some way to motivate those kids to do that? Absolutely… it's hard as a teacher to motivate those kids that don't even want to participate." (Implementer 3) **It's easy to implement** "But I just don't think it's very difficult to implement." (Implementer 10)
Optimism	**Optimism depends on student's motivation to be active** - Teachers had mixed feelings about the success of the DPA policy, linking their optimism to student's motivation to be active. "You're going to have someone in that group that does not want to do that. That doesn't like it. And so, you can't force them, you know? Our hands are tied. So the whole DPA is an awesome idea, but it's not practical if the kid doesn't want to do it. They're not going to do it. So you just try to do it as much as you can and get them to participate as much as they're willing to." (Implementer 8) "…the kids that are going to be active, are going to be active. And the kids that aren't, aren't." (Non-implementer 3)
Beliefs about consequences	**Takes time out of schedule** "I was just going to say I can't think of any negative impact other than the fact that it takes away from teaching time- If you are incorporating it outside of the lunch and the recess." (Implementer 3) "I think some teachers just don't see the importance of it or feel like they – it's one more thing they just can't afford to lose instructional time on." (Implementer 7) **Requires extra planning and set up time** "Because already as a teacher you spend so much of your own time during your lunch hour, your prep

Table 3.3. Exemplary quotes or explanations for the themes

Beliefs about consequences	or after school preparing for like your core subject areas. And then so to prep like for DPA, just- it's a lot as it is..." (Implementer 4) **No impact on PA levels** "If you look at some of these kids that's all they do at lunch and recess is play. They come in exhausted because, you know... and the ones that don't, don't do it anyway. Like that's the irony. Like a lot of the kids that don't run around at recess, probably don't... they're not the ones that are running around at DPA either, right?" (Implementer 8) **versus increases PA levels of those who need it most** "Yes I would say [students are more active with DPA compared to without]-- and when you asked that question, like I think of particular students. Um because I know that those ones would not move. Like I watch them outside too and they just kind of hang around or sit out there. Like they're not the ones who play either. So if we don't do it, for those ones, I know they, they won't do anything else. Whereas then you have those naturally athletic and energetic ones who, you'll go outside, and you know they'll still be playing and running around and their heart rate will get up. So if we don't do it for them, they will still be fine." (Implementer 4) **Student boredom** "And that's the thing too - they get bored really quickly too." (Implementer 8) **Heightens awareness of physical activity importance (for student and teacher)** "I think it's at least started important conversations that need to happen. It has at least let all of those people- you know, students, teachers, admin- know that this is something critical that needs to be addressed and accounted for. So I think it has heightened awareness." (Implementer 7) **Student enjoyment is activity dependent** "Um, my kids... yeah I mean my kids love it. They love that I would put that in a schedule. They like different activities, although they moan and groan at the different ones because they're not interested. Um, I think kids just want to run around." (Implementer 10) **It's a mental break (for student and teacher)** "It's good for the students, it's good for me. Like, it's umm even - like I eat my snack then too. And I actually - I want to say earlier in my career, even last year, like I used to go out and do a lap with them, just 'cause I found for me,

	just the fresh air, the sunshine - if it's sunny that day - and I would walk it as well. I used to run it. Umm but just to get moving, it helps me as

Table 3.3. Exemplary quotes or explanations for the themes

Beliefs about consequences	well. It's a mental break for them, it's a mental break for me." (Implementer 3) **It improves students' attention and focus which improves the learning environment** "Some positive impacts for the students and teachers would be we do see more focus out of the kids after they burn off some energy. Especially the high-energy students. Um, negative effects... I think the only negative effects we would say, it would be that it... I don't know. I don't think there would be any. Some would complain about that it takes up time, right, out of their schedule, but I would argue then, 'you're getting that time back because you're getting more quality time focus time out of the students.' " (Implementer 1) "I think it's beneficial for all teachers because- because of the increased focus and... and their general happiness, level of happiness that just gives a more positive atmosphere in the classroom. And so that positive atmosphere - if you've got a positive atmosphere, kids will learn more, you know, then if they're stressed or tired or hungry. Ya." (Implementer 2)
Intentions	**Teachers' priorities and interests differ** "The interest part is hard because you're either interested or you're not. And obviously everybody's interests vary. So obviously that's an interest of mine. Is it an interest of other teachers? No, they are interested in other stuff. Umm is there a way to support them? Absolutely, with stuff like that. Umm even just one person on staff going to these workshops, getting educated, getting that experience and collecting the resources and then coming back and presenting those resources to the rest of the staff. Now, that's what I did. Now, can I boost their interest in it by doing those things? No. Can I force them to use it? No. It's up to them after that. So it's hard." (Implementer 3) **DPA is dropped for other subjects (contingent intentions)** "It's unfortunate that we kind of always push physical activity to the, you know, if we have time we'll do it. But it is the reality of most teachers. We're so worried about making sure that our content courses are covered, right? So that's the biggest thing is if we're behind schedule-wise in our class, then DPA is the one that we're always saying, "oh, we could make

	up another 15 minutes, because we already have that scheduled in. So we'll take 15 minutes and not do DPA today." (Implementer 1)
Goals	**Planning for and scheduling DPA into the timetable** "I think it definitely has to do with having a set schedule that's working now, and this is now the third year of kind of this type of schedule that I've been

Table 3.3. Exemplary quotes or explanations for the themes

Goals	using. So like I said, first year was my first year in elementary school here and then second year was kind of, I did a similar schedule and then I changed everything around and actually built in DPA in these blocks. So I think that's the major drive behind it." (Implementer 1)
Reinforcement	**Lack of monitoring** - No teachers said that they were assessed on whether or not they implement DPA. While they are required to report children's fulfillment of DPA on the report cards (i.e., 'meeting', or 'not meeting'), most teachers believed this system had no effect on the implementation of the policy. "It's kind of like having a law, right? If you have a law in place on paper, that's all good. But if it's never enforced from your law officials, right? Then no one's ever going to take... they're not going to put any stock into it. So that's how I feel right now. It's not really... 'enforce' is a bad way of putting it, but, yeah. It's never monitored I guess." (Implementer 1)
Emotion	**It's frustrating** "I don't think it's just frustration around DPA, but it's frustration around finding the time to accomplish all the expectations. And it's not horrible because I mean, I absolutely love my job and I wouldn't want to do anything else. … So I don't think it's just DPA, I think it's just the rigors of it all." (Non-implementer 2) **I'm worried that students will get hurt** "But I mean because I'm not trained in that kind of stuff, it does worry me sometimes that I'm doing the activities that are by trained people and then, you know I'm a smart person, so I know about injury and I know about warming up and that kind of stuff but I'm not an expert. So what would happen if a kid pulled a muscle really badly or something and their parents... their parents probably could get angry and I could get in some sort of trouble. So that's a worry of mine. I guess it's a, it would be a restriction." (Implementer 10) **It's a joke** "When you brought it up of course I was smiling or if not a smirk, cause it's joke-like. How do you fit it in a day already that's overscheduled." (Implementer 6) **I enjoy it too** "And it's funny – you'd think that it's for the kids but I use it a lot for myself too. If I can get a stretch in there, I'm feeling better for

	the rest of the day." (Implementer 6) "And I love doing it. I look forward to that movement break." (Implementer 7)
Environmental context and resources	**Lack of time due to curricular demands** "And honestly, in my world, the days fly. And just accomplishing the curriculum is enough in those hours that we're given with the kids. That's what I find." (Non-implementer 1) "Because of what you have to jam into your day. You've got to do reading, you've got to do writing, you have to do - especially at elementary school - you have to do math. You have music. You have science, socials. You have like, we're teaching 12 different subjects, right. So, umm there's days where ya, it's hard to get that in there. Ya, for sure." (Implementer 5) **and schedule interruptions** "And time, like realistically, like our teaching day is- there is a lot to get through. And there's - in elementary school there are so many interruptions in the day. So actually like full instructional days, sometimes you just feel- like you always feel like you are racing against time. And this term in particular. You get like pro-days and assemblies and you're out on workshops, or whatever. So it just becomes too- that time is always your-- and to give up like 30 minutes, that's a lot of time. It doesn't seem like it but in a day, like it's a lot." (Implementer 4) **Resources (ideas or equipment) and administration or training workshops are helpful/sufficient versus not age-appropriate/insufficient -** Overall, teachers explained that the resources made available when DPA was first mandated were helpful but have since gone missing or been broken. Some teachers discussed how the resources were silly and not age-appropriate for older students. **Teachers' autonomy is decreased** "I think before it became a report card thing, I think a lot of us were having some sort of break within the day because we know it's needed. But to kind of have where it's like well you have to do it- telling someone you have to do something, changes it. I think if you don't have to do it, sometimes you are more willing to do it. Like today, the concert was voluntary. Well we all showed up to it, right? We're not stupid. Fifty minutes of you know, taking them out of class and, you know? They can listen to music and get some music enlightenment. But I think the 'Big Brother method' doesn't work well." (Implementer 8) **versus supported** "Like, I feel supported that they give us the flexibility to do it at any point in the day." (Implementer 1) **There are space constraints** "We have space constraints. My kids are very big and so, you know when they're... they like to move and they

Table 3.3. Exemplary quotes or explanations for the themes

	like to move big! So, when we do something in the classroom like aerobics, we've got desks everywhere and it's really difficult to do anything where they're lying down. So that's definitely... I'd say even more than time, it's space." (Implementer 10) "But we don't have like the carpet areas like the primary's would have - where you have room that you could do aerobic type stuff or that ActionSchools stuff, or… because of the size of the children. It's squishy." (Non-implementer 3)

Table 3.3. Exemplary quotes or explanations for the themes

Environmental context and resources	**It depends on the weather** "I definitely think that weather though is a huge factor in the amount that people get because I notice in the Spring time there is way more classes outside doing things and being active. Because in the wintertime, what do you do? Like it's mucky, it's snowy, it's cold. So to get dressed- especially if you have primary kids- and go out, it's like, it's a huge job." (Implementer 4) **It is harder at an intermediate level** "When the DPA first came out, I tried. You know, we had those, you know, 'Get Up and Move and Dance.' And I found it, honestly, I found it easier in primary doing it then I have in intermediate. Because it seemed like the things, the projects that we did were shorter projects and they were shorter chunks of time. And you just had more space in the classroom. And so we did get up and do, you know, impromptu dance parties or, you know, chair aerobics. You know, we did those kinds of things that they brought in to teach us how to do. But when I got to intermediate and the demands became greater, and they do have a longer attention span…so I definitely in intermediate feel the demands of the time more so than I did in primary. It was much easier in primary to do this." (Non-implementer 2) "I've just found with the older kids that sometimes - like there's definitely kids into the games and stuff and then there's other kids that they hate that. At the age that they're at." (Implementer 3)
Social influences	**The school system prioritizes academics** "But there's already so many other initiatives that exist in schools. Um and lots of those focus around academics. And it totally depends on your school too and what the focus is at your school. Umm because I know some places that is the focus because academically, they're where they need to be. But for us, some of those core areas are more important at this point because we have kids who can't read at grade levels. So for us that becomes our primary focus." (Implementer 4) **versus they prioritize DPA** "So when I came to this elementary school that was kind of built in with their system and from what I understand other elementary schools do a similar thing, because there's no morning recess scheduled. They kind of build in an

	unofficial morning recess which is the DPA and snack. So that's what they kind of do." (Implementer 1) **I implement DPA just like other teachers** "And I'm not aware of anybody in the school that's doing it any other way. So not just do we not have a school policy, I'm not even sure if individuals - how individuals are approaching it other than what I'm doing." (Non-implementer 1) "Ya, the other intermediate teachers I know, like I said, they are running a lap.

Table 3.3. Exemplary quotes or explanations for the themes

Social influences	I know that some of the primary teachers, they just go outside and do like play on the playground time. And then there's the one class where I see the teacher walks around the school with her class. So I think that everybody's trying to get in it, one way or another." (Implementer 4) **Students don't participate** "And a lot of times they act very silly. They just think it's funny and it just becomes something where you're like, you know, I've said this before, I'm guilty of it, where it's like 'well if you guys aren't going to do it, if you're not... the purpose of DPA is to be moving the whole time. Um, that... we're just going to pull it and we're not going to do it.'" (Implementer 10) **and you can't force them to move** "You'll see them out there and you cannot force them. That's the challenge with DPA. I can say we are going to go out and do this. But you cannot force, make them run or whatever…I think the dilemma with DPA is that yeah, I think it's great, but you cannot force the children to physically, to do it. They do whatever they feel like at their level." (Implementer 8) **A champion teacher who shares resources is helpful** "If one person is willing to take on that organizational force and really bring people together and create the program, then it will happen." (Non-implementer 1) "Every time I find something good, I will send it to other people. Like, 'oh here's this really cool kids yoga thing,' or 'here's this really cool dance thing' and I'll send it along to teachers I know. Sometimes all of them. And all of the time the feedback is really good." (Implementer 10) **Students cue teachers verbally** "Sometimes they say 'can we have a break?' I'm like 'OK, we can do that.'" (Implementer 8) **and non-verbally** "I guess I'm just drawing judgment upon my experience and what I see. Observation. Umm are my kids wiggling in their seats, ready to go, losing focus at that time of the day? Ya, they are ready for a break. So we go, we do that break. We eat our snack. We come back in and by the time all that is said and done, they are refocused, they are ready to focus for another hour and 15 minutes or whatever it is. Umm and that's

	why, ya I guess that's why I do it." (Implementer 3) "It's usually based on the, you know, they usually cue me. They usually, you know, from their attention. That I'm like 'Ok, we need to do something here to get them up and moving and oxygen...' Like they just need to that - you know, a burst of oxygen in their brains to just kind of wake them up. You know what I mean? Like, ya. So, it's basically – it's them. I take my cues from them." (Implementer 2)

* All quotes are in parentheses and clarifying text is not.
Note: In this table, implementer refers to instructional implementer and non-implementer refers to non-instructional implementer

3.3.4 Comparison of Barriers and Facilitators by Teacher Implementation Approach

Teachers, irrespective of implementation approach (i.e., whether or not they provided DPA during the instructional school day) experienced similar barriers and facilitators with regards to *Skills* (e.g., DPA-specific training, previous training/experience), *Knowledge* (e.g., lack of knowledge about DPA requirements), *Environmental context and resources* (e.g., poor, inappropriate or lack of DPA-specific training; lack of time due to curricular demands and schedule interruptions; weather and space constraints), *Reinforcement* (e.g., lack of monitoring), *Social influences* (e.g., school-level priorities, support from other teachers, student participation), and *Optimism* (e.g., mixed feelings about success of policy).

Where teachers who implemented DPA during instructional time differed from those who relied on non-instructional time was in their *Goals* and *Behavioural regulation* (e.g., planning for and scheduling DPA in timetable; providing schedule to students), *Social/professional role and identity* (e.g., strong personal physical activity identity and belief in responsibility to get children active at school), experience of the *Consequences* (e.g., linking physical activity to improvements in attention and focus for a better classroom learning environment) and *Social influences* (e.g., recognizing and responding to children's verbal and non-verbal cues to move throughout the day).

3.4 Discussion

The current study builds on previous research examining the factors influencing the implementation of DPA in Canada through the inclusion of an evidence-based determinant framework by which to provide a theory-based analysis of the implementation barriers and facilitators. Embedding these factors within the TDF domains enables researchers to develop interventions aimed at targeting the constructs shown to have the most salient influence on behaviour. This behavioural diagnosis is also relevant to policy makers who wish to better support teachers in their implementation efforts. In this study, teachers most often discussed factors within the *ECR, Beliefs about consequences*, *Social influences, Knowledge* and *Intentions* domains. When organized heuristically, these domains are representative of all sources of behaviour in the COM-B model, namely capability (*Knowledge*), opportunity (*ECR, Social influences*) and motivation (*Beliefs about consequences, Intentions*) components, and have important implications for theory selection in intervention design. These findings suggest that all components are interacting to influence teachers' DPA implementation behaviours, and therefore selecting a theory that broadly encompasses all determinants of behaviour may be more successful at promoting behavior change. Alternatively, reflective motivation theories may not be the most effective option for intervention design because they fail to consider the broader physical and social environmental influences on behaviour.

To create interventions, the relevant theoretical domains can be mapped onto intervention functions (e.g., via the Behaviour Change Wheel framework [BCW]) [25] and behaviour change techniques [22]. For example, possible intervention functions to target *ECR* include Training, Restriction, Environmental restructuring and Enablement. To minimize teachers' perception of a lack of time (due to curricular demands), an intervention could be designed to *train* teachers how

to incorporate physical activity into other lessons. Likewise, consideration of competing behaviours, namely other school curriculum subjects, may be another means by which to minimize the burden of a lack of time. As another example, the education intervention function could be used to target the teachers' lack of knowledge of DPA policy guidelines, and could be delivered by improving policy guideline dissemination and providing clear recommendations to teachers on how to achieve these guidelines.

After using the TDF to understand the behaviour, intervention designers can select the behaviour change techniques (BCTs), or active intervention components, aimed at targeting the relevant domains. For instance, BCTs that have been mapped to the ECR domain include: restructuring the physical or social environment, discriminative (learned) cue, prompts/cues, or avoidance/changing exposure to cues for the behaviour [37]. To address the lack of time example provided above, schools could *restructure the environment* by creating policies whereby teachers must schedule opportunities for their students to be active into their timetables. Final decisions about intervention functions, BCTs and modes of delivery should be selected according to what can be feasibly and acceptably delivered within the specific school context [22].

Whilst the most cited theoretical influences on implementation showed some consistency across teacher type (e.g., *Knowledge*, *Skills*, *ECR*, *Social influences*, *Reinforcement*, *Optimism*), there were important variations. Non-instructional implementing teachers did not plan for (i.e., set goals) or schedule DPA into their timetables (i.e., regulate their provision of DPA), both of which helped to facilitate instructional implementing teachers provision of DPA opportunities during the instructional school day. Non-instructional implementers reported the benefit of non-instructional physical activity to student's attention and learning but were not able to speak to the benefits that occurred as a result of providing PA opportunities during the instructional day;

whereas experiencing these beneficial consequences reinforced the behaviour of instructional implementers. Similarly, although non-instructional teachers may have experienced cues (e.g., fidgeting, losing focus) from students, they did not respond in the provision of DPA. These variations should also be considered for intervention design and delivery in specific contexts.

3.4.1 Implications

Similar to the review examining the barriers and facilitators to DPA policy implementation in Canada [38], this study highlights teachers' emphasis on factors relating to *ECR*, *Beliefs about consequences*, and *Social influences*. Relatedly, the identified themes within these TDF domains have been reported in other DPA studies [16-20, 39-42], as well as other studies examining the implementation of school-based PA initiatives [43,44]. For example, similar themes in the *ECR* domain include lack of time in the schedule due to competing curricular demands [16-18,20,39-41,44-47] access to resources (space, facilities, equipment and ideas) [16-18,20,39-45], and inclement weather [39-41]. Related *Beliefs about consequences* themes include an increase in teacher workload, burden and stress 17,39,41], improved student focus, attention and/or academic performance [16,17,39,41,43,46], leading to a better class learning environment [16-18,41], and overall student enjoyment and interest in physical activity [16,39,41]. Similar themes within the *Social influences* domain include level of support from staff, administration and other school champions [17,19,20,39,43,44], and student participation/preferences [17,19,20,40,43]. Due to these similarities, it is possible that intervention designs based on this study may be effective within other school contexts (different provinces/countries).

Addressing barriers to implementation is important because these factors affect fidelity, which in turn has implications on the policy meeting its desired outcomes. Very little research

has examined the impact of these policies on children's physical activity levels at school [15, 38]. Considering the different approaches to implementation by teachers in this study, it is possible the different approaches result in different outcomes. This study compares similarities and differences in perceived barriers and facilitators to DPA implementation by teacher-reported implementation approach, suggesting that a targeted intervention approach is necessary for different contexts. Future studies should examine effectiveness of these approaches on physical activity levels of children at school through objective measurement. This study's findings can be used to provide context for and interpret why different DPA policy implementation approaches succeed or fail to meet intended outcomes at the student level [48].

3.4.2 Strengths and Limitations

While use of the Theoretical Domains Framework to categorize and comprehend implementation barriers and facilitators is a strength, the TDF is not a theory, and therefore it cannot provide an explanation as to how these domains are connected and influence one another [48], limiting our understanding of how these factors interact in complex contexts. While the TDF showed good utility for categorizing barriers and facilitators within this context, it was difficult to differentiate between some domains (e.g., *Beliefs about consequences* and *Optimism*), noted too by other researchers [31,33]. Additionally, using the TDF framework to guide the interview schedule and deductively code barriers and facilitators means that the researchers approached the data with an informed, yet potentially strong bias. However, the interview protocol was designed to minimize leading questions and extracting barriers and facilitators prior to coding into specific domains was done to minimize bias of identification of relevant text and increase trustworthiness. Finally, while the interviewer asked participants to provide examples of barriers/facilitators that they had experienced versus perceived to impact DPA implementation,

and efforts were made to minimize hypothetical barrier/facilitator extraction, it is possible that this distinction was not clearly discernable for participants. According to Sparkes and Smith [49], a general weakness of content analyses is that they suggest that the more themes or categories that are counted reflect the meaningfulness or significance of that category. In this study, the total count (n) coded to each TDF domain included repeated barriers/facilitators and each count reflect the proportion of time that the teachers dedicated to discuss the respective factor. Therefore, frequency of barriers/facilitators coded to domains should not be a proxy for importance or significance. Some domains or themes that occurred only a few times may be highly meaningful to a teachers' implementation of DPA and thus be areas of potential interest (and future research) for those creating interventions to target these factors in the future.

Given that the effectiveness of school-based physical activity policies depends on their implementation, it is important to understand the challenges that teachers face in providing physical activity opportunities at school and to identify the levers that increase implementation. This study theoretically identified the barriers and facilitators impacting the implementation of the DPA policy in British Columbia and this information can be used to explain how the context influences the success or failure of the policy. The advantage of using a theoretical framework to understand the barriers is that it can assist researchers in the systematic development of future interventions to target the factors shown to impede implementation.

List of abbreviations

DPA: Daily Physical Activity policy

TDF: Theoretical Domains Framework

PABAK: prevalence adjusted bias adjusted Kappa statistic

ECR: Environmental context and resources (TDF domain)

Declarations

Ethics approval and consent to participate

This research was performed in accordance with the Declaration of Helsinki and ethical approval was obtained from the Canadian University's Behavioural Research Ethics Board for research involving humans, and the respective school district. All participants provided written informed consent.

Consent for publication

Not applicable

Availability of data and material

The datasets generated and/or analysed during the current study are not publicly available in order to maintain participant privacy.

Additional files

Additional file 3.1: Interview guide. Interview guide organized by TDF domain.

Additional file 3.2: TDF coding manual. TDF domain definitions and coding notes used to code barriers and facilitators

Additional file 3.3: Double extraction agreement. Inter-coder percent agreement across four barrier and facilitator extraction rounds.

Additional file 3.4: Ineligible extracted barriers and facilitators. Total counts of extracted barriers and facilitators that were ineligible or uncodable.

Additional file 3.5: Inter-coder agreement statistics. Inter-coder agreement statistics including percent agreement, Kappa and PABAK and the number of observations used during each coding round.

Competing interests

All authors declare that they have no competing interests.

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Authors' contributions

KW conceptualized the study, and MJ/HG provided intellectual input into the methodological design. KW conducted the interviews, transcribed and analyzed the interview data and drafted the manuscript. RM provided double extraction and coding of implementation barriers and facilitators. All authors reviewed and approved the final manuscript.

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Endnotes

[a] Over the course of the planning for and data collection of this study, the BC Ministry of Education revised the DPA policy statement multiple times. As such, there is no longer any

division between PE and non-PE days. The DPA requirements of 30 minutes of physical activity are now required irrespective of school days with or without PE.

3.5 References

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3.6 Additional files for Study 2

Additional file 3.1. Interview guide

Purpose	Question
Participant Demographics	What grade do you currently teach? How many years of experience do you have teaching in elementary school? (all in BC? Prior to 2008)
Knowledge (TDF)	Before this study, were you aware of the current DPA initiative's requirement for daily physical activity at school for children? What is your understanding of the expectations of the DPA policy? Can you please explain your understanding of the DPA policy? How does this policy relate to the physical activity guidelines for children aged 5-13? What are they?
Implementation Strategies	From my understanding, there are no specific guidelines from the Ministry of Education on how to implement DPA, so I am interested in finding out more about how BC schools are meeting these requirements. How is the DPA policy implemented at your school? Does your school provide any guidelines on how to do so? How do you implement the DPA policy in your classroom? What is your most common strategy to implement DPA in your classroom? Why do you choose some activities over others? How do you ensure that you implement DPA? How do you try to ensure that the children are working at a moderate and/or vigorous intensity?
Broad Questions re: Implementation factors	Are there any factors that affect if or how you implement DPA in your classroom/school? If so, what? Are there situations that make it difficult to conduct DPA? Is it difficult to get the children active at moderate and vigorous intensities?

Additional file 3.1. Interview guide

Goals (TDF)	Are there any strategies you have put in place to ensure you could implement the DPA policy in your classroom? Do you make a plan as to how you implement the DPA policy in your classroom? Do you follow it?
Skills (TDF)	Do you feel as though you had the necessary skills and training to implement DPA in your classroom? (put it in context relating to working prior to 2008 if applicable) Were you provided with additional training to implement DPA? Have you received additional support materials to implement DPA (e.g. game ideas, equipment, funding)? Please provide examples.
Beliefs about capabilities (TDF)	Do you think that implementation of DPA has anything to do with confidence- from the teachers, children, parents, etc.? Do you feel confident educating and encouraging students to engage in physical activity? Do you feel confident implementing DPA? What would help you feel more confident to implement DPA?
Behavioural Regulation/ Reinforcement (TDF)	Are any methods being used to assess accountability to DPA implementation by the schools or teachers? (E.g., report cards, monitoring school compliance/success of the DPA policy)? Does your school principal or administration check to ensure DPA is being conducted in your classroom? What role/effect do you think the DPA grading system in report cards has had on the implementation of this policy? How do you think DPA should be monitored in schools/classrooms? Are you rewarded or reprimanded for (not) implementing DPA?
Intentions (TDF)	At the outset of the program/of the week, did you intend to implement the DPA policy? (Since inception), has your willingness to implement DPA changed over time (more or less)? Has your motivation changed about doing DPA over the course of your teaching experience?

Additional file 3.1. Interview guide

Memory, Attention and Decision Processes (TDF)	Do you sometimes forget to implement DPA in your classroom? Are there any situations that make it difficult for you to remember to implement DPA?
Environmental Context and Resources (TDF)	What factors influence whether or not you implement DPA? Are there any competing tasks or time constraints that influence your decision to implement DPA? If so, what? Do you have all the materials and equipment you need to implement DPA in your classroom? Have you received implementation support in terms of program support materials and training?
Social Influences (TDF)	Are other teachers in your school implementing DPA? Do you feel supported by other teachers/principal/administration/school district to implement the DPA policy? Is there anyone you would want to receive support from?
Social/Professional Role and Identity (TDF)	Does the DPA policy align with you personal PA beliefs and/or teaching philosophy? In general, do you think of yourself as someone who engages in physical activity? Maintains a healthy diet? Did you feel as though you had ownership of how you conduct DPA? Do you see any ethical, legal or social issues with implementing the program?
Optimism (TDF)	Do you feel that the DPA policy will be successful?
Beliefs about Consequences (TDF); Perceived outcomes	What positive or negative impact do you think the DPA policy has had on the school community (school, teachers, students, and parents)? Do you think that children are more physically active at school when they engage in DPA compared to when they do not? Or compared to when they are in PE class?
Emotions (TDF)	What are your feelings about conducting DPA? (For example: scared, worried, excited)

Additional file 3.1. Interview guide

Final Questions	Do you have any feedback on how to improve the DPA policy? Is there anything else you would like to add about your experience as a teacher implementing DPA in your classroom?

Additional file 3.2. TDF coding manual

TDF Domain	Definition	Notes (Themes)
Skills (physical, cognitive and interpersonal)	An ability or proficiency acquired through practice	• (Lack of) DPA-specific training* • Previous experience/training
Knowledge	An awareness of the existence of something	• (Lack of) DPA-specific training* • Previous experience/training
Memory, attention and decision processes	The ability to retain information, focus selectively on aspects of the environment and choose between two or more alternatives	• Forget/remember about DPA
Behavioural regulation	Anything aimed at managing or changing objectively observed or measured actions	• Self-monitoring (e.g., tracking DPA implementation)
Social/professional role and identity	A coherent set of behaviours and displayed personal qualities of an individual in a social or work setting	• Personal physical activity beliefs/identity • (Not) teacher's role/responsibility
Beliefs about capabilities	Acceptance of the truth, reality, or validity about an ability, talent, or facility that a person can put to constructive use	• Ease or difficulty of implementation • Comfort/energy/confidence level
Optimism	The confidence that things will happen for the best or that desired goals will be attained	• (No) effect on overall PA levels

Additional file 3.2. TDF coding manual

Beliefs about consequences	Acceptance of the truth, reality, or validity about outcomes of a behaviour in a given situation	• Positive: teachers/children aware of PA as important/beneficial, child enjoyment/fun; impact on child focus/learning; increases on children's PA levels or participation • Negative: takes time away from teaching; no effect on children's PA levels or participation, injury/pain (due to poor student skill/ability), student frustration/boredom
Intentions	A conscious decision to perform a behaviour or a resolve to act in a certain way	• Priority/value/(self) pressure at individual level • General motivation • Deciding to drop DPA for other subjects ("Contingent intentions") • Trying/effort
Goals	Mental representations of outcomes or end states that an individual wants to achieve	• Plan/schedule DPA on timetable, writing DPA on board
Reinforcement	Increasing the probability of a response by arranging a dependent relationship, or contingency, between the response and a given stimulus	• Perception of (lack of) monitoring
Emotion	A complex reaction pattern, involving experiential, behavioural, and physiological elements, by which the individual attempts to	• Personal fun/enjoyment • Frustration

Additional file 3.2. TDF coding manual

Emotion	deal with a personally significant matter or event	
Environmental context and resources	Any circumstance of a person's situation or environment that discourages or encourages the development of skills and abilities, independence, social competence, and adaptive behaviour	• (Lack of) DPA-specific training* • Poor/inappropriate training • Autonomy supportive (e.g., flexibility to conduct DPA whenever) • Curriculum demands • Weather/time of year • Lack of time • Schedule interruptions (e.g., assemblies, field trips) • Space • Equipment • Ideas
Social influences	Those interpersonal processes that can cause individuals to change their thoughts, feelings, or behaviours	• Supportive others (teachers, administration, principal) • Mentorship (i.e., sharing resources; champion) • Priority/value at group level (e.g., whole-school approach/school culture) • Pressure to focus on other subjects • Generic support (i.e., no resources specified) • (Dis)similar others • School recommendations/ specifications on DPA implementation • Students** – injury/illness/ tiredness; needs to move/cues; motivation/preferences/ participation

Coding manual based on definitions provided in Cane, O'Connor & Michie (2012). TDF, Theoretical Domains Framework

*A general lack of training was always coded under Skills AND Knowledge AND ECR
** Students influence teacher's implementation of DPA for multiple reasons: injury, cues (seeing that the children are not focused, asking for DPA break)

Additional file 3.3. Double extraction agreement

Round	*n* barriers	*n* facilitators	*n* total	Total mean percent positive agreement
1	40	30	70	85.7
2	38	44	82	85.4
3	30	66	96	86.5
4	55	40	95	87.4
Total (average on all)	163	180	343	86.3

Additional file 3.4. Ineligible extracted barriers and facilitators

Round	***n* barriers**	***n* facilitators**	***n* total**
Round 1	0	0	0
Round 2	1	1	2
Round 3	2	0	1+1
Round 4	2	0	2
Round 5	2	3	5
Round 6	2	2	4
Round 7	2	4	6
Round 8	4	9	13
Round 9	1	8	9
Round 10	8	5	13
Round 11	1	3	4
Round 12	1	7	8
Total	**26**	**42**	**68**

*Factors were deemed ineligible mostly due to them being hypothetical, or not affecting the targeted behaviour, namely teacher's provision of DPA opportunities during instructional time
** Items were deemed uncodable if they were too vague to be certain which domain the factor fit under

Additional file 3.5. Inter-coder agreement statistics

Round	***n* barriers**	***n* facilitators**	**% total (*n* observations)**	**Mean percent positive agreement (*n* observations*)**	**Mean Kappa (±SD)**	**Mean PABAK (±SD)**
Round 1	44	32	9.1 (76)	35.3 (139)	0.47 ± 0.49	0.84 ± 0.14
Round 2	10	48	7.0 (58)	61.8 (89)	0.75 ± 0.41	0.92 ± 0.13
Round 3	37	43	9.6 (80)	63.1 (141)	0.76 ± 0.34	0.91 ± 0.12
Round 4	38	33	8.5 (71)	63.7 (113)	0.79 ± 0.34	0.92 ± 0.12
Round 5	18	15	4.0 (33)	75.0 (48)	0.87 ± 0.29	0.95 ± 0.10
Round 6	21	43	7.7 (64)	65.2 (112)	0.79 ± 0.30	0.92 ± 0.12
Round 7	39	32	8.5 (71)	66.3 (104)	0.79 ± 0.36	0.93 ± 0.11
Round 8	49	30	9.5 (79)	61.3 (137)	0.78 ± 0.34	0.91 ± 0.13
Round 9	29	54	10.0 (83)	55.2 (154)	0.70 ± 0.41	0.89 ± 0.15
Round 10	46	49	11.4 (95)	54.3 (173)	0.70 ± 0.35	0.89 ± 0.12
Round 11	22	39	7.3 (61)	62.5 (96)	0.75 ± 0.38	0.92 ± 0.12
Round 12	38	23	7.3 (61)	52.6 (116)	0.66 ± 0.39	0.88 ± 0.14
Total (across all rounds)	391	441	100.0 (832)	59.7 (1422)	0.73 ± 0.37	0.91 ± 0.13

*Some factors were coded under multiple domains if applicable. Mean percent was calculated based on each code the B/F item was given.

Chapter 4: Study 3 – Effectiveness of a School-Based Physical Activity Policy in British Columbia, Canada: A Mixed Methods Observational Study[4]

4.1 Background

Physical activity is essential to the physiological and psychosocial health and development of children [1,2]. As such, authoritative national and international organizations provide guidelines recommending minimum levels of physical activity required to achieve optimal benefits [3-6]. In Canada, it is recommended that children participate in a minimum of 60 minutes of moderate-to-vigorous physical activity (MVPA) every day [7]; however, the majority of children in Canada are failing to meet these guidelines [8]. Concurrently, children are becoming increasingly sedentary, which has negative health consequences independent of MVPA levels [9]. Physical inactivity and increased sedentary behaviour in childhood are risk factors for being overweight or obese [10], which can persist into adulthood [11]. Public health governing bodies have prioritized initiatives to help combat physical inactivity and obesity amongst children [3,12,13], often targeting schools as an environment through which to deliver physical activity initiatives [14,15].

In 2008, the Ministry of Education in British Columbia (BC) mandated one such policy, the Daily Physical Activity (DPA) policy, requiring elementary schools to help students in grades kindergarten to seven achieve at least 30 minutes of physical activity between the instructional (within-class) and non-instructional (lunch and recess) time on days without

[4]This manuscript has been submitted (citation follows). The reference section and additional files for this manuscript are included at the end of this chapter.

Weatherson, K.A., & Jung, M.E. (submitted January 20, 2017). Effectiveness of a school-based physical activity policy in British Columbia, Canada: A mixed methods observational study. *International Journal of Behavioral Nutrition and Physical Activity.*

physical education[a] (PE) [16]. Therefore, the DPA policy requires the behavior change of teachers (i.e., to provide opportunities for students to be active during breaks and/or class time), and of students (i.e., to be more physically active at greater intensities when given these opportunities).

While school-based physical activity policies have the potential to increase children's physical activity [14], the effectiveness of the DPA policy on student PA levels has not yet been examined in BC [17]. Evaluation of policies is imperative as it can inform future policy development (or refinement) and warrant ongoing implementation, measure unintended consequences, enhance policy support, and provide accountability to stakeholders [12,18]. There are two key forms of evaluation: implementation and outcome. Implementation is the conversion of policy plans into action [19]. Implementation evaluation examines the progress and process of how this occurs. Outcome evaluations measure the ultimate outcomes of action as a result of policy implementation; for example, change in knowledge, behaviour and health [12]. The effectiveness of school-based physical activity policies depends on their implementation [20] and thus it is important to examine and link implementation processes to impacts/outcomes. Unfortunately, as with other governmental health policies in schools [21], no monitoring mechanism was put in place prior to the DPA policy mandate, making it challenging to measure the effectiveness of the policy in BC. Further complicating evaluation is the autonomy given to schools and teachers to decide how they implement the DPA policy guidelines [16]. As a result, teachers' DPA implementation approach may vary and have a heterogeneous effect on student's physical activity levels. Mâsse, Naiman and Naylor [20] were the first and only team to examine BC teachers' DPA implementation. They found that teachers approach implementation either prescriptively (requiring all students to participate during instructional time) or non-

prescriptively (providing non-instructional opportunities but not requiring students to participate).

4.1.1 Purpose

This study had two primary research objectives. The first objective was to build on the findings by Mâsse et al. [20] by classifying the delivery method utilized by teachers to implement the DPA policy. We wanted to confirm that teachers in this school district used the two implementation approaches defined by Masse et al [20] to deliver the DPA policy: prescriptive approaches (i.e., providing DPA opportunities during instructional time) or non-prescriptive approaches (i.e., providing non-instructional opportunities but not requiring students to participate).

The second objective was to compare the amount of physical activity children attain at school when exposed to different DPA implementation approaches and determine if children who receive DPA during instructional time are more active on PE or non-PE (DPA) days. While the DPA policy does not specify physical activity intensity requirements, the overall purpose of the school policy is to help students achieve half of the Canadian physical activity guidelines of 60 minutes MVPA for the total day while at school [16]. Given that physical activity in the moderate-to-vigorous intensity levels help children achieve optimal health, this study measures and compares MVPA levels of students at school as a marker for meeting DPA requirements and does not include light intensity physical activity. Based on the limited research examining DPA effectiveness in Canada [22,23], it was hypothesized that: 1) children at school do not accumulate enough MVPA during the school day to meet DPA policy requirements. However, it was hypothesized that children in prescriptive DPA classes will accumulate 2a) less sedentary behaviour (SB), 2b) more light physical activity (LPA) and 2c) more MVPA during the entire

school day than children in non-prescriptive classes. To determine when total MVPA minutes occurred, we examined the differences in time spent in MVPA during instructional and non-instructional time. It was hypothesized that 3) the prescriptive group would accumulate more instructional MVPA minutes than the non-prescriptive group. No hypothesis was put forth regarding non-instructional MVPA since prescriptive implementation occurs during instructional time. To examine activity differences between PE and DPA days, it was hypothesized that 4) irrespective of implementation group, children will obtain more MVPA on PE days compared to DPA days. Finally, we also explored sex differences in MVPA (on DPA and PE days), since sex is a significant predictor of PA among children [24]. It was hypothesized that 5) males would accumulate more total, instructional and non-instructional MVPA than females irrespective of day.

4.2 Method

4.2.1 Overall Design

This study used mixed methods in a multi-phase exploratory sequential design to examine the differences in children's physical activity and sedentary behaviour at school during different DPA delivery methods. Teacher interviews were used to categorize the teacher's classroom based on DPA implementation approach. A random sample of children from each class wore an accelerometer to objectively measure physical activity at school for one school week (5 days). The STROBE checklist for observational studies [25] guided reporting of the methods and results (see Additional file 4.1).

4.2.2 Sample Selection and Recruitment

One school district from British Columbia representing over 30 public elementary schools was approached to participate in this study. Principals of all elementary schools were

emailed an information letter to request time to present the study to their intermediate teachers. Teachers were eligible to participate if they were grades 4, 5 or 6 certified school teachers in publicly funded elementary schools with at least one year of experience teaching at an elementary school level, and were currently teaching in the 2015-2016 school year. In total, principals from 13 elementary schools (42% response rate) provided approval for their teachers to participate. Thirty-three (of 40) teachers from 11 of these schools (83% response rate) provided written consent to complete a short survey and potentially participate in an interview. The short survey consisted of questions relating to the teacher's DPA implementation approaches and basic demographic information. Maximum variation sampling was used to recruit teachers for the interview to ensure representation across teacher-reported implementation approaches [26]. In total, twelve teachers (4 male, 8 female) from 10 schools were chosen for the interview (M_{age}=45.83, *SD*=9.90) with teaching experience varying from 5 to 34 years (*M*=16.25, *SD*=9.50). Of those teachers who were interviewed, one teacher taught grade 4, three teachers taught grade 4/5, two teachers taught grade 5, four teachers taught grade 5/6 and two teachers taught grade 6. The interviews were used to categorize the teacher's classroom based on DPA implementation approach.

KW presented and explained the study to students from each classroom of the grades 4-6 teachers who were interviewed. Random sampling, stratified for sex, was used to recruit 10 children (5 males, 5 females) from those students who wanted to participate in each class. All students were eligible and invited to participate unless they provided a reason why they must not engage in physical activity (i.e., injury, pre-existing condition). Informed written parent consent and child assent was obtained for each student. In total, 119 children (60 males, 59 females),

aged 9 – 12 years (M_{age}=10.50, *SD*=0.97) provided consent and wore accelerometers for one week at school.

4.2.3 Data Collection

4.2.3.1 Interviews

KW conducted semi-structured interviews with 12 teachers between February and April 2016. All interviews were conducted individually except for one interview, which included two grade 6 teachers from one school. These two teachers shared a formal platooning schedule (i.e., complete curriculum together within two classrooms) and both implemented the same DPA implementation approach. Each interview lasted between 32 and 64 minutes (*M*= 52.91, *SD* = 9.93). The interview consisted of open-ended questions relating to 1) teaching experience, 2) DPA implementation approaches, and 3) factors (i.e., barriers and facilitators) that affect the implementation of DPA (analysis of implementation factors presented in Weatherson et al. [27]). Verbal consent was obtained from each participant to audio-record the interview and participants received a monetary reimbursement ($40) for their participation.

4.2.3.2 Physical Activity

Accelerometer data collection occurred from March to June 2016. KW visited the class on the first day of data collection to distribute the accelerometers and provide wear instructions to the children. Students were assigned a numbered accelerometer to wear for the entire school day for five consecutive school days (Monday to Friday). Students were instructed to wear the accelerometers around the waist with the unit placed on the right hip. For those students not randomly selected to participate, they were given a low-cost pedometer during the data collection period, with similar instructions. Students were reminded that the study was not a competition

and to participate in their typical activities at recess and lunch break. To increase wear compliance, children (participants and non-participants) were provided with a pedometer to keep if they wore their respective device for the data collection period. After day 1 of data collection, the teacher distributed the monitors each morning, ensured that all accelerometers were positioned correctly at the beginning of each day and after lunch break and collected the monitors at the end of each school day. Classroom teachers were reminded to teach as they would on any normal school day (i.e., keeping with their DPA implementation approach) and were provided with a timetable in which to record the times at which recess, lunch, and PE occurred, as well as when DPA was implemented (if applicable). On the last day of data collection, KW returned to the classroom at the end of the day to collect the accelerometers and reward participation prizes (pedometers).

4.2.4 Measures

4.2.4.1 Implementation Approach

Digital recordings were transcribed verbatim directly into NVivo qualitative data analysis software [28] by KW and two research assistants. Interview transcripts were checked for accuracy by the interviewer. Implementation approach was assessed by descriptively analyzing the responses teachers provided when asked “How do you implement the DPA policy in your classroom?” or “What is the most common strategy you use to implement the DPA policy?” Classroom timetables during accelerometer data collection were used to confirm that each teacher held to their reported implementation approach.

4.2.4.2 Objective Physical Activity

The ActiGraph wGT3X-BT accelerometer (ActiGraphTM, LCC, Fort Walton Beach, FL, USA) was used to measure children's movement at school. This ActiGraph model is a triaxial motion sensor that measures acceleration in three planes. The accelerometer measures an individual's acceleration (in "counts"), which is summed over a specified interval of time (an "epoch"). The ActiGraph wGT3X-BT accelerometer has been validated by indirect calorimetry in youth [29]. ActiLife software version 6.13.2 [30] (ActiGraph, Pensacola, Florida) was used to download raw acceleration data (Axis 1) into activity counts summed at 15-second epoch lengths, which were screened for spurious data. Non-wear time parameters included sixty minutes of continuous zeroes and counts occurring outside the predefined hours in the school day. A valid day was defined as a ratio of school time, with children required to wear the accelerometer for at least 80% of the school day [31]. Each student needed at least 2 valid wear days to be included in the analysis. Further details for accelerometer data processing and cleaning are available in Additional files 4.2 and 4.3, respectively.

Accelerometer data was analyzed using Evenson and colleagues [32] cut-points for children because they showed the best classification accuracy at all intensities and for all ages [33-35], and it has been recommended to use cut-points that have been validated using the epoch length used to establish them [36]. The main outcome variables, in minutes, calculated for each child participant included: 1) total SB, 2) total LPA, and 3) total, instructional and non-instructional MVPA. The classroom timetable was used to categorize 1) total school day (instructional and non-instructional), 2) non-instructional time (recess and lunch break), and 3) instructional time (total school day minus lunch and recess breaks). Outcome variables on days with PE were compared to days without PE (DPA days).

4.2.5 Statistical Analysis

Raw data were transferred to SPSS (Version 24) [37] for statistical analysis. Preliminary analyses were conducted to screen data for entry errors, missing data and to identify outliers. Durations (mean minutes) and proportion of time spent in SB, LPA and MVPA within each time period were calculated for each individual and proportions were compared between implementation approaches (i.e., prescriptive versus non-prescriptive). Descriptive statistics were calculated on all participant variables. Assumptions of normality were examined and managed according to recommendations by Field [38] and Tabacknick & Fidell [39]. Chi square and independent-sample t-tests were conducted to assess for differences in child sex and age between implementation groups. To examine differences in children's total SB, LPA and MVPA between implementation groups (hypotheses 2a-c), independent-sample t-tests were conducted. To examine differences in instructional and non-instructional MVPA between groups (hypothesis 3), Multivariate Analysis of Covariances (MANCOVAs) were conducted. To examine hypothesis 4, paired-sample t-tests were conducted to assess differences in MVPA by day (PE vs DPA day) within each implementation group. Finally, independent-sample t-tests were used to determine sex differences in instructional, non-instructional and total MVPA on PE and DPA days (hypothesis 5). Differences between estimates were considered statistically significant at $p<0.05$.

4.3 Results

4.3.1 Implementation Approaches

The descriptive analysis of interview data for DPA implementation delivery method resulted in two groups of teachers: 1) teachers who provided DPA opportunities during classroom instructional time and required all students to participate (herein referred to as

prescriptive group; n = 9), and 2) teachers who encouraged students to be active during non-instructional times (recess and lunch breaks) and therefore did not provide additional classroom time to engage in physical activity (herein referred to as non-prescriptive group; n = 3). These classification names and definitions of implementation approaches were derived from Mâsse, Naiman and Naylor [20]. These groups were confirmed through the classroom timetables provided by teachers during accelerometer data collection, with prescriptive teachers writing DPA down in their timetable.

4.3.2 Participant Demographics

Figure 4.1 shows flow of student participants from recruitment to analysis. At recruitment, 119 children (60 males, 59 females), aged 9 – 12 years (M_{age}=10.50, SD=0.97) provided consent and wore accelerometers for one week at school. In total, 114 students (56 females, 58 males) were included in the analyses. Participant demographics by implementation group are displayed in Table 4.1. A chi square test showed no significant difference in sex between implementation strategy group (p=.92). An independent-samples t-test showed a significant difference in mean age between groups, such that the non-prescriptive group was older (M_{age}=11.46, SD=0.58) than the prescriptive group (M_{age}=10.17, SD=0.84; t(96)= -7.25, p<.001). To account for this difference, Multivariate Analysis of Covariance (MANCOVA) was conducted with age as a covariate.

Figure 4.1. Student participant flow chart

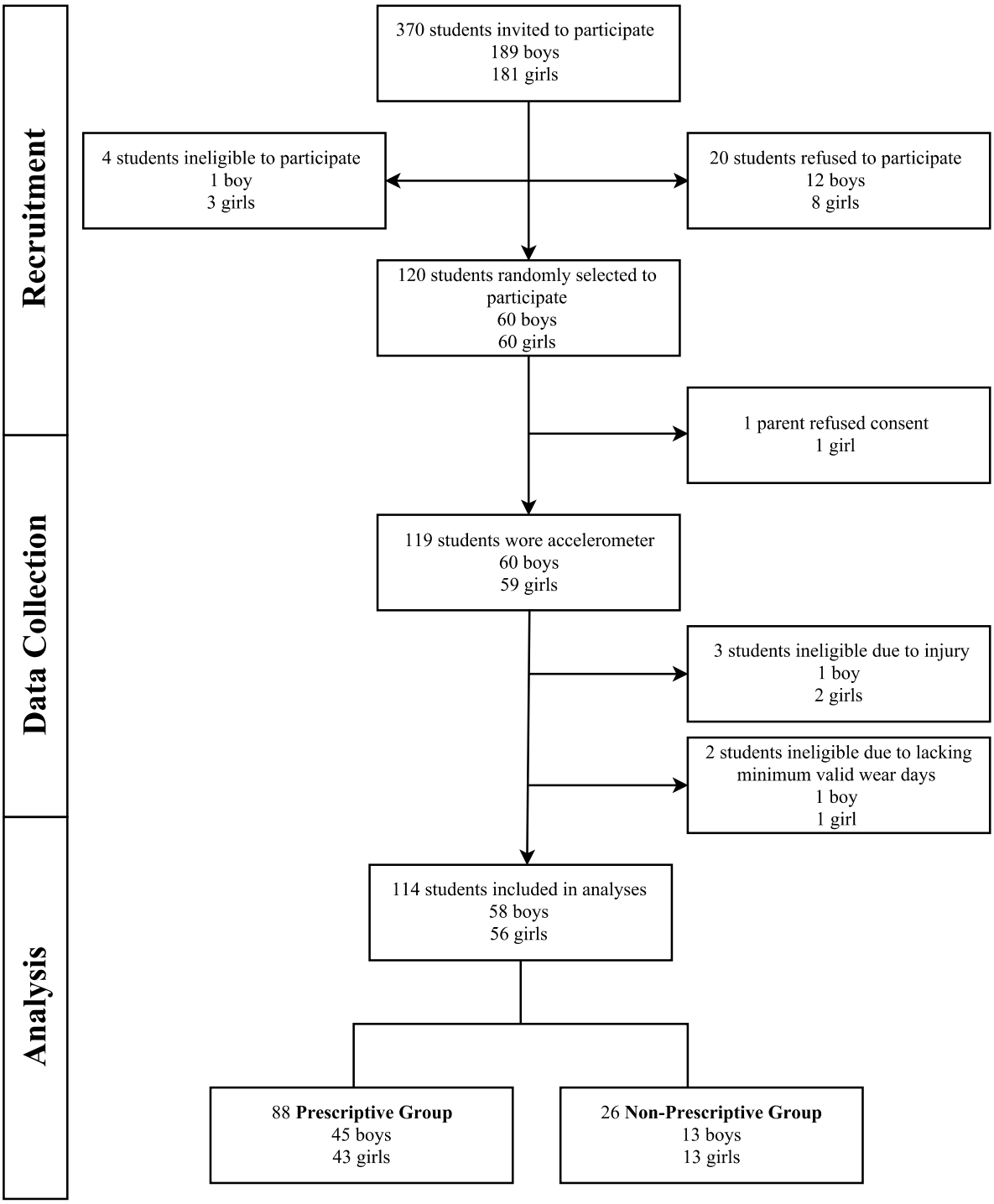

Table 4.1. Student demographics

	Prescriptive (*n* = 88)	**Non-prescriptive** (*n* = 26)	**Total** (*n* = 114)
Sex, %			
Female	48.9 (43)	50.0 (13)	49.1 (56)
Male	51.1 (45)	50.0 (13)	50.9 (58)
Age (yrs), %			
9	18.2 (16)	-	14.0 (16)
10	36.4 (32)	3.8 (1)	28.9 (33)
11	22.7 (20)	46.2 (12)	28.1 (32)
12	4.5 (4)	50.0 (13)	14.9 (17)
Grade, %			
4	15.9 (14)	-	12.3 (14)
4/5	22.7 (20)	-	17.5 (20)
5	38.6 (34)	-	29.8 (34)
5/6	22.7 (20)	34.6 (9)	25.4 (29)
6	-	65.4 (17)	14.9 (17)

4.3.3 Physical Activity

All school days were 360 minutes (from 8:30am to 2:30pm). Amount of non-instructional time (i.e., outdoor lunch and recess break) ranged from 40 to 51 minutes per day across schools (*M*=45.68, *SD*=3.49). An independent-samples t-test indicated that there was a significant difference in non-instructional minutes per day between groups, such that the prescriptive group received fewer minutes of recess/lunch break per day (*M*=44.72, *SD*=3.05) than the non-prescriptive group (*M*=48.92, *SD*=2.91); t(112)= -6.246, p < .001. To statistically control for this, all statistical tests compared percent proportion of school time spent in LPA, MVPA and SB (not mean minutes).

Table 4.2 displays the average minutes and percent proportions of SB, LPA and MVPA accumulated during the total, non-instructional, instructional school day on PE and DPA days across the total sample. In support of hypothesis 1, children did not meet the DPA guidelines of 30 minutes of MVPA on DPA days (~28 minutes MVPA). However, on PE days children

accumulated more MVPA (~33 minutes MVPA). Table 4.3 presents differences in mean minutes and percent proportions of total SB, LPA and MVPA by implementation group on PE and DPA days. In support of hypothesis 2, children in the prescriptive group accumulated less SB and more LPA and MVPA compared to those in the non-prescriptive group, according to percent proportions, irrespective of day. However, proportion of time in SB on DPA days was not significantly different. Notably, the prescriptive group spent a greater percent proportion of their DPA days in MVPA (M=4.4, SD=1.7) compared to the non-prescriptive group (M=2.9, SD=1.4); $t(98) = 3.72$, $p < .001$, $g = 0.90$. Similarly, the prescriptive group spent a greater proportion of their time in MVPA on PE days (M=5.9, SD= 1.9) compared to the non-prescriptive group (M=3.0, SD=1.6); $t(96) = 5.75$, $p < .001$, $g = 1.57$.

Table 4.2. Total sedentary time and physical activity on days with DPA, PE, and All Days combined

	DPA days (*n* = 100)		PE days (*n* = 98)		All days (*n* = 114)	
	Mean minutes (SD)	Proportion (SD)	Mean minutes (SD)	Proportion (SD)	Mean minutes (SD)	Proportion (SD)
Total time						
SB	219.13 (31.43)	50.3 (6.8)	210.53 (32.51)	48.6 (7.1)	215.36 (29.85)	49.5 (6.4)
LPA	108.95 (25.55)	22.5(6.0)	116.38 (25.23)	23.9 (5.9)	110.90 (23.86)	22.7 (5.5)
MVPA	27.54 (11.42)	4.1 (1.7)	32.94 (13.25)	5.4 (2.2)	29.40 (11.52)	4.6 (1.8)
Instructional time						
SB	205.11 (27.52)	65.2 (8.8)	198.36 (29.19)	63.1 (9.4)	202.16 (25.93)	64.3 (8.3)
LPA	90.08 (24.63)	28.7 (7.8)	95.41 (24.26)	30.3 (7.7)	90.74 (22.52)	28.9 (7.2)
MVPA	14.90 (6.54)	4.7 (2.1)	20.55 (8.27)	6.5 (2.6)	17.13 (6.75)	5.4 (2.1)
Non-instructional time						
SB	14.02 (7.73)	30.5 (16.5)	12.16 (6.72)	26.7 (14.8)	13.19 (6.72)	28.8 (14.5)
LPA	18.87 (5.38)	41.3 (10.8)	20.98 (6.23)	45.7 (11.3)	20.16 (5.12)	43.9 (9.4)
MVPA	12.63 (7.20)	28.0 (16.5)	12.40 (6.96)	27.6 (16.3)	12.28 (6.38)	27.2 (14.8)

DPA, Daily Physical Activity; PE, physical education; SB, sedentary behaviour; LPA, light physical activity; MVPA, moderate-to-vigorous physical activity

Note: Percent proportions do not add up to 100% because students did not always wear the device for the total 360 minutes per day and therefore did not have 100% valid minutes per day.

Table 4.3. Comparison of total SB, LPA and MVPA by implementation approach on DPA and PE days

Implementation approach group	Sedentary		Light		MVPA	
	Mean minutes (SD)	Proportion (SD)[1]	Mean minutes (SD)	Proportion (SD)	Mean minutes (SD)	Proportion (SD)
DPA days						
Prescriptive (*n* = 78)	216.23 (30.41)	49.9 (6.6)	112.21 (24.45)	23.5 (5.7)***	29.64 (11.15)	4.4 (1.7)****
Non-prescriptive (*n* = 22)	229.44 (33.54)	51.7 (7.4)	97.38 (26.54)	18.9 (5.7)***	20.08 (9.15)	2.9 (1.4)****
PE days						
Prescriptive (*n* = 82)	206.12 (29.04)	47.7 (6.4)*	118.18 (22.40)	24.7 (5.1)**	35.53 (12.40)	5.9 (1.9)***
Non-prescriptive (*n* = 16)	233.11 (40.40)	53.0 (8.9)*	107.17 (36.06)	19.7 (7.9) †**	19.67 (9.00)	3.0 (1.6)***

SB, sedentary behaviour; LPA, light physical activity, MVPA, moderate-to-vigorous physical activity; PE, physical education; DPA, Daily Physical Activity

Independent-sample t-tests used to determine significant proportional differences between groups with*$p<0.01$; **$p<0.05$; ***$p\leq0.001$; ****$p<0.0001$

[1]In this table, proportion means the percentage of the designated time spent in each outcome variable. For example, the prescriptive group spent 49.9% of their DPA days in SB, which resulted in a mean of 216 minutes.

† Adjusted for Brown-Forsythe unequal variance

Mean minutes and percent proportions of instructional, non-instructional and total day in MVPA by implementation approach group on DPA and PE days are displayed in Table 4.4. Table 4.4 also indicates whether either group fulfilled the DPA requirement of 30 minutes MVPA. While collectively the prescriptive group almost met the DPA policy requirements, four individual classes did not meet the requirement (individual class data not shown). None of the classes in the non-prescriptive group fulfilled the DPA policy requirements. To examine whether implementation approach had an effect on instructional and non-instructional MVPA on DPA and PE days (hypothesis 3), MANCOVAs were conducted (age adjusted means are presented in text, see Table 4.4 for raw unadjusted means). On DPA days, the prescriptive group spent a greater percent proportion in MVPA during instructional ($M_{adjusted}$=5.2, SE=0.2) and non-instructional ($M_{adjusted}$=31.1, SE=2.1) time than the non-prescriptive group ($M_{adjusted}$=2.9, SE=0.5 and $M_{adjusted}$=19.9, SE=4.0, respectively); $F(2, 82) = 8.53$, $p < .001$; Pillai's trace =.172, partial η^2 =.172. Likewise, on PE days, the prescriptive group had a greater percent proportion of time in MVPA during instructional ($M_{adjusted}$=7.1, SE=0.3) and non-instructional ($M_{adjusted}$=30.5, SE=2.0) time than the non-prescriptive group ($M_{adjusted}$=3.5, SE=0.7 and $M_{adjusted}$=16.1, SE=4.6, respectively); $F(2, 78) = 10.65$, $p < .001$; Pillai's trace = .214, partial $\eta^2 = .214$.

Table 4.4. Mean minutes and proportion of non-instructional, instructional and total MVPA by implementation approach on DPA and PE days

Implementation approach group	Non-instructional MVPA		Instructional MVPA		Total MVPA		Meeting DPA?	
	Mean minutes (SD)	Proportion (SD)[1]	Mean minutes (SD)	Proportion (SD)	Mean minutes (SD)	Proportion (SD)	Yes	No
DPA days								
Prescriptive (*n* = 78)	13.58 (7.46)	30.6 (17.1)*	16.06 (6.42)	5.1 (2.0)*	29.64 (11.15)	4.4 (1.7)**		✓
Non-prescriptive (*n* = 22)	9.27 (5.02)	19.0 (9.9)*	10.81 (5.30)	3.5 (1.7)*	20.08 (9.15)	2.9 (1.4)**		✓
PE days								
Prescriptive (*n* = 82)	13.13 (7.10)	29.7 (16.6)*	22.40 (7.28)	7.1 (2.3)*	35.53 (12.40)	5.9 (1.9)*	✓	
Non-prescriptive (*n* = 16)	8.61 (4.76)	16.9 (9.3)*	11.06 (6.42)	3.6 (2.1)*	19.67 (9.00)	3.0 (1.6)*		✓

MVPA, moderate-to-vigorous physical activity; PE, physical education; DPA, Daily Physical Activity

MANCOVAs and independent-sample t-tests used to determine significant proportional differences between groups with *p=.001, **p<.001

[1]In this table, proportion means the percentage of the designated time spent in MVPA. For example, the prescriptive group spent 30.6% of their non-instructional time (recess and lunch breaks) in MVPA, which resulted in a mean of 17.1 minutes on DPA days.

To test hypothesis 4, paired-samples t-tests were conducted to compare the percent total MVPA accumulated on PE days versus DPA days for each group. There was a significant difference in the prescriptive group scores for percent total MVPA on DPA days and PE days; $t(71) = 7.82$, $p<.001$, $d = 0.89$. However, there was no difference in percent total MVPA accumulated on DPA and PE days for the non-prescriptive group; $t(11) = -1.32$, $p=.213$. Finally, supplementary analyses indicated that there was a significant difference in MVPA by sex, such that female students accumulated less total, instructional and non-instructional MVPA compared to male students (see Table 4.5).

Table 4.5. Mean minutes and proportion of PE and DPA days in MVPA by sex

	N	Mean minutes (SD)	Difference Males vs Females (Mean Diff±95% CI)	Proportion (SD)
PE days				
Total MVPA				
Males	49	39.02 (13.21)	12.15 (7.41 to 16.89)***	0.06 (0.02)
Females	49	26.87 (10.24)		0.05 (0.02)
Instructional MVPA				
Males	49	23.82 (8.02)	6.56 (3.49 to 9.61)***	0.08 (0.03)
Females	49	17.27 (7.22)		0.05 (0.02)
Non-Instructional MVPA				
Males	49	15.20 (7.39)	5.61 (3.04 to 8.18)***	0.34 (0.18)
Females	49	9.59 (5.22)		0.21 (0.12)
DPA days				
Total MVPA				
Males	51	30.79 (12.12)	6.63 (2.29 to 10.97)**	0.05 (0.02)
Females	49	24.15 (9.65)		0.04 (0.01)
Instructional MVPA				
Males	51	16.61 (6.81)	3.49 (0.97 to 6.00)**	0.05 (0.02)
Females	49	13.12 (5.79)		0.04 (0.02)
Non-Instructional MVPA				
Males	51	14.17 (8.00)	3.14 (0.36 to 5.93)*	0.32 (0.18)
Females	49	11.03 (5.92)		0.24 (0.13)

MVPA, moderate-to-vigorous physical activity; PE, physical education; DPA, Daily Physical Activity

Independent-sample t-tests used to determine significant mean or proportional differences between males and females overall with *p≤.05; **p≤.01; ***p≤.001

4.4 Discussion

This study provides evidence to support that the ways in which provincially mandated school physical activity policies are implemented at a classroom-level have an impact on the effectiveness of the policy at reaching it's intended outcomes at the student-level. While it is not a guarantee that students will meet policy recommendations, teachers who provide additional opportunities for students to be active during instructional time (i.e., beyond non-instructional recess and lunch breaks) may help students to accumulate less sedentary behaviour, and more

light and moderate-to-vigorous physical activity. Overall, the prescriptive group was less sedentary and more active (LPA and MVPA) than the non-prescriptive group, irrespective of school day type (PE or DPA). Most importantly, children who were provided with DPA opportunities during instructional time were more active during this time and were not less active during non-instructional time, resulting in more total MVPA accumulated during the school day. Although this study did not measure physical activity during leisure time, other studies have shown that increased physical activity at school does not result in children spending less time in PA outside of school [40,41]. Continued efforts to increase children's physical activity during the instructional school day are warranted for improving total daily physical activity levels in youth.

Neither the total sample nor either implementation group met the DPA guidelines of 30 minutes of MVPA on DPA days. With only 27.4 minutes of the total school day spent in MVPA, these students are less physically active than other BC students. For example, Nettlefold and colleagues [42] measured PA in a group of 380 children (8-11 years) in another region of BC and found that male and female children spent 64 and 53 minutes of the school day, respectively, in MVPA. While it has been shown that children in BC are more active compared to the rest of the country [43], this study does not support these findings. However, the significant sex differences demonstrated in our study whereby males were more active than females, was consistent with past research [24].

Overall, the prescriptive group was more active on PE days compared to DPA days. The non-prescriptive group accumulated the same amount of MVPA irrespective of day. Mandatory daily physical education has shown to contribute more to youth's physical activity at school than other policy and built environment changes [44]. Future research should examine whether daily

PE or DPA is more effective at increasing children's daily-accumulated physical activity at school.

The prescriptive group children were significantly younger. Since children become less active as they get older [45], the prescriptive group being younger may account for some of the observed differences in MVPA. Another possible explanation for the lower PA level in the non-prescriptive group may be related to the factors that impede teachers' implementation of the DPA policy. In this study, the interviewed intermediate teachers believed that they experienced additional barriers to DPA implementation compared to primary teachers in their schools (data presented in Weatherson et al. [27]). While there is an established physical activity decline with age in youth [46,47], the DPA policy requirements for 30 minutes of MVPA during the school day are identical for children in grades kindergarten to 7. Therefore, the policy should be designed to account for these age differences. Policy makers may need to consider providing additional training and resources for teachers of older students to overcome factors affecting implementation and fulfillment of the policy in higher grades.

Weatherson and colleagues [27] identified that there is ambiguity in policy delivery guidelines such that teachers lack the knowledge on what constitutes appropriate delivery of the DPA policy. Teachers may be unaware of what activities during what time of the day counts towards fulfilling the requirements. As a result, some teachers believe that non-instructional breaks at recess and lunch provide sufficient time for students to achieve these guidelines (i.e., non-prescriptive implementers), while others provide additional opportunities during instructional time because they are not confident that children take advantage of these break times (i.e., prescriptive implementers). The teachers in this study were broadly dichotomized into two groups based on provision of DPA opportunities during instructional time. Future research is

needed to better understand how DPA delivery effects group differences in children's physical activity outcomes. One method that may help to further explain class differences is to identify the behaviour change techniques (BCTs) [48], or active components, employed by teachers in DPA delivery. For example, prescriptive implementers scheduled DPA into their timetables (goal setting and action planning BCTs) compared to non-prescriptive implementers. Understanding BCT delivery might aid in DPA policy development. Future research should also focus on the long-term impact of school-based PA policies on childhood overweight and obesity [21].

4.4.1 Strengths and Limitations

The major strength of this study was the mixed methods design which simultaneously measured and linked PA outcomes to policy implementation approach. However, there are limitations that should be considered alongside the findings from this study. Specifically, a lack of baseline data (as a result of no formal monitoring system prior to implementation) made it difficult to isolate and measure the effectiveness of the DPA policy. The findings of this study are prospective but not causal, thus we cannot say that DPA implementation caused one group to have higher PA levels as compared to the other group. Instead, we measured the difference in PA outcomes and compared across two types of DPA implementation approaches. An important limitation of natural experiments is that there are numerous uncontrollable variables that may contribute to the observed differences between implementation groups. Similarly, it was difficult to recruit teachers who took a non-prescriptive approach (i.e., did not implement DPA during instructional time), which resulted in unequal group sizes and ages. To account for this limitation, we used adjusted t-tests and controlled for age where appropriate.

Techniques used for accelerometer data handling are not standardized and directly influence the estimated duration of time spent in PA intensities. For example, there is a lack of consensus in wear time and non-wear time validations parameters for a valid day. Discrepancies in reporting may result in potential inclusion/exclusion of non-valid accelerometer data. For this reason, the researchers aimed to be transparent in all decisions regarding data handling techniques and parameters. A strength of this study relating to accelerometer data handling is that we summed raw accelerometer data at 15-seconds to coincide with Evenson's cut-points [32] that were established and validated using these shorter epoch lengths, thus not having to modify cut-points.

The implementation of school-based physical activity policies, which govern the amount of physical activity children obtain while at school, is recommended as a public health strategy to support the development of physical activity behaviours in school-aged children. This study aimed to measure the impact that teacher DPA policy implementation approach has on children's light and moderate-to-vigorous physical activity and sedentary behaviour while at school. The results revealed that teachers who provided opportunities for students to be active during the instructional school day enabled students to accumulate more MVPA than those who were not given these opportunities. However, a prescriptive implementation approach did not guarantee that students met policy recommendations. These findings demonstrate that heterogeneity in policy implementation can create variations in policy effectiveness. How policies are implemented at a local level impacts the effectiveness of the policy and this may help to explain why Canadian children are consistently amongst the least active children around the globe despite Canada's favourable investment in physical activity policies and programming [49]. Measures should be taken to assist teachers in the implementation of school-based physical

activity policies. For example, interventions aimed at targeting teacher-reported barriers to DPA policy implementation may prove to be effective.

List of abbreviations

DPA: Daily Physical Activity

BC: British Columbia

PE: Physical education

MVPA: Moderate-to-vigorous physical activity

LPA: Light physical activity

SB: Sedentary behaviour

MANCOVA: Multivariate Analysis of Covariance

BCT: Behaviour change techniques

Declarations

Ethics approval and consent to participate

This research was performed in accordance with the Declaration of Helsinki and ethical approval was obtained from the Canadian University's Behavioural Research Ethics Board for research involving humans (# H15-01069), and the respective school district. All participants provided written informed consent.

Consent for publication

Not applicable

Availability of data and material

All data generated or analyzed during this study are included in this published article (and its supplementary information files).

Additional files

Additional file 4.1: STROBE checklist. Completed STROBE checklist indicating page number in manuscript of relevant content for observational studies.

Additional file 4.2: Accelerometer data processing parameters. Additional details on accelerometer data processing parameters, including rationale.

Additional file 4.3: Accelerometer data cleaning results. Additional detail on accelerometer data cleaning, including spurious data, valid wear days, data transformation and normality testing.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

KW conceptualized the study, and MJ provided intellectual input into the methodological design. KW collected and analyzed the data and drafted the manuscript. All authors reviewed and approved the final manuscript.

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Endnotes

[a] Over the course of the planning for and data collection of this study, the BC Ministry of Education revised the DPA policy statement multiple times. As such, there is no longer any division between PE and non-PE days. The DPA requirements of 30 minutes of physical activity are now required irrespective of school days with or without PE. We retained this separation for our analysis to explore whether days with PE are more effective at helping students achieve the guidelines.

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4.6 Additional files for Study 3

Additional file 4.1. STROBE checklist

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1,2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2,3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4,5
Objectives	3	State specific objectives, including any prespecified hypotheses	5,6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7-9
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	9-10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	9-11
Bias	9	Describe any efforts to address potential sources of bias	6-7
Study size	10	Explain how the study size was arrived at	7 (Maximum variation sampling)
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	10-11; Additional file 2 and 3
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	10-11; Additional file 2 and 3
		(*b*) Describe any methods used to examine subgroups and interactions	10-11 (sex)
		(*c*) Explain how missing data were addressed	9-10
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	N/A

Additional file 4.1. STROBE checklist

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	11-12; Figure 1
		(b) Give reasons for non-participation at each stage	Figure 1
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	11; Table 1
		(b) Indicate number of participants with missing data for each variable of interest	11
Outcome data	15*	Report numbers of outcome events or summary measures	12-15; Tables 2-5
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Tables 2-5 are all unadjusted. Age was a covariate in tests pg 14
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Table 5
Discussion			
Key results	18	Summarise key results with reference to study objectives	15-16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	17-18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16-17
Generalisability	21	Discuss the generalisability (external validity) of the study results	15-18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	20

Additional file 4.2. Accelerometer data processing parameters

Axis 1 of each 15-second epoch file was visually screened for spurious data points (extremely high values) and patterns (extended periods of the same count value). If a single 15-second count exceeded 3000 counts, the participant's data was flagged and KW visually inspected the activity graph for that individual to decide if the counts appeared to be unusual. Although there are no established maximum count values for children, the maximum count value was set at >3000 counts as a conservative estimate based on Esliger and colleagues [1] standardized upper limit cut value of >15,000/minute, which was used for free-living physical activity monitoring in adults. This method however was used only as a means to flag any potential erroneous/spurious data for further examination, as it has been shown that spurious data classification is epoch-dependent [2]. Due to the intermittent burst-like nature of their movement, children are even more likely to exceed this maximum count value during 15-second epochs. If a participants' data was flagged, KW visually inspected the participant's graph to decide if the count was unusual (compared to the child's PA over the 5 days, daily graphs and teacher timetable).

The ActiLife wear time validation program was used to determine valid wear time, using customizable settings. A *minimum length* of sixty minutes of continuous zeroes (*activity threshold*) was considered non-wear time and not included in analysis for total time worn. To detect wear/non wear times, only Axis 1 was used (not vector magnitude). *Spike tolerance* was set at 2 minutes [3] and the *spike level to stop* was set at 100 counts per minute. A valid day was defined as a ratio of school time, such that children wearing the accelerometer for at least 80% of the school day were considered valid for analysis (e.g., 288 minutes of wear time per 360 minute

school day). This method of using 80% of a monitoring day has been used in other studies [4]. Any accelerometer data occurring outside the predefined valid hours in the school day (i.e., 8:30am – 2:30pm) were not included in the analyses. Likewise, any days in which a child was not at school, as confirmed by student physical activity logs and teacher attendance lists, were not included in the analyses. To be included, the student must have had at least 2 valid wear days of the 5 total wear days. While three days is the most often reported number of minimum wear days in other children studies [5], these parameters are for a 7-day wear period. Additionally, two days were chosen as the minimum number of acceptable wear days because the DPA requirements specify activity on days with no PE, and some classrooms only had two days during the week when this occurred.

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Additional file 4.3. Accelerometer data cleaning results

After visual inspection, sixteen 15-second epoch counts (4 minutes total from MVPA) were excluded from the analyses, due to abnormal spikes from participants taking the device off. The overall total number of valid wear days ranged from 2 to 5 days (*M*=4.56, *SD*=0.78). The total number of valid DPA days (excluding field trip days) ranged from 0 to 4 days (*M*=2.35, *SD*=0.91) and the total number of valid PE days (excluding field trip days) ranged from 0 to 4 days (*M*=1.77, *SD*=0.95). Raw data was transformed into composite scores (mean minutes and mean proportion) for non-instructional, instructional and total SB, LPA, and MVPA on PE days, DPA days and all days combined. For all variables, there were no z-scores ±3.29, indicating no outliers. Tests of normality (skewness, kurtosis) and homogeneity of variances were examined for each outcome variable within each group. Kolmogorov-Smirnov indicated significant differences for % instructional MVPA on DPA days and % total MVPA on DPA days within the prescriptive group (*p*'s<.05). For the non-prescriptive group, Shapiro-Wilk was significant for % non-instructional MVPA on PE says (*p*=.001), % total SB on DPA days (*p*=.014) and PE days (*p*=.003) and % total LPA on PE days (*p*=.003). Levene's test of equal variance showed a significant difference for % non-instructional MVPA on DPA and PE days (*p*=.005 and *p*=.021, respectively) and for % total LPA on PE days (*p*=.048). In cases of unequal variance, adjusted p-values using Brown-Forsythe correction were reported. Variables were not transformed, as robust procedures were used to overcome violations in equal variances [1]. Furthermore, in all cases, the variance was larger in the prescriptive group and therefore the probability values are conservative and significant findings can be trusted [2].

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Chapter 5: General Conclusion

Like many other school-based health policies (Williams et al., 2013), there has been little research examining the implementation and effectiveness of the Daily Physical Activity policy in British Columbia (BC; Olstad et al., 2015). Policy evaluation is fundamental to understanding how a policy translates into practice. Implementation evaluation examines the progress and process of delivery, whereas outcome evaluation measures the ultimate outcomes of implementation. When measured together, evaluation can generate evidence on how and why a policy was or was not successful. This thesis research represents an evaluation of the implementation and effectiveness of the DPA policy in one BC school district. First, a scoping review was conducted to broaden our understanding of the current DPA policy literature Canada-wide and inform the design of Studies 2 and 3. Study 2 examined the barriers and facilitators affecting teacher's implementation of the DPA policy during the instructional school day. Finally, Study 3 compared the children's physical activity and sedentary levels when teacher implementation consisted of provision of DPA opportunities during instructional and non-instructional time combined versus only non-instructional time. This general conclusion of the thesis provides a brief summary of findings from all three studies, integrates the results in an overall discussion, presents the strengths, limitations and challenges associated with conducting this thesis research, highlights the potential impacts on policy, practice and future research, and concludes with a brief review of the research quality.

5.1 Study 1

Study 1 was a mixed-methods scoping review summarizing the implementation and effectiveness of the DPA policy across Canadian elementary schools in Alberta, British Columbia and Ontario. This included examination of: i) the implementation status of DPA in

Canada, ii) the implementation approaches used to deliver the DPA policy during the school day, iii) the barriers and facilitators to DPA policy implementation, and iv) the effectiveness of DPA policy implementation at increasing the physical activity of children at school. The Theoretical Domains Framework (TDF) was used to categorize the implementation barriers and facilitators.

With the limited research examining the DPA policy in Canada, the current status and approaches used to implement DPA and the student-level effectiveness is not well understood; however, the review revealed that DPA deliverers (i.e., teachers, principals, and administration) often report many barriers to DPA implementation. Overall, most of the barriers relate to the TDF domains of *Environmental context and resources* (i.e., lack of training, time and resources), *Beliefs about consequences* (i.e., burden on teacher, classroom influences) and *Social influences* (i.e., lack of student/parent interest). Understanding these barriers from a theoretical perspective is key to creating solutions to overcoming them in the future. The review added this theoretical analysis to the existing literature and is relevant to other studies examining the implementation of school-based interventions and polices that commonly report similar barriers and facilitators to uptake. Additionally, this analysis provided contextual results by which to compare the findings of Study 2.

5.2 Study 2

Study 2 built on Study 1 by examining the barriers and facilitators to DPA implementation in one BC school district using the Theoretical Domains Framework. In this study, elementary teachers most often discussed factors within the *Environmental Context and Resources*, *Beliefs about consequences*, *Social influences, Knowledge,* and *Intentions* domains. These domains are representative of all sources of behaviour in the COM-B model (Michie, Atkins, & West, 2014). Therefore, in intervention design targeting school-based DPA, selecting

a theory that broadly encompasses all of the aforementioned determinants of behaviour may be more successful at promoting behavior change. The first three domains of this study are comparable to the findings from Study 1. Together, these findings suggest that a teacher's provision of DPA is highly influenced by the broader physical and social environment, and their beliefs about the consequences of implementation.

Study 2 also examined and compared barriers and facilitators according to if and how the teacher implemented the DPA policy during the instructional school day. Teachers who implemented DPA during instructional time differed from those who relied on non-instructional time in relation to *Goals*, *Behavioural regulation*, *Social/professional role and identity*, and *Beliefs about Consequences*. These variations should also be considered for intervention design and delivery in specific contexts.

5.3 Study 3

The third and final study of the thesis compared the impact of two DPA implementation approaches on student's physical activity and sedentary behaviours at school. As measured by accelerometers, teachers who provided opportunities for students to be active during instructional time (i.e., prescriptive group) had students who accumulated more physical activity (LPA and MVPA) and less sedentary time at school compared to those who only received opportunities during non-instructional time (i.e., non-prescriptive group). While the prescriptive group was more active overall, neither group met the DPA guidelines of 30-minutes of MVPA during school time. Overall, students were more active on PE days compared to non-PE days. These findings demonstrate that heterogeneity in policy implementation creates variations in policy effectiveness and the student sample in this study participates in low levels of physical activity at school compared to other BC students.

5.4 Integration of Findings

Often in multi-methods studies, the results are segregated in different publications (Stange, Crabtree, & Miller, 2006). Unfortunately, lack of integration precludes the research from capitalizing on the strengths of both methodologies (Albright et al., 2013). In Study 3, data integration occurred by connecting the analysis of teacher's implementation approach in phase 1 to inform the collection of accelerometer data in phase 2. In this section, qualitative and quantitative results are broadly discussed together to merge the data.

The purpose of using mixed methods to concurrently measure implementation and effectiveness was to better understand *why* and *how* the DPA policy succeeded or failed at achieving its intended outcomes. On non-PE days, the children in this study did not achieve the DPA guidelines of 30 minutes of MVPA. However, children with teachers who used a prescriptive approach to DPA were provided with additional opportunities to be active during instructional time and were more active and less sedentary at school compared to children with teachers who used a non-prescriptive approach to DPA and hence not given these opportunities. Using prescriptive implementation approaches appear to be more effective. This research encourages teachers to provide PA opportunities during instructional time.

It may seem intuitive that more opportunities for physical activity during instructional time equates to more PA overall. As mentioned above, there were similarities in the most discussed barriers and facilitators by TDF domain in Study 1 and 2. However, there were important distinctions in perceived barriers and facilitators depending on the teacher's implementation approach (i.e., whether or not the teacher provided DPA opportunities during instructional time). Similar barriers and facilitators were noted by both teacher groups with regards to *Skills* (e.g., DPA-specific training, previous training/experience), *Knowledge* (e.g.,

lack of knowledge about DPA requirements), *Environmental context and resources* (e.g., poor, inappropriate or lack of DPA-specific training; lack of time due to curricular demands and schedule interruptions; weather and space constraints), *Reinforcement* (e.g., lack of monitoring), *Social influences* (e.g., school-level priorities, support from other teachers, student participation), and *Optimism* (e.g., mixed feelings about success of policy).

Although it may seem that targeting barriers to DPA implementation may provide an effective means to improve implementation, an important distinction may be the factors that assist the prescriptive teachers in providing more PA opportunities during instructional time. While there are added challenges to the provision of PA opportunities during instructional time (as opposed to relying on non-instructional time for children to be active), the prescriptive teachers were able to overcome these challenges. Prescriptive teachers discussed facilitators with regards to *Goals* and *Behavioural regulation* (e.g., planning for and scheduling DPA in timetable; providing schedule to students), *Social/professional role and identity* (e.g., strong personal PA identity and belief in responsibility to get children active at school), experience of the *Consequences* (e.g., linking PA to improvements in attention and focus for a better classroom learning environment) and *Social influences* (e.g., recognizing and responding to children's verbal and non-verbal cues to move throughout the day). Specifically, scheduling DPA into their timetable created a reinforcing cycle whereby it became easier to deliver DPA over time. Firstly, scheduling demonstrates the prescriptive teacher's motivation and intention to provide DPA. When DPA was repeatedly offered to students, the students became familiar with the routine and expected it each day. In turn, students would remind the teacher about DPA if the teacher forgot. Establishing a routine also helped the teacher recognize and link DPA provision to improvements in student behaviour and learning.

If a policy is worth being mandated, then it is worth having the mechanisms in place to facilitate the fulfillment of the policy. Mandatory scheduling may be necessary. For example, DPA could be included in the curriculum, requiring a certain number of teaching minutes per day. Alternatively, it may be a better option to mandate daily physical education (PE). Students in this study were more active on PE days compared to non-PE days. To my knowledge, Manitoba is the only Canadian province that has mandated daily PE, specifying 150 minutes in a 6-day cycle (25 minutes per day; Manitoba Government, 2016). Research suggests that daily physical education policies positively impact children's PA (Lagarde, & Leblanc, 2010); however, Hobin and colleagues (2014) found that Manitoba's PE policy did not prevent the grade-related decline in adolescents physical activity levels.

5.5 Limitations

As with any study, the current research is not without limitation or caveat. While each manuscript addressed limitations and strengths of its respective study, this section addresses limitations and strengths to the overall research.

5.5.1 Observational Design

Study 2 and 3 in this thesis were observational and involved the observation of teachers and students in their natural school setting. Observational studies are useful to evaluate the applicability of policy in real-world settings. In particular, a number of important policy issues including implementation barriers and facilitators could not be answered without observational research methods. However, in Study 3, use of observational methods limits the interpretation of findings to relationships. Future efforts could build on current research by manipulating

implementation approach to examine whether changing DPA implementation approaches could instigate subsequent short- and long-term changes in children's PA.

5.5.2 Individual- and School-Level Confounding Factors

Relatedly, a primary challenge of observational designs is the issue of confounding. Study 2 compared the relationship between teacher DPA implementation approach and children's PA and sedentary behaviour. For feasibility reasons, other student- (e.g., gender, weight status, participation in team sports, parent support) and school-level (e.g., school area socioeconomic status, use of PA as a reward versus a punishment, established community partnerships) factors shown to influence children's PA levels were not measured (Biddle, Atkin, Cavill, & Foster, 2011; Leatherdale, Manske, Faulkner, Arbour, & Bredin, 2010). Similarly, multi-level modeling was not used to examine the relationship between variables within and across multiple schools, which would have adjusted for these potential confounders (Heck, Thomas, & Tabata, 2014). Therefore, it is not possible to definitively conclude whether outcome effects are a result of the implementation approach, because of these other significant variables, or a combination of these factors (Tjomsland et al., 2015). It is important for readers and future researchers to consider if alternative explanations for the study results exist.

5.5.3 Generalizability

The main strategy that drove sampling for Study 2 and 3 included purposeful (maximum variation) sampling of elementary school teachers in one BC school district. While random sampling was used to choose student participants, it is possible that each school district has their own implementation processes; therefore, the findings are specific to this district and are not generalizable across the province. Furthermore, DPA implementation approaches by teachers

may not reflect all approaches used within the district. Statistical generalizations cannot be made; however, given the replication in TDF domains across Studies 1 and 2, the findings and conclusions (i.e., policy intervention suggestions) from Study 2 may be transferable to similar contexts or settings.

5.6 Strengths

5.6.1 Mixed Methods

One of the strengths of this research was the complementary use of mixed methods. Mixed methods research approaches allow researchers to investigate complex problems, such as those in policy evaluation. For this thesis, both qualitative and quantitative methods were needed to address each phase's research questions and ensure methodological congruence between all elements of the research design (Richards & Morse, 2013). A mixed methods approach allowed for the examination of the DPA policy process in greater depth and breadth, while reducing the bias inherent in one methodological paradigm.

5.6.2 Concurrent Measurement of Implementation and Effectiveness

Implementation must be tied to outcome evaluation in order to determine why and how policy outcomes were or were not achieved (DeGroff & Cargo, 2009; Saunders et al., 2005). In this thesis, Study 2 identified the implementation barriers and facilitators to provide context for why different DPA implementation approaches succeed or fail at meeting PA outcomes in Study 3. Study 3 is novel in that it is the first study to examine the student-level effectiveness of the DPA policy in BC.

5.6.3 Use of Theory

Finally, another strength of this research was the use of a theoretical framework to categorize barriers and facilitators to DPA policy implementation in Study 2. The majority of DPA policy research conducted prior to this thesis did not include theory (see Study 1). The Theoretical Domains Framework was useful in the evaluation of DPA policy implementation because it incorporates constructs from 33 theories, which single theories may omit. Use of the TDF allowed for broad identification of the factors influencing policy implementation and provision of theoretical suggestions on intervention design to target these factors in the future.

5.7 Challenges

There were many challenges that arose during the research process. *First*, elementary schools in BC have the autonomy to choose how they deliver the DPA policy guidelines. Unfortunately, a flexible delivery model means that the implementation approaches may vary considerably across districts and schools. These differences are challenging for researchers because the evaluation design and specific measures must be closely related to the policy implementation strategy (McGraw et al., 2000). To overcome such variability in how the DPA policy was enacted, the teacher sample was broadly categorized into one of two implementation approaches (see Study 3).

Second, differences in policy implementation also create variations in policy effectiveness (Taylor et al., 2010) and there were challenges associated with measuring these variations during evaluation. Specifically, no provincial monitoring procedures were established with policy development to evaluate the adoption, implementation or effectiveness of the DPA policy in BC. As a result, there were no established markers of success and no baseline data, which made it difficult to isolate and measure the effectiveness of the policy (Ramanathan et al.,

2008; Rychetnik, Frommer, Hawe, & Shiell, 2002). To overcome this challenge, we classified success as 30 minutes of MVPA and used a cross-sectional design to compare the effect of two implementation approaches on children's physical activity and sedentary behaviours (see Study 3).

Third, policies are evolving processes that fluctuate over time and evaluation efforts must continue to adapt to these changes (DeGroff & Cargo, 2009). Over the course of planning for and data collection of this study, the BC Ministry of Education revised the DPA policy statement multiple times. For example, at the beginning of this research, the DPA requirements of 30 minutes of PA were mandated on days without physical education (PE). At the time of analysis and writing, these specifications were required irrespective of school days with or without PE. In Study 3, we retained this separation for our analysis to explore whether days with PE are more effective at helping students achieve the guidelines. Most recently, the DPA policy is now included in the learning standards of the Physical and Health Education curriculum (BCED, 2016a).

As suggested by Taylor, McKenna, and Butler (2010), a mixed methods approach was used to minimize some of the inherent challenges associated with policy evaluation and to capture the complexity of policy processes and outcomes. These challenges highlight the current state of policy research and further press the need for more research in the area.

5.8 Policy, Practice and Research Implications

The findings from this research have several implications for policy, practice, and research. In the area of policy, it is recommended that provinces require school districts to report on adherence to provincial regulations governing physical activity policies. According to a review conducted by Olstad and colleagues (2015), there are varying degrees of strength and

comprehensiveness regarding DPA policies in Canada. Specifically, the DPA policy for elementary schools in BC received a weak rating due to being ambiguous and allowing local districts choice over implementation procedures. A flexible delivery model can hinder policy implementation and effectiveness. It may be necessary for schools and districts to report implementation compliance to improve adherence. The current practice of reporting is limited to a checkbox on student report cards, but this does not detail whether or not the teacher provided DPA opportunities. To properly track and monitor individual schools and school districts, provincial ministries may need to thoroughly specify policy requirements and establish a database on reporting requirements.

The purpose of the DPA policy is to help students in grades kindergarten to grade 7 achieve 30 minutes of PA during the school day, contributing to half of the daily 60 minutes recommended in national PA requirements (BCED, 2016b). In order to meet this goal, schools and teachers must provide opportunities for students to be active during the instructional and non-instructional school day. Unfortunately, teachers experience barriers to this goal. Given the emphasis on barriers related to the *Environmental context and resources*, *Beliefs about consequences*, and *Social influences*, it is recommended that provinces/districts provide and fund mandatory and ongoing teacher training, education, and resources for DPA policy implementation. These provisions may assist with the lack of knowledge and confidence reported by teachers in DPA delivery. It may also be necessary for policy makers to provide additional resources for intermediate elementary teachers to counteract the increasing experience of implementation barriers as student's PA declines with age.

This thesis represents one of few studies that have examined DPA policy implementation and is the first to examine the effectiveness of the DPA policy in BC. Future research is needed

to determine how policy implementation and impact differ across other school districts in BC. Relatedly, a longitudinal examination of children's PA at school would help researchers understand the long-term impact of the DPA policy. In Study 3, moderate-to-vigorous PA was chosen as the marker of DPA policy success. However, neither implementation group met the 30-minute requirement. Future research could examine the impact of the DPA policy on other important outcomes, including behavioural (i.e., attention, focus) and academic (i.e., learning) outcomes. Finally, researchers may consider developing interventions that target identified barriers and facilitators or manipulating the teacher's implementation approach to measure the impact of these changes on student's PA at school.

5.9 Research Quality

Qualitative components of phase 1 were presented in Study 2 (implementation barriers and facilitators) and Study 3 (implementation approaches), and quantitative components from phase 2 were presented in Study 3 (accelerometer data). According to Creswell and Plano Clark (2007), there are no set criteria for judging the quality of mixed methods research. Some researchers have indicated that validation strategies should apply a separate set of criteria to judge the quality of the individual quantitative and qualitative components (O'Cathain, 2010). For example, quantitative components are to be assessed on rigour (validity and reliability), whereas qualitative components should be assessed on trustworthiness (credibility, transferability, dependability, confirmability; Giddings & Grant, 2009). Others have suggested that mixed methods validation strategies should be driven by what component is given priority in the research (Bryman, 2006; Giddings & Grant, 2009). However, as stated in the introduction, the overall thesis research involved multi, mixed methods whereby both qualitative and quantitative components were essential to answering the research questions and therefore given

equal priority. There have been multiple attempts to conceptualize the quality assessment of mixed methods research, each with different criteria and terminology. O'Cathain (2010) created a quality framework for mixed methods research across different stages of research that synthesize elements from over a dozen conceptualizations. This section will highlight specific items from O'Cathain's framework that strengthened the quality domains at each stage of the overall study, including: planning quality, design quality, data quality, interpretive rigor, inference transferability, and reporting quality.

5.9.1 Planning quality

Items within the planning quality domain include foundational element, rationale transparency, planning transparency and feasibility. Foundational element refers to the comprehensive review of the literature to situate the study (inform research question and methods). This item was achieved in Study 1, whereby a scoping review of DPA policy literature was conducted prior to the development and design of Studies 2 and 3. Simultaneously, Study 1 represents a form of bracketing knowledge gained from the literature by overtly writing it down so that you can compare and contrast your data with previous knowledge (Richards & Morse, 2013). The second and third items in planning quality are rationale and planning transparency. These items require justification for use of mixed methods and details about overall design. This information was reported in the general introduction of the thesis (see section 1.7). Finally, all components of the study were feasibly completed within the resources available (time, money, womanpower).

5.9.2 Design quality

There are four items within the design quality domain: design transparency, suitability, strength and rigor (see definitions in O'Cathain, 2010). Each item was addressed in the general introduction (see section 1.7) and the introduction sections of Studies 2 and 3 (see section 3.1 and 4.1). Overall, a mixed methods approach was best suited to answer the research questions and there was consistency of all research aspects of the study (i.e., methodological congruence). One specific design strength was triangulation, or obtaining data from several sources (i.e., questionnaire, interview, teacher timetable) to confirm teacher DPA implementation approach.

5.9.3 Data quality

Items within the data quality domain include data transparency, data rigor/design fidelity, sampling adequacy, analytic adequacy, and analytic integration rigor. To satisfy data transparency and rigor/design fidelity requirements, each of the methods must be described in sufficient detail and implemented with rigor (see sections 1.7, 3.2, and 4.2). Sampling techniques and sample size for each method differed based on qualitative and quantitative phase of the research. Data analysis techniques were reported in detail for each study. For example, in Study 2, the Theoretical Domains Framework was used to establish the interview guide, a TDF expert was sought to refine the questions and the interview was piloted with two elementary school teachers to ensure the questions would obtain reliable responses. In addition, two researchers conducted barrier and facilitator extraction and coding, with coding reliability being assessed statistically. Finally, a detailed coding manual was established (see Additional file 2 in Study 2) and an expert coder was sought for difficult coding decisions. In Study 3, analytic integration

occurred by classifying the teacher's classroom based on DPA implementation approach so that differences in PA and sedentary time could be compared between students.

5.9.4 Interpreting rigor and inference transferability

Items within the interpreting rigor domain relate to if conclusions are based on the findings (see items in O'Cathain, 2010). In this thesis, the implementation findings regarding barriers/facilitators and delivery approaches emerged from the interview data. The PA and sedentary behaviour findings came from the accelerometer data. Overall, interpretations were consistent with current DPA literature (see sections 2.3, 2.4, 3.3, 3.4, 4.3, and 4.4) and it is likely that other researchers would reach the same conclusions. The inference transferability domain refers to where conclusions can be applied. While the findings from this thesis are not transferable to populations, they may be transferable to other similar contexts and settings (ecological transferability). Study 3 and the general conclusion integrate the findings and show how they relate to the current DPA policy literature. Policy, practice and research implications are discussed in section 5.8).

5.9.5 Reporting quality

Finally, items within the reporting quality domain include report availability, reporting transparency and yield. Given the submission of all three studies, reporting of all key aspects of the research are included in the thesis and the research was successfully completed within allocated resources. Together, the findings from all three studies complement one another to enhance breadth and depth of understanding to the research questions.

5.10 Conclusion

This manuscript-style thesis comprised three studies exploring the implementation and effectiveness of a school-based Daily Physical Activity (DPA) policy in elementary schools. The premise behind this research was that the success of school-based policies is dependent on their implementation and there are numerous individual, environmental and social-cultural factors that influence how policies are implemented at a school- and classroom-level. Consequently, it is important to understand the barriers and facilitators to the implementation of the DPA policy by teachers, which can help explain how their approach impacts students' physical activity levels.

Summarizing past DPA policy literature across Canada in *Study 1* provided the context by which to examine the implementation and effectiveness of the DPA policy in BC. *Study 2* and *3* built upon previous literature by exploring the implementation process of BC's DPA policy by teachers and represents the first investigation as to the impact of the policy on students' physical activity levels at school. Collectively, results from this thesis research provided evidence suggesting that current implementation approaches differ by teacher yet do not help students achieve adequate physical activity levels at school. Based on this research, evidence-based intervention strategies can be employed to modify barriers and enhance facilitators associated with DPA policy implementation and improve the effectiveness of this policy. Future interventions targeting the theoretically relevant barriers are suggested as possible next steps to enhance the implementation and effectiveness of the DPA policy in BC.

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Appendices
Appendix A: Principal Information Letter

Principal Information Letter
Daily Physical Activity Policy Study

Principal Investigator:
Mary E. Jung, Ph.D.
School of Health and Exercise Sciences
University of British Columbia
Contact Number: (250) 807-9670
mary.jung@ubc.ca

Research Assistant:
Katie Weatherson, BHK
School of Health and Exercise Sciences
University of British Columbia
Contact Number: (250) 807-8419
kate.weatherson@gmail.com

Dear [Name of Principal],

My name is Katie Weatherson and I'm a graduate research assistant at the University of British Columbia, Okanagan campus. I am currently conducting a study that aims to understand how elementary school teachers implement the Daily Physical Activity policy in their classrooms and to measure the effects that these strategies have on the physical activity levels of children at school. The research is designed to provide feedback to teachers and schools on how to improve implementation practices and to policy makers on how to improve policy recommendations. The reason for my writing is to obtain your permission to invite Grade 4, 5 and 6 teachers within your elementary school to participate in the study. The study will consist of a short questionnaire and potentially one interview, where they will be asked to discuss the strategies they use to deliver DPA, and their perceptions of the factors influencing DPA implementation in their classrooms (these will occur between November 2015 and February 2016). The survey will take 5 minutes to complete and the interview will take about 45-60 minutes to complete and will occur during non-school hours. In total, we will be inviting approximately 20 teachers from School District [redacted] to take part in the interview.

Of the teachers that we interview, we will also provide physical activity monitors (called accelerometers) to 10 randomly selected students in their classroom for a 5-day period. For those students not randomly selected, they will be given pedometers to wear for the school week. This will occur between March and May 2016).

None of the questions that we ask are of a delicate or intrusive nature and there are no known risks associated with teachers' involvement in this study. Similarly, no personal information is collected from the students. Teacher and student participation is entirely voluntary, and even if they initially choose to take part in this study they may subsequently withdraw at any time without having to give any reason and without experiencing any negative consequences.

Any information that is provided within the questionnaires or interviews will be confidential, as will the physical activity data collected from the students. This means that no personal information that can identify students or teachers will be made available within any reports that may result from this research. In addition, all completed questionnaires and interview transcripts will be kept in a locked and secure room in the Health and Exercise Psychology Lab located in University of British Columbia, Okanagan campus and shall not be made available to anyone other than the researchers involved in this study.

Teachers that participate in the interview will receive a $20 honorarium. Students that are invited to wear the accelerometers will receive a small gift of their choice (~$2-3 dollars each) at the end of the data collection period if they wear the accelerometers and return them. For those children not involved in the accelerometer components of the study, they will be given their pedometers to take home.

In this research we are interested in gaining a better understanding of teachers' strategies for and factors associated with the implementation of the Daily Physical Activity policy at school. The information collected will provide a strong foundation for the refinement and development of future policies designed to support children's physical activity in schools.

The principal investigator for this study is Dr. Mary Jung, Assistant Professor in the School of Health and Exercise Sciences at The University of British Columbia (UBC). If you have any questions or want further information about the study please contact Dr. Mary Jung at (250) 807-9670 or by email at mary.jung@ubc.ca. Alternatively, if you have any concerns about your rights or your teachers' or students' rights as research subjects please contact the 'Research Participant Complaint Line' in the UBC Office of Research Services at 1-877-822-8598 or by email (RSIL@ors.ubc.ca).

The research assistant will follow up with you via telephone in a week.

Thank you for your help,

Katie Weatherson, BHK Mary Jung, PhD

Appendix B: Teacher Consent Form

a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA

Faculty of Health and Social Development
School of Health and Exercise Sciences
Reichwald Health Sciences Centre
3333 University Way
Okanagan Campus
Kelowna, B. C., Canada, V1V 1V7

Teacher Information Letter and Consent Form

Daily Physical Activity Policy in the School District #[redacted] Region

Principal Investigator: Dr. Mary Jung Ph.D.
Assistant Professor
School of Health and Exercise Sciences
The University of British Columbia
Phone: (250) 807-9670

Research Assistant: Katie Weatherson, BHK
Candidate for Masters of Science
Health and Exercise Psychology Lab
The University of British Columbia, Okanagan Campus
Phone: (250) 807-8419

INVITATION
You are being invited to take part in this research study because you are currently teaching as a grade 4, 5 or 6 elementary school teacher in School District [redacted], have at least one year of experience teaching primary school and can read and speak English.

YOUR PARTICIPATION IS VOLUNTARY
Your participation in this study is entirely voluntary and it is your decision whether or not to take part in this study. Before you decide, it is important for you to understand what this research will involve. This document will explain the study, why the research is being done, what you will be asked to do and what will happen to you, and the possible benefits, risks and discomforts associated with the study.

If you would like to participate please inform the research assistant and sign your name and provide your phone number in the provided space below for a research assistant from UBC to

contact you. If you decide to participate in this study you are free to withdraw at any time and without giving any reasons for your decision.

If you do not wish to participate, you do not have to provide any reason for your decision, nor will you face any repercussions. Please take time to read the following information carefully before you decide.

WHO IS CONDUCTING THE STUDY?
This study will be conducted by Dr. Mary Jung at UBC Okanagan and her Master's student Katie Weatherson and will take place at various elementary schools in School District [redacted].

BACKGROUND
Physical activity plays a key role in the health and learning of school-aged children. According to Canadian Physical Activity Guidelines, children should participate in at least 60 minutes of moderate-to-vigorous physical activity (MVPA) every day to achieve these benefits. In an attempt to help school-aged children in British Columbia (BC) meet daily MVPA recommendations, the Ministry of Education mandated a Daily Physical Activity (DPA) policy in 2008 that requires elementary schools to provide at least 30 minutes of DPA as part of the educational program for children in grades 1-7. In BC, the DPA policy has not yet been evaluated and it is unknown whether school boards promote implementation of this policy and support teachers to effectively implement the initiative. It is also unknown if the DPA program substantially increases children's MVPA while at school. The proposed study as follows has been developed by Dr. Mary Jung and her Master's of Science student Katie Weatherson at the University of British Columbia, who will be the primary researchers of the study.

WHAT IS THE PURPOSE OF THE STUDY?
The aim of this study is to evaluate the implementation and effectiveness of the DPA policy in School District #[redacted] in British Columbia with the goal of understanding how teachers implement DPA, the factos that influence their strategies to meet the requirements and how these strategies impact physical activity levels of children at school. Evaluation will provide evidence on whether the policy helps foster physical activity in school-aged children across BC and help to provide recommendations on policy improvement.

The primary purpose of this study is to explore teachers' perspectives on the process of DPA implementation in SD[redacted] elementary schools in BC. The secondary purpose of this study is to measure the physical activity of children in a subsample of elementary classrooms engaging in a DPA at school.

WHO CAN PARTICIPATE IN THIS STUDY?
You may be able to participate in this study if you are currently employed as a grade 4, 5 or 6 elementary school teacher in School District [redacted], have at least one year of teaching experience and can read and speak English.

WHO SHOULD NOT PARTICIPATE IN THE STUDY?
There are no exclusion criteria to participation in this study, other than not meeting the inclusion criteria above.

WHAT DOES THE STUDY INVOLVE?
This study has two phases. Participating in one phase of the study does not mean that you have to participate in all phases of the study. The first phase involves completing a short one-page survey, which will take approximately 5 minutes. This survey will ask you questions about you and your teaching experience (i.e., age, sex, number of years teaching, grade levels taught) as well as questions about your school environment and DPA implementation strategies used. Based on your responses to these questions, the researchers may invite you to participate in an interview, which will take approximately 45-60 minutes and be audio-recorded. The interview will consist of questions about your DPA implementation strategies and the factors associated with these decisions. The survey and interview are completely confidential, meaning that no one will be able to trace your answers back to you, including your principal, or fellow teachers.

Following completion of the survey and interview, you will be invited to partake in the second phase of the study. The second phase involves assisting researchers in measuring the physical activity levels of children in your classroom while at school for one school week (5 days). To do this, the researchers will train you to distribute and correctly position small activity monitors called accelerometers on each child at the beginning of each school day. Teachers will be required to complete a weekly timetable and ensure that children are wearing the accelerometer correctly at the start of each day and after lunch break. Teachers will distribute the accelerometers at the beginning of each school day and collect them at the end of each school day. The data collected from the students in your classroom will also be completely confidential, meaning that this information will not be shared with your principal, or fellow teachers or anyone other than the researchers.

WHAT ARE THE POSSIBLE HARMS AND DISCOMFORTS?
There are no physical or health risks associated with participation in this study and the information you provide in the survey and interview will be kept completely confidential.

WHAT ARE THE POTENTIAL BENEFITS OF PARTICIPATING?
The benefits to you that could arise from participation in this research are unknown. However, the research is designed to gain expert knowledge from teachers on how to improve DPA implementation practices in order to provide feedback to policy makers on how to improve the policy recommendations. The information collected will provide a strong foundation for the refinement and development of future policies designed to support children's physical activity in schools.

WHAT HAPPENS IF I DECIDE TO WITHDRAW MY CONSENT TO PARTICIPATE?
Your participation in this study is entirely voluntary and you may refuse to participate or withdraw from the study at any time without any explanation.

If you withdraw from the study your data collected up to the point of withdrawal from the study must be kept for data analysis purposes under strict provisions of confidentiality.

WILL MY TAKING PART IN THIS STUDY BE KEPT CONFIDENTIAL?
Your confidentiality will be respected. No information that discloses your identity will be released or published without your specific consent to the disclosure. However, research records identifying you may be inspected in the presence of the Investigator or his or her designate by representatives, Health Canada, and the UBC Research Ethics Board for the purpose of monitoring the research. However, no records which identify you by name or initials will be allowed to leave the Investigators' offices. In addition, because this study is part of a Masters' thesis project, it is considered a public document and as such will be uploaded on the Internet via cIRcle. This is no way affects your confidentiality. All records will kept for 5 years after publication.

WHAT HAPPENS IF SOMETHING GOES WRONG?
Signing this consent form in no way limits your legal rights against the sponsor, investigators, or anyone else, and you do not release the study doctors or participating institutions from their legal and professional responsibilities.

REMUNERATION
There is no monetary cost associated with participating in the study. In total, the time commitment required if you choose to participate in this study is approximately 60 minutes for phase 1 and approximately two hours over the course of phase 2. You will receive a $20 honorarium if you complete the interview and an additional $20 honorarium if you assist the researchers in measuring children's physical activity in phase 2.

WHO DO I CONTACT IF I HAVE QUESTIONS ABOUT THE STUDY DURING MY PARTICIPATION?
If you have any questions or desire further information with respect to this study, you may contact Dr. Mary Jung at (250) 807-9670.

WHO DO I CONTACT IF I HAVE ANY QUESTIONS OR CONCERNS ABOUT MY RIGHTS AS A SUBJECT?
If you have any concerns or complaints about your rights as a research participant and/or your experiences while participating in this study, contact the Research Participant Complaint Line in the UBC Office of Research Services at 1-877-822-8598 or the UBC Okanagan Research Services Office at 250-807-8832. It is also possible to contact the Research Participant Complaint Line by email (RSIL@ors.ubc.ca).

If you are interested in learning about the results of this research, please provide a mailing address or email address to which we may send you the study findings:
_____
_____
_____

Your signature on this consent form means:

- You have read and understood the information in this consent form.
- You have been able to ask questions and have had satisfactory responses to my questions.
- You understand that all of the information collected will be kept confidential and that the results will only be used for scientific purposes.
- You understand that your participation in this study is voluntary.
- You understand that you are completely free at any time to refuse to participate or to withdraw from this study at any time.
- If you withdraw from the study your data collected up to the point of withdrawal from the study must be kept for data analysis purposes under strict provisions of confidentiality.
- You understand that you are not waiving any of your legal rights as a result of signing this consent form.
- You understand that participation in this study will have no impact on your occupation.

You have received a signed copy of this consent form for your own records.

You consent to participate in this study.

_____	_____	_____
Participant's Signature	Printed Name	Date

_____	_____	_____	_____
Signature of Witness	Printed Name	Study Role	Date

Appendix C: Teacher Recruitment Survey

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ID Code: _____

Teacher DPA Survey

What is your age? _____ years old

What is your gender? ☐Male ☐Female

What grade level do you currently teach? (Check all that apply)
☐Grade 4 ☐Grade 5 ☐Grade 6

How many years of teaching experience do you have at an elementary school? _____ years

Do you have specialized training in health and physical education (i.e., undergraduate, teachers' college degree)? (Check one) ☐Yes ☐No

How many students do you currently have in your classroom (this year)? _____ students

How often do you conduct DPA for a full 30 minutes on days your students do not receive a physical education class? (Check one)

☐ Never ☐Rarely ☐Sometimes ☐Often ☐Always

What is the most common implementation strategy you use to implement DPA in your classroom? (Check one)
☐ In addition to daily PE class
☐ As part of daily PE class
☐ Only on days with no PE class
☐ I don't implement DPA (the students are active at recess and/or lunch)
☐ None of the above/Other

Please explain in detail how you implement DPA during the school day:

_____

_____

_____

_____

_____

_____

_____

Do you enjoy conducting DPA? (Check one)
☐ Never ☐Rarely ☐Sometimes ☐Often
☐Always

Do you believe that DPA should be a permanent component of the curriculum? (Check one)
☐ Never ☐Rarely ☐Sometimes ☐Often
☐Always

Are there any barriers to implementing DPA in your classroom? (Check one)
☐Yes ☐Sometimes ☐No ☐I don't know

Do you think that students in your classroom are more physically active at school when they engage in DPA compared to when they do not? (Check one)
☐Yes ☐Sometimes ☐No ☐I don't know

Would you like to participate in Phase 2 of this study, measuring the physical activity of children in the classroom while at school?
☐Yes ☐No ☐I don't know/I need more information

If yes or unsure, please provide your contact information below so that the researchers may contact you to provide you with more details.

Name: _____

Phone Number: _____

Email: _____

THANK YOU!

Appendix D: Study Explanation for Student Recruitment

Study Explanation for Student Recruitment

Hi Class. My name is Katie and I am a student just like you but I go to the university here in Kelowna. I'm here to tell you about a research study that I am doing and to see if you would like to participate in this study. This study is looking at student's' physical activity at school. I want to compare how much physical activity youth get at school, when they do PE, and at recess and lunch and during activities in the classroom.

Before you decide if you want to be in this study, I will explain what I am going to ask you to do for the study:

1. I want you to wear a physical activity monitor for **5 days** when you are at school (Monday – Friday). Some of you will be asked to wear physical activity monitors called accelerometers, which look like this [show accelerometer]. The other students will be given another device called a pedometer, which looks like this [show pedometer]. The only difference between the devices is how you wear it and how information is recorded. The accelerometer has an elastic band and is worn around your waist. The pedometer is worn on your pants by a clip. The accelerometer also does not display your activity like a pedometer does. How we decide who gets to wear what device will be by a random choosing, like picking out of a hat. So, ten of you (5 boys and 5 girls) will be asked to wear the accelerometer and the others will be given the pedometer to wear. [Demonstrate how to wear both devices].
2. This is not a competition and you do not have to do any more activity than you would normally do at school. In fact, I don't want you to change anything about what you do at school everyday so I can measure exactly how much PA you normally get at school. So, for example if you like to play sports at recess, then continue to play sports. If you like to talk to your friends, then continue to do that.
3. During the week, the teacher will give you the monitor to wear and collect it before you leave at the end of the day. So that means you don't have to wear it at home.
4. If you wear the device for 5 days in a row for the whole school day, you will get to keep a pedometer and your name will be entered to win a prize [movie passes]. I will get you to record your wear on a recording sheet [show the sheet]. On this sheet you will check the days you wear the device for the whole day and explain why you didn't wear it on other days (i.e., sick). If you are wearing a pedometer, you can record the number of steps that you walked each day. If you have the accelerometer, you will not be able to see that information.

If you want to be in the study, there are a few things you have to know:

5. We will not be collecting any information from you other than the physical activity. You do not have to tell us your name or your age.
6. You don't have to be in the study if you don't want to. If you decide to be in the study but then change your mind later, that is completely ok. No one will be mad at you if you

don’t want to do it anymore. But id you want to be in the study, I will also be asking your parents if they would like you to be in the study.

7. You can ask questions any time, now or later. You can talk to me, your teacher or your family.

Does anyone have any questions?

Explain randomization: Please write your full name on this piece of paper that I hand out. If you want to participate you will put your name into one of two “YES” envelopes (boys/girls). If you don’t want to participate, you will put your name into the “NO” envelope. I will be drawing 10 names from the “YES” envelopes (5 boys and 5 girls). If your name is drawn, you will be asked to wear the accelerometer. If your name is not drawn, you will be given the pedometer to wear. If your name is drawn to wear the accelerometer, you can only wear that device. You will not be able to wear the pedometer. This is VERY important because it makes sure the results of my study are accurate and you would be breaking the rules of science for randomization. Does that make sense?

For those of you who’s name is drawn: In order to be in this study, you have to bring these forms home to your parents to sign and return them to your teacher. There is one form for you parents to sign and another for you to sign.

For those of you wearing the pedometers or who are not wanting to participate, you do not have to get the forms signed, but there is a information sheet to bring home to your parents.

Appendix E: Parent Information Letter for Non-participating Students

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Faculty of Health and Social Development
School of Health and Exercise Sciences
Reichwald Health Sciences Centre
3333 University Way
Okanagan Campus
Kelowna, B. C., Canada, V1V 1V7

Parent/Guardian Information Letter
Daily Physical Activity Policy in the School District [redacted] Region

Dear Parent/Guardian,

My name is Katie Weatherson and I'm a graduate research assistant at the University of British Columbia. I am currently conducting a study that aims to understand how elementary school teachers implement the Daily Physical Activity policy in their classrooms and to measure the effects that these strategies have on the physical activity levels of children at school. The research is designed to provide feedback to teachers and schools on how to improve implementation practices and to policy makers on how to improve policy recommendations. I have visited your child's classroom and explained the study to the students. As part of this study, a total of 10 students from your child's classroom have been randomly selected to participate. For those selected, they were invited to wear a physical activity monitor (called an accelerometer), for a 5-day period while at school. Your child has NOT been randomly selected to participate. However to ensure that all children feel included, we will be providing those children not selected to participate, including your child, with physical activity monitors (called a pedometer) to wear for the same 5-day period. No children will be asked to wear the physical activity monitors during their private life. They will be asked to put the devices on at the first bell of school, and then take it off at the dismissal bell. These monitors are small devices worn on the hip (it's the size of a small pack of cards) and measure how much physical activity students achieve at school on a daily basis. There will be 20 other classrooms participating in this study.

This research study will take place during regular school hours and it will not interfere with regular classroom activities. There are no foreseeable risks for your child to participate in this study. Student participation is entirely voluntary, and even if students initially choose to take part in this study they may subsequently withdraw at any time without having to give any reason and without experiencing any negative consequences.

No information that discloses your child's identity will be collected. We will not collect the physical activity information that is recorded by the pedometers – the pedometer your child is offered to wear will be his/hers to keep at the end of the week.

If you have any questions or want further information about the study please contact myself or Dr. Mary Jung at (250) 807 9670.

Yours sincerely,

Mary E. Jung, Ph.D.
School of Health and Exercise Sciences
University of British Columbia
Contact Number: (250) 807-9670
mary.jung@ubc.ca

Katie Weatherson, BHK
School of Health and Exercise Sciences
University of British Columbia
Contact Number: (250) 807-8419
kate.weatherson@gmail.com

Appendix F: Parent Information Letter and Consent Form for Participating Students

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Faculty of Health and Social Development
School of Health and Exercise Sciences
Reichwald Health Sciences Centre
3333 University Way
Okanagan Campus
Kelowna, B. C., Canada, V1V 1V7

Parent/Guardian Information Letter
Daily Physical Activity Policy in the School District [redacted] Region

Principal Investigator:
Mary E. Jung, Ph.D.
School of Health and Exercise Sciences
University of British Columbia
Contact Number: (250) 807-9670
mary.jung@ubc.ca

Research Assistant:
Katie Weatherson, BHK
School of Health and Exercise Sciences
University of British Columbia
Contact Number: (250) 807-8419
kate.weatherson@gmail.com

Dear Parent/Guardian,

My name is Katie Weatherson and I'm a graduate research assistant at the University of British Columbia. I am currently conducting a study that aims to understand how elementary school teachers implement the Daily Physical Activity policy in their classrooms and to measure the effects that these strategies have on the physical activity levels of children at school. The research is designed to provide feedback to teachers and schools on how to improve implementation practices and to policy makers on how to improve policy recommendations. I have visited your child's classroom and explained the study to the students. As part of this study, your child has been randomly selected and invited to wear a physical activity monitor (called an accelerometer), for a 5-day period while at school. The children will not be asked to wear the accelerometers during their private life. They will be asked to put the accelerometer on at the first bell of school, and then take it off at the dismissal bell. These monitors are small devices worn around the waist (it's the size of a small pack of cards) and measure how much physical activity students achieve at school on a daily basis. There will be 200 other children in this study.

This research study will take place during regular school hours and it will not interfere with regular classroom activities. There are no foreseeable risks for your child to participate in this study. In addition to your permission, your child must agree to participate in the study. Student

participation is entirely voluntary, and even if students initially choose to take part in this study they may subsequently withdraw at any time without having to give any reason and without experiencing any negative consequences.

No information that discloses your child's identity will be collected. All physical activity information that is collected by the accelerometers will remain confidential and will be kept in a locked and secure room in the Health and Exercise Psychology Lab in the University of British Columbia, Okanagan campus and shall not be made available to anyone other than the researchers involved in this study. Further, data from all 200 children will be analyzed together, in aggregate format. Because this study is part of a Masters' thesis project, it is considered a public document and as such will be uploaded on the Internet via cIRcle. This is no way affects your child's confidentiality. All records will kept for 5 years after publication.

If you wish for your child to take part in this research, please complete this form and return it to your child's teacher. Alternatively, you can email or phone myself or Dr. Jung using the contact details identified above and we will ensure that your son/daughter does not take part in this study. Also, even if you have consented for your child to take part in this study, we also require his/her own consent as well before s/he can be invited to take part. If you have any questions or want further information about the study please contact myself or Dr. Mary Jung at (250) 807 9670. Alternatively, if you have any concerns about your rights or treatment as a research subject please contact the 'Research Participant Complaint Line' in the UBC Office of Research Services at 1-877-822-8598 or by email (RSIL@ors.ubc.ca) or contact the UBC Okanagan Research Services Office at 250-807-8832.

SO, IF YOU WANT YOUR CHILD TO TAKE PART PLEASE **SIGN THIS FORM AND RETURN** THIS TO YOUR CHILD'S TEACHER:

I …… WANT
(Parent/Guardian Name)

MY CHILD ……..…… TO TAKE PART IN THIS STUDY.
(Child's Name)

Signed…… Date……..
(Parent/Guardian Name)

Yours sincerely,

Mary E. Jung, Ph.D.
School of Health and Exercise Sciences
University of British Columbia
Contact Number: (250) 807-9670
mary.jung@ubc.ca

Katie Weatherson, BHK
School of Health and Exercise Sciences
University of British Columbia
Contact Number: (250) 807-8419
kate.weatherson@gmail.com

Appendix G: Child Assent Form

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ASSENT FOR CHILDREN 7-13 years old

Study title: Physical Activity at School
Investigators: Dr. Mary Jung, Katie Weatherson

Why we are here?

We are researchers conducting a study that is looking at children's' activity and playtime at school. We want to see if you would like to be in this study. This form tells you about the study. If there is anything you do not understand, please ask your parent, your guardian or your teacher.

Why are we doing this study?

We want to see how much physical activity children get at school, when they do daily physical activity (DPA), physical education (PE), and at recess and lunch.

What will happen to you?

If you want to be in the study these things will happen:

1. You will wear a physical activity monitor with an elastic band around your waist each day for 5 days (one week of school).

   Every morning, your teacher will give you the monitor to wear and collect it before you leave at the end of the day.

   You do not have to do any more activity than you would normally do at school.

This is what the physical activity monitor belt looks like and how you would wear it.

Will the study hurt?

There is no pain from wearing the activity monitor. It will feel like you are wearing a belt.

What do I get for being in the study?

If you decide to be in the study and you wear the activity monitor for 5 days in a row, you get to pick a toy gift.

What if you have any questions?

You can ask questions any time, now or later. You can talk to the researchers, your teacher, your family or someone else.

Who will know what I did in the study?

Any information you give to the study staff will be kept private (*or secret*). Your name will not be on any study paper and no one but the study staff and your teacher will know that it was you who was in the study.

Do you have to be in the study?

You do not have to be in the study. No one will be mad at you if you don't want to do this.

If you don't want to be in this study, just say so. We will also ask your parents if they would like you to be in the study. Even if your parents want you to be in the study you can still say no.

Even if you say yes now you can change your mind later. It's up to you.

Do you have any questions?
What questions do you have?

Assent

I want to take part in this study. I know I can change my mind at any time.

_____ Verbal assent given **Yes** □

Print name of child

Written assent if the child chooses to sign the assent.

_____ _____ _____

Signature of Child **Age** **Date**

I confirm that I have explained the study to the participant to the extent compatible with the participants understanding, and that the participant has agreed to be in the study.

_____ _____ _____

Printed name of Person obtaining assent **Signature of Person obtaining assent** **Date**

Appendix H: Explanation for Phase 2 Data Collection

Phase 2 Data Collection SOP: Instructions for Teacher and Students

Instructions for teacher:

- It is VERY important that you teach the way you normally would teach in the classroom. Please do NOT try to change your lessons/teaching style because you are in the study.
- Please record on the timetable the times at which lunch and afternoon recess, PE, and any classroom time DPA occurs throughout the day. Please try to record the time that each occurs as accurately as possible and try to write this down within the same hour/day that it occurred (i.e., not at the end of the week).
- If you do not or forget to do DPA as you normally would do during this week, that is OK! Just record that in the timetable I have given you.
- Please remember to remind the students to take the devices off before they go home for the day (this is very important for children wearing the accelerometer and not so important for children wearing the pedometers). They can place their accelerometers back into their labeled ziploc bags and keep at their desk or yours.
- The ten students wearing the accelerometer have been assigned a number that corresponds to the number on their device. It is VERY important that the students with the accelerometers get the same numbers each day.
- ANY QUESTIONS?

Instructions for students:

- REMEMBER: This is NOT a competition. You do not have to do any more activity than you would normally do at school. Please do what you normally like to do at lunch/recess/PE.
- EXPLAIN and DEMONSTRATE to students how the accelerometer is worn: It is VERY IMPORTANT that the device is worn correctly or it won't record accurate information. To wear it correctly, you have to make sure that the belt is tight enough so it doesn't move around as you do throughout the day (it has to stay in one place). The red box has to stay on your RIGHT hip with the yellow happy face sticker is pointing up! So when you look down the face is smiling at you. So make sure you check it once and awhile to make sure that the happy face is looking at you.
- Please remember to wear the device during the whole school day. So when you have PE and get changed into gym clothes, please remember to keep the device on for your PE class and make sure it is facing the right direction.
- Recording your wear of the devices: If you wear your device for the whole school day, please put a sticker in the top box. If you did not wear the device, there is a box to explain why. For those of you wearing the pedometers, you can record the number of steps you took at school at the end of each day (remember to reset it at the beginning of each day!). For those of you wearing the accelerometer you will not be able to record any of that information.
- If you wear the device for each day that you are at school, you get to keep a pedometer and your name will be entered to win a larger prize.

- PLEASE DO NOT LET ANYONE ELSE WEAR YOUR DEVICE. If you were chosen to wear the accelerometer, you have to wear it. You cannot switch with your friend and wear the pedometer one day and the accelerometer another day.
- If you chose to not wear the device, that is completely ok, but please leave your device with your teacher.

- ANY QUESTIONS?

Appendix I: Teacher Timetable

ID CODE: _____

Classroom Timetable

	Monday	Tuesday	Wednesday	Thursday	Friday
8:00am					
8:15am					
8:30am					
8:45am					
9:00am					
9:15am					
9:30am					
9:45am					
10:00am					
10:15am					
10:30am					
10:45am					
11:00am					
11:15am					
11:30am					
11:45am					
12:00pm					
12:15pm					

12:30pm					
12:45pm					
1:00pm					
1:15pm					
1:30pm					
1:45pm					
2:00pm					
2:15pm					
2:30pm					
Notes:					

Appendix J: Pedometer Log

Student Initials: _____

PEDOMETER – PHYSICAL ACTIVITY DEVICE LOG

Monday	Tuesday	Wednesday	Thursday	Friday
Reason I did not wear it:	Reason I did not wear it:	Reason I did not wear it:	Reason I did not wear it:	Reason I did not wear it:
Total Steps Taken:	Total Steps Taken:	Total Steps Taken:	Total Steps Taken:	Total Steps Taken:

Appendix K: Accelerometer Log

Student Initials: _____ _____ ID Code: _____ Accel #: _____

ACCELEROMETER - PHYSICAL ACTIVITY DEVICE LOG

Monday	Tuesday	Wednesday	Thursday	Friday
Reason I did not wear it:	Reason I did not wear it:	Reason I did not wear it:	Reason I did not wear it:	Reason I did not wear it:

Appendix L: Raw Classroom Accelerometer Data for Study 3

Table 1. Mean minutes and proportion of day in MVPA by class and implementation strategy on PE days

Prescriptive implementation group						
	Non-instructional MVPA		Instructional MVPA		Total	
Class	Mean minutes (SD)	Proportion (SD)[1]	Mean minutes (SD)	Proportion (SD)	Mean minutes (SD)	Proportion (SD)
1 (*n* = 10)	17.89 (8.76)	39.8 (19.5)	17.98 (6.80)	5.7 (2.2)	35.86 (14.74)	5.0 (1.9)
2 (*n* = 9)	7.78 (6.43)	17.3 (14.3)	21.81 (5.14)	6.9 (1.6)	29.58 (11.35)	5.6 (1.5)
3 (*n* = 9)	14.07 (7.00)	31.3 (15.5)	22.11 (9.34)	7.0 (3.0)	36.18 (15.58)	5.9 (2.5)
4 (*n* = 7)	12.68 (5.17)	25.4 (10.3)	21.54 (3.07)	7.0 (1.0)	34.21 (7.87)	5.6 (0.9)
5 (*n* = 10)	11.76 (5.32)	29.4 (13.3)	26.26 (8.09)	8.2 (2.5)	37.93 (12.17)	6.8 (2.1)
6 (*n* = 10)	11.90 (5.61)	26.4 (12.5)	23.58 (5.69)	7.5 (1.8)	35.48 (10.07)	6.1 (1.5)
7 (*n* = 10)	16.13 (10.23)	40.3 (25.6)	29.30 (5.72)	9.2 (1.8)	45.43 (14.21)	7.7 (1.6)
8 (*n* = 8)	13.44 (4.70)	28.0 (9.8)	20.33 (6.83)	6.5 (2.2)	33.77 (11.02)	5.4 (1.8)
9 (*n* = 9)	11.93 (5.57)	26.5 (12.4)	17.54 (6.44)	5.6 (2.0)	29.47 (8.00)	4.7 (1.6)
Total (*n* = 82)	**13.13 (7.10)**	**29.7 (16.6)***	**22.40 (7.28)**	**7.1 (2.3)***	**35.53 (12.40)**	**5.9 (1.9)***
Non-prescriptive implementation group						
10 (*n* = 7)	10.54 (6.62)	20.7 (13.0)	10.46 (4.27)	3.4 (1.4)	21.00 (9.52)	2.9 (1.2)
11 (*n* = 9)	7.11 (1.97)	13.9 (3.9)	11.53 (7.94)	3.7 (2.6)	18.64 (9.01)	3.0 (1.9)
12 (*n* = 0)	-	-	-	-	-	-
Total (*n* = 16)	**8.61 (4.76)**	**16.9 (9.3)***	**11.06 (6.42)**	**3.6 (2.1)***	**19.67 (9.00)**	**3.0 (1.6)***

MVPA, moderate-to-vigorous physical activity; PE, physical education

*$p<0.001$

[1]In this table, proportion means the percentage of the designated time spent in MVPA. For example, class 1 spent 39.8% of their non-instructional time (recess and lunch breaks) in MVPA, which resulted in a mean of 17.89 minutes on PE days.

Table 2. Mean minutes and proportion of day in MVPA by class and implementation strategy on DPA days

Prescriptive implementation group								
	Non-instructional MVPA		Instructional MVPA		Total		Meeting DPA?	
Class	Mean minutes (SD)	Proportion (SD)[1]	Mean minutes (SD)	Proportion (SD)	Mean minutes (SD)	Proportion (SD)	Yes	No
1 (*n* = 8)	17.43 (9.19)	38.7 (20.4)	15.47 (4.55)	4.9 (1.4)	32.90 (13.04)	4.4 (1.4)	✓	
2 (*n* = 9)	7.49 (6.45)	16.6 (14.3)	12.81 (2.64)	4.1 (0.8)	20.29 (7.94)	3.4 (0.8)		✓
3 (*n* = 9)	15.28 (7.06)	34.0 (15.7)	22.64 (6.63)	7.2 (2.1)	37.91 (10.65)	6.0 (1.7)	✓	
4 (*n* = 8)	13.91 (8.02)	27.8 (16.0)	16.13 (5.80)	5.2 (1.9)	30.03 (8.87)	4.4 (1.4)	✓	
5 (*n* = 10)	15.63 (5.70)	39.1 (14.2)	19.75 (7.76)	6.2 (2.4)	35.38 (11.07)	5.4 (2.0)	✓	
6 (*n* = 9)	12.80 (6.67)	28.4 (14.8)	13.08 (2.70)	4.2 (0.9)	25.88 (8.41)	3.6 (0.8)		✓
7 (*n* = 8)	15.06 (9.29)	37.7 (23.2)	19.68 (6.05)	6.2 (1.9)	34.74 (14.12)	5.3 (1.7)	✓	
8 (*n* = 10)	15.91 (6.45)	33.2 (13.4)	9.64 (2.88)	3.1 (0.9)	25.55 (7.93)	2.9 (0.8)		✓
9 (*n* = 7)	7.55 (2.01)	16.8 (4.5)	15.95 (6.23)	5.1 (2.0)	23.50 (5.98)	4.1 (1.5)		✓
Total (*n* = 78)	**13.58 (7.46)**	**30.6 (17.1)***	**16.06 (6.42)**	**5.1 (2.0)***	**29.64 (11.15)**	**4.4 (1.7)****		✓
Non-prescriptive implementation group								
10 (*n* = 4)	13.88 (8.34)	27.2 (16.4)	13.13 (6.06)	4.3 (2.0)	27.00 (14.21)	3.7 (1.8)		✓
11 (*n* = 9)	8.45 (3.85)	16.6 (7.6)	13.95 (4.66)	4.5 (1.5)	22.41 (7.65)	3.7 (1.2)		✓
12 (*n* = 9)	8.03 (3.48)	17.8 (7.7)	6.64 (2.22)	2.1 (0.7)	14.67 (4.74)	1.9 (0.6)		✓
Total (*n* = 22)	**9.27 (5.02)**	**19.0 (9.9)***	**10.81 (5.30)**	**3.5 (1.7)***	**20.08 (9.15)**	**2.9 (1.4)****		✓

MVPA, moderate-to-vigorous physical activity; PE, physical education

* p=0.001, **p<0.001

[1]In this table, proportion means the percentage of the designated time spent in MVPA. For example, class 1 spent 38.7% of their non-instructional time (recess and lunch breaks) in MVPA, which resulted in a mean of 17.43 minutes on DPA days.