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THE INFLUENCE OF CLASSROOM PHYSICAL ACTIVITY BREAKS AT DIFFERENT TIMES OF DAY ON ON-TASK BEHAVIOUR AND PHYSICAL ACTIVITY LEVELS IN PRIMARY SCHOOL CHILDREN

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by

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Abstract

Classroom physical activity breaks (CAB) are beneficial for increasing children's physical activity (PA) levels as well as the amount of time spent being on-task within the classroom. This study examined the effect of CAB at different times within the school day on on-task behaviour and PA levels in primary school (grade 1-3) children. Thirty-five children participated in CAB in four different conditions (within-subject): morning (AM), afternoon (PM), both the morning and afternoon (BOTH), and no CAB (CTRL). PA levels were monitored via activPAL accelerometers for 24 h starting at the beginning of the school day. On-task behaviour was observed for 45-140 min following each CAB, with the amount of time students spent being on-task as well as 3 types of off-task (motor, verbal, and passive) being recorded. When compared to control, the AM condition and PM condition increased on-task behaviour (AM: Δ10.4%, $p<0.001$, PM: Δ10.5%, $p<0.001$), while performing BOTH CAB increased on-task behaviour even further (Δ14%, $p<0.001$). The AM condition was most beneficial for reducing off-task motor (Δ-6.5%) and off-task verbal (Δ-3%) behaviour, while the PM condition was most beneficial for reducing off-task passive (Δ-9%) behaviour. These effects were greatest in those students demonstrating higher amounts off-task behaviour during CTRL ($r>0.67$, $p<0.001$). Students participated in an additional 8.4 min ($p=0.07$), 12.2 min ($p<0.001$), and 6.3 min ($p=0.09$) of 24 h moderate-vigorous physical activity (MVPA) following a CAB vs CTRL in the AM, PM, and BOTH conditions, respectively. Additionally, performing any of the CAB conditions increased the number of steps taken during the school day, by an average of 2007 steps ($p<0.009$). Overall, these results demonstrate that CAB improve both on-task behaviour and PA levels, regardless of time of day. However, performing two CAB (BOTH) is recommended to derive the greatest improvements in on-task behaviour and all types of off-task behaviour across the school day.

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MVPA – moderate-vigorous physical activity

BMI – body mass index

PAL – physically active lessons

HIIT – high-intensity interval training

SIT – sprint interval training

BSD – balanced school day

TSD – traditional school day

CAB – classroom activity break

AM – morning activity break condition

PM – afternoon activity break condition

BOTH – morning & afternoon activity break condition

CTRL – no activity break condition

CHAPTER 1

Literature Review

Introduction

Primary school children are at a critical age for developing habits that will impact both their health and academic achievement throughout their life. Two factors that play an important role in influencing these outcomes are physical activity and classroom behaviour. Classroom behaviour within primary school students is a significant area of concern, as noted by teachers when discussing issues related to classroom management (Demir 2009; Riley et al. 2011). Specifically, behavioural regulation within the classroom refers to tasks such as being attentive, following instructions, and inhibiting inappropriate actions (McClelland et al. 2007) and this plays an important role within the classroom as it has been shown to positively predict literacy, math, and vocabulary skills (McClelland et al. 2007), as well as overall academic achievement (O'Brennan et al. 2014; Owen et al. 2016). Inappropriate behaviours disrupt the classroom environment and hinder learning, while teachers' strategies to manage them also takes away from valuable learning time in the classroom (Riley et al. 2011). Common strategies utilized include verbal and nonverbal warnings, speaking one-on-one with students, and implementing a reward-punishment system (Demir 2009), which are implemented following inappropriate behaviour, thus making them reactive strategies. It is clear that there is a need for effective and efficient proactive strategies that will reduce these behaviours and improve students' engagement in the classroom.

In terms of physical activity, Canada's "24 h Movement Guidelines for Children and Youth" includes suggestions on the amount of time within a 24 h period that children should spend being sedentary as well as engaging in light and moderate-vigorous physical activity (MVPA) (Tremblay et al. 2016). These guidelines indicate that children between the ages of 5-17 y old should participate in 60 min of MVPA per day in order to experience health benefits (Tremblay et al. 2016). However, the 2018 ParticipACTION Report Card on Physical Activity for Children and

Youth found that only 35% of Canadian children 5-17 y old are meeting physical activity guidelines, achieving a grade of D+ for overall physical activity (Barnes et al. 2018; ParticipACTION 2018). Additionally, various daily behaviours and individual characteristics such as active play, sedentary time, and physical fitness have been given a grade of D, D, and D+, respectively (Barnes et al. 2018). Overall, it is clear that Canada's youth are not active enough.

Physical Activity in Children

Physical inactivity is problematic because engaging in sufficient physical activity is associated with numerous important benefits, especially for children. It is well-known that physical activity is associated with various health indicators in children such as lowering blood pressure and cholesterol, reducing the risk of developing obesity and metabolic syndrome, improving bone density, and more (Janssen et al. 2010). In addition to health benefits, physical activity is also positively associated with cognitive benefits in children such as cognitive function, including memory and attention (Chu et al. 2016; Davis et al. 2011; Pesce et al. 2009), concentration (Budde et al. 2008), and academic achievement (Castelli et al. 2007; Chu et al. 2016; Davis et al. 2011; Kao et al. 2017; Rasberry et al. 2011). More specifically, children's physical fitness was positively associated with academic achievement and performance in various subjects such as math and reading, and overall academics (Castelli et al. 2007; Chu et al. 2016; Kao et al. 2017), whereas BMI had negative associations (Castelli et al. 2007; Chu et al. 2016).

The relationship between physical activity and academic achievement may be explained by the Executive Function Hypothesis, which proposes that physical activity induces physical changes within the brain in areas related to executive functioning, such as the prefrontal cortex, that alter thinking, decision-making, and behaviour (Donnelly et al. 2016). These changes lead to

improvements in executive function, which has been shown to predict improvement in academic achievement (Donnelly et al. 2016). This has been shown in cross-sectional studies where children with a higher fitness level had altered brain structure as well as greater cognitive functioning and academic achievement than children of lower fitness levels (Donnelly et al. 2016). Additionally, improvements in cognitive functioning can also be seen following an acute bout of physical activity (Donnelly et al. 2016). A dose-response relationship has been observed in terms of the amount of physical activity children participate in on a regular basis, where greater physical activity levels is associated with greater changes in brain structure, cognitive functioning, and academic achievement (Donnelly et al. 2016). Overall, between the overwhelming lack of physical activity in children and the positive benefits associated with participating in physical activity, it is clear that children need to become more physically active.

On-Task Behaviour

One aspect of behavioural regulation or classroom behaviour that has gained popularity within research is on- and off-task behaviour. On-task behaviour can be defined as behaviour that is engaged in, and related to, the learning task at hand (Daly-Smith et al. 2018). Conversely, off-task behaviour can be defined as behaviour that is disengaged from, and unrelated to, the learning task at hand, and can be divided into three categories (Ma et al. 2014) – verbal (i.e. talking to classmates), motor (i.e. fidgeting), and passive (i.e. staring off into space). A proactive approach to improving behavioural regulation such as on-task behaviour may be increasing children's physical activity levels, as physical activity has shown positive associations with on-task behaviour in classroom settings (Carlson et al. 2015; Howie et al. 2014; Ma et al. 2014; Mahar et al. 2006; Szabo-Reed et al. 2017; Webster et al. 2015b). For example, incorporating physical activity into

classroom lessons improved on-task behaviour for observations ranging from 5 (Szabo-Reed et al. 2017) – 50 min (Ma et al. 2014) following the activity. However, some of the positive outcomes observed were due to a decrease in on-task behaviour across the observation period in the control group that did not receive any physical activity (Daly-Smith et al. 2018). Regardless, preventing a decrease in on-task behaviour, as demonstrated in a control group, is still a beneficial influence of physical activity on on-task behaviour.

Additionally, intensity and duration of the physical activity bout seem to be important in influencing the improvement in on-task behaviour. Most of the research demonstrating a positive relationship between physical activity and on-task behaviour has been conducted using physically active lessons (PAL), which consists of incorporating physical activity into an academically related classroom lesson (Daly-Smith et al. 2018). These PAL are generally longer duration and moderate-intensity in nature, which has been shown to lead to consistent improvements in on-task behaviour (Daly-Smith et al. 2018). Overall, moderate-intensity bouts of at least 15 min have been found to be most beneficial in improving on-task behaviour (Daly-Smith et al. 2018).

However, more intense forms of exercise such as high-intensity interval training (HIIT) or sprint interval training (SIT) have been shown to lead to similar health benefits as moderate-intensity exercise among adults (Boutcher 2011; Burgomaster et al. 2008; Gibala et al. 2006; Macpherson et al. 2011), and has successfully been used in children in a variety of formats (Ketelhut et al. 2020; Leahy et al. 2020; Tottori et al. 2019). The high-intensity nature of these types of exercise allow the bouts of activity to be significantly shorter than moderate-intensity exercise, while still exerting the same benefits. Therefore, it is plausible that shorter bouts of physical activity may also be successful in improving on-task behaviour if they are intense enough, leading to a more time efficient strategy to improve on-task behaviour in students.

Schools, Physical Activity, and On-Task Behaviour

It is important to consider on-task behaviour and physical activity within the school day because it is known that children spend a large amount of time at school. Prior research has shown that primary school students typically spend less than 60% of their time on-task in regular education classrooms (Fischer et al. 1980; Lee et al. 1999; Godwin et al. 2016), and students are more on-task in the morning than they are in the afternoon (Godwin et al. 2016; Martin et al. 2015; Muyskens and Ysseldyke 1998). Inherent opportunities for physical activity throughout the school day, such as recess and physical education class, can positively influence children's physical activity levels. Specifically, recess has been shown to account for 24-25% of total steps per day (Tudor-Locke et al. 2006), while physical education class has been shown to significantly contribute to children's MVPA, as students obtained ~10 min more physical activity on days where they had physical education class than on days they did not (Weaver et al. 2016). However, scheduling for recess and physical education class is currently a low priority for schools, therefore most of the school day is spent in the classroom during lessons (Weaver et al. 2016). This is problematic, as 64% of a child's total daily sedentary time occurs within the classroom (Bailey et al. 2012), and consequently, children are only participating in 15-30 min of MVPA (Carlson et al. 2013), and obtaining less than 50% of the recommended step guidelines (~12,000 steps), while at school (Tudor-Locke et al. 2006; Tudor-Locke et al. 2011). Therefore, because children spend a lot of time in the classroom, and this time is largely sedentary and off-task, the classroom is an ideal place for an intervention that has the potential to improve both physical activity and on-task behaviour.

An important consideration when examining on-task behaviour and physical activity at school is how classroom time and recess time is scheduled. The Balanced School Day (BSD) has been widely implemented in Canadian schools over the last decade, and consists of dividing the school day into three 100 min blocks of classroom time separated by two 40 min nutrition and recess breaks (Clark et al. 2019; Wu et al. 2015). Conversely, the Traditional School Day (TSD) consists of two 15 min recess breaks and one longer 60 min lunch break (Clark et al. 2019; Wu et al. 2015). Supporters of the BSD believe that it improves student concentration and academic success, and provides more opportunity for continuous physical activity (Dorman et al. 2013), however, there has been little research to date to support these ideas (Clark et al. 2019; Wu et al. 2015). Although there is no research to our knowledge investigating on-task behaviour in the BSD, one study has shown that on-task behaviour is highest for shorter instructional periods of 10 min (Godwin et al. 2016), which equates to one tenth of a classroom period following the BSD. Additionally, the benefits of BSD on physical activity levels have yet to be observed, as MVPA between TSD and BSD was not different in kindergartens or children age 10-12 y (Clark et al. 2019; Vanderloo & Tucker 2016). Overall, the proposed benefits provided by the BSD for classroom behaviour and physical activity levels have yet to be confirmed, therefore TSD and BSD can be regarded as equal until shown otherwise.

Physical Activity Compensation

In addition to physical activity levels within the school day, it is also important to consider children's physical activity at other times of the day. Specifically, a large portion of a child's physical activity occurs during the after-school period (Bailey et al. 2012; De Baere et al. 2015; Tudor-Locke et al. 2006), which may be affected if physical activity levels during the school day

were to increase. This idea relates to the concept of physical activity compensation, which is based on the "activitystat" hypothesis first put forth by Thomas Rowland as part of the biological basis of physical activity (Gomersall et al. 2013; Rowland 1998) (Figure 1). This hypothesis states that when a child's physical activity is either increased or decreased during one part of the day, there will be a compensatory change in physical activity during a later part of the day, or even the following day, in order to maintain a constant and consistent level of physical activity over time (Gomersall et al. 2013; Ridgers et al. 2014). The activitystat hypothesis typically refers to a situation where a child compensates for increase physical activity in one part of their day by lowering their physical activity later that day, or the next day (Gomersall et al. 2013). However, compensation can also work the other way, termed "activity synergy," which refers to when participating in an active behaviour increases physical activity later on (Goodman et al. 2011).

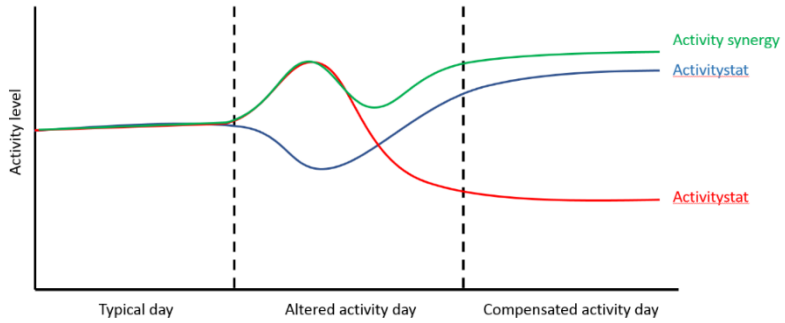

Figure 1: Depiction of the activitystat and activity synergy hypotheses

Some early observational and cross-sectional studies show support for the activitystat hyposthesis (Gomersall et al. 2013), such as an additional 10 min spent in MVPA (Ridgers et al. 2014) or stepping (Ridgers et al. 2015) on one day was associated with 5 min and 9 min less of MVPA and stepping, respectively, the following day (Ridgers et al. 2014; Ridgers et al. 2015). Other studies show no signs of compensation or support for the activitystat hypothesis, therefore this research is largely indirect and contains mixed results (Gomersall et al. 2013; Goodman et al.

2011; Reilly 2011). More recent experimental approaches to examining physical activity compensation have shown no support for the activitystat hypothesis (Costigan et al. 2018; O'Sullivan et al. 2018; Ridgers et al. 2018). A major difference between these studies that oppose the activitystat hypothesis and those that support it is the implementation of a physical activity intervention. Early observational studies seem to show that when children are left to modulate their physical activity on their own, they will compensate for alterations in order to keep a constant physical activity level (Ridgers et al. 2014; Ridgers et al. 2015). However, when additional physical activity is intentionally implemented as a discrete bout, children do not compensate their physical activity levels later the same day (Costigan et al. 2018; Ridgers et al. 2018), or 3 days following (O'Sullivan et al. 2018) the intervention. This provides promising evidence that physical activity interventions could increase children's overall physical activity levels by avoiding the effects of the activitystat hypothesis.

Classroom Activity Breaks

Classroom activity breaks (CAB) are a type of physical activity intervention for children that are gaining popularity within schools and the research field for improving physical activity levels and on-task behaviour. CAB can be defined as "short bouts of physical activity, often moderate to vigorous in nature, between periods of academic instruction" (Daly-Smith et al. 2018). Various examples of CAB within the literature are outlined in Table 1, which demonstrates the variety of exercises used and how the CAB are performed, as well as the lack of information provided regarding specific details of the CAB. One specific example of interest is the "FUNtervals" CAB implemented by Ma and colleagues (Ma et al. 2014). FUNtervals consisted of performing large, whole body movements along with a fun story line to keep children engaged.

Exercises were performed in a Tabata format, which involved 20 sec of exercise interspersed by 10 sec of rest, repeated eight times, resulting in a 4 min workout (Ma et al. 2014).

In addition to CAB, physical activity within the classroom can also take place in the form of physically active lessons (PAL), which consist of incorporating physical activity into classroom lessons while students learn new academic material (Daly-Smith et al. 2018; Watson et al. 2017). Typically, PAL are of lower intensity and longer duration than CAB as they range from 10 to 60 minutes (Daly-Smith et al. 2018; Watson et al. 2017) and often either report low- to moderate-intensity physical activity, or fail to report intensity at all (Daly-Smith et al. 2018; Watson et al. 2017). Major concerns in terms of feasibility of PAL include time efficiency and teacher planning; although there are many accessible forms of PAL that teachers can purchase which have already developed PAL plans, teachers have mentioned that they do not directly link to their school's specific curriculum, and therefore teachers had to spend additional time adapting these PAL in order to teach the academic content in a way that made sense for their class (Gately et al. 2013). Planning and preparation for lessons already accounts for a significant portion of a teacher's daily reponsibilities, therefore teachers perceive this additional planning as a significant barrier to implementing PAL within their classrooms (Gately et al. 2013).

In addition to the actual duration of the PAL, additional time is required for additional equipment set up and clean up of the activity resulting in significant time taken away from regular classroom lessons (Gately et al. 2013; Goh et al. 2013). Time efficiency is important because teachers cite that time is a primary barrier preventing them from implementing more physical activity within the classroom (Cothran et al. 2010; Gately et al. 2013; Goh et al. 2013; Webster et al. 2015a). This is mostly due to an overloaded curriculum that places priority on academics

(Cothran et al. 2010; Gately et al. 2013; Goh et al. 2013; Webster et al. 2015a), which is problematic because of the sedentary nature of academic lessons.

In contrast with PAL, the high-intensity nature of CAB allow them to be more time efficient, as they range from 4 to 10 min (Bershwinger et al. 2013; Carlson et al. 2015; Erwin et al. 2011; Ma et al. 2014; Ma et al. 2015; Murtagh et al. 2013; Watson et al. 2019) in duration. Additionally, they often involve no additional equipment (Beemer et al. 2018; Erwin et al. 2011; Ma et al. 2014; Murtagh et al. 2013) and therefore set up and clean up is minimal. This has been exemplified by students taking only ~1 min to transition from lesson time to the activity break, and less than 30 seconds to transition from the activity break back to lesson time (Beemer et al. 2018). Therefore, time efficient CAB may be a feasible intervention for improving children's physical activity levels (Erwin et al. 2011), perhaps even more so than PAL.

Table 1: *Classroom activity breaks within the literature*

Name	Reference	Exercises Performed	Format of Exercises	Duration
FUNtervals	Ma et al. 2014	Large, whole body movements	Performed following a story line Tabata (20 sec on, 10 sec rest)	4 min
Bizzy Break!	Murtagh et al. 2013	Mobility and aerobic exercises	Performed along with music	5-10 min
ACTI-BREAK	Watson et al. 2018		Incorporated games, following instructions, and technology	5 min
Classroom based activity break	Webster et al. 2015	Exercises focused on MVPA and gross motor skills	Four exercises for 30 sec each, repeated four times	8 min
Physical activity breaks	Erwin et al. 2011	Activities that could be performed in a small space	Various activity break cards provided to the teacher	5-10 min
Teacher led activity breaks	Bershwinger et al. 2013	Included, but not limited to, jumping jacks, spelling jacks, walking breaks, outdoor/classroom games	Created by teachers/students Numerous classroom games	5-15 min
Brain BITES	Howie et al. 2014	Whole body aerobic exercises	Fun and engaging, performed to music	5, 10, or 20 min

Classroom Activity Breaks & Physical Activity

To further illustrate the potential of CAB to be a successful intervention for improving children's physical activity levels, research has begun to reveal a positive association between CAB and physical activity in children (Carlson et al. 2015; Daly-Smith et al. 2018; Watson et al. 2017). Following CAB interventions across six elementary schools, children's physical activity levels were positively influenced by the intervention (Carlson et al. 2015). Specifically, students of teachers who reported holding CAB at any point throughout the intervention were 75% more likely to meet MVPA guidelines, and consequently 11% more students met the guidelines than students of teachers who never implemented CAB (Carlson et al. 2015). If CAB are capable of this effect in Canadian children, then the percentage of children meeting the physical activity guidelines would increase from 35% to 46%, consequently improving the Overall Physical Activity grade from a D+ to a C-. Overall, minutes of CAB per day had a small, positive association with student MVPA (Carlson et al. 2015).

Further, it has been shown that CAB can positively influence children's physical activity both in terms of steps (Bershwinger and Brusseau 2013; Erwin et al. 2011) and minutes of MVPA (Bershwinger and Brusseau 2013; Carlson et al. 2015). More specifically, it was found that following implementation of 10 min CAB 1-3 times per day, children's steps increased by 18% and their minutes of MVPA increased by 26% (Bershwinger and Brusseau 2013), which led to students taking an average of 5651±627 steps and participating in 22.3±3.5 min of MVPA per day at the end of the intervention (Bershwinger and Brusseau 2013). Similarly, implementation of a single 10 min CAB per day led to a 33% increase (~1100 steps) in number of steps students took during the school day (3317±1592 steps) compared to a control group that did not receive any

CAB (2195±919 steps) (Erwin et al. 2011). Overall, it is clear that CAB have a strong potential to positively influence children's physical activity levels.

Classroom Activity Breaks & On-Task Behaviour

In addition to physical activity, CAB have also been shown to be beneficial in improving on-task behaviour (Daly-Smith et al. 2018; Watson et al. 2017). To date, most of the research has implemented PAL, while fewer studies have examined the effects of CAB (Daly-Smith et al. 2018; Watson et al. 2017) (Table 2). However, of the few studies that have investigated CAB and on-task behaviour, results consistently show that CAB are associated with improvements in on-task behaviour (Howie et al. 2014; Ma et al. 2014; Webster et al. 2015b). Across these studies, the average improvement in on-task behaviour was 16.5% (Howie et al. 2014; Ma et al. 2014; Webster et al. 2015b). Some CAB were teacher led (Webster et al. 2015b), whereas others were researcher led (Howie et al. 2014; Ma et al. 2014), however the improvement in on-task behaviour remained consistent, indicating that adequately trained teachers can successfully implement CAB.

Table 2: Classroom activity breaks and on-task behaviour

Reference	Age	CAB	On-task behaviour measurement	Results
Howie et al. 2014	Grade 4 & 5	5, 10, or 20 min Researcher led Aerobic activities	Direct observation from videotapes	10% improvement in on-task behaviour following 10 min CAB
Ma et al. 2014	Grade 2 & 4	4 min Researcher led HIIT	Direct observation in the classroom	Grade 4: 12% improvement Grade 2: 27% improvement
Webster et al. 2015	Preschool (age 3-5)	10 min Teacher led Exercise focused on MVPA and gross motor skills	Direct observation in the classroom	17% improvement in on-task behaviour

NOTE: CAB – classroom activity break; HIIT – high-intensity interval training; MVPA – moderate-vigorous physical activity

Additionally, intensity and duration of the CAB seem to influence improvements in on-task behaviour (Daly-Smith et al. 2018). CAB of 10 min in duration have consistently shown successful results (Carlson et al. 2015; Howie et al. 2014; Webster et al. 2015b), however it was found that CAB 5 min in duration had no influence on time spent on task (Howie et al. 2014). This may indicate that in order for CAB to be shorter than 10 min, the physical activity must be more intense, as a 4 min CAB in the form of high-intensity interval training was successful in improving on-task behaviour in grade 2 and grade 4 students (Ma et al. 2014). Interestingly, this form of CAB, termed FUNtervals (Ma et al. 2014), was associated with the largest improvement, as on-task behaviour increased by 27% in the grade two classroom. These findings may highlight the efficiency and success of short, high-intensity CAB for improving on-task behaviour.

Another important consideration is the initial amount of on-task behaviour students exhibit and how this influences the magnitude of improvement seen following a CAB. It has been documented that children who exhibit the lowest levels of on-task behaviour during a normal classroom lesson experience the largest improvement following a CAB (Ma et al. 2014; Mahar et al. 2006; Webster et al. 2015b) (Table 3). For example, low on-task children spent almost 0% of the observation time exhibiting on-task behaviour, which then increased to ~50% following a CAB (Ma et al. 2014). Consequently, significant correlations were observed between the amount of off-task behaviour on a no-activity day and the decrease in all three types of off-task behaviour on days where CAB were implemented ($r = 0.72\text{-}0.82$, $p<0.001$) (Ma et al. 2014). This indicates that CAB may be most beneficial for students who normally exhibit lower levels of on-task behaviour.

Although previous research has shown that students spend more time on-task in the morning than the afternoon (Godwin et al. 2016; Martin et al. 2015; Muyskens and Ysseldyke 1998), there has been no research to date investigating how the three types of off-task behaviour

change across the school day, nor how CAB might improve on-task behaviour in the morning compared to the afternoon.

Table 3: Improvement in on-task behaviour between high- and low- on-task students

Reference	Mean Improvement	High On-task Improvement	Low On-task Improvement
Ma et al. 2014	Grade 2: 27% Grade 4: 12%	Grade 2: 17% Grade 4: 7%	Grade 2: 50% Grade 4: 37%
Mahar et al. 2006	8%	-	20%
Webster et al. 2015	17%	2%	31%

Gaps in the Literature

Although CAB are capable of inducing an improvement in on-task behaviour following the CAB, current research is limited in the sense that there is a general lack of standardization as to when and how often CAB are taking place during the school day. For example, some interventions highly encourage teachers to provide at least one CAB each day (Erwin et al. 2011; Mahar et al. 2006), while some allow scheduling of CAB to be left to teacher discretion (Watson et al. 2019). The latter statement is exemplified by 15% of interventions taking place before the first recess, 25% between the first recess and lunch, and 60% between lunch and the end of the day (Murtagh et al. 2013). This is of importance because it highlights the lack of standardization in the time of day CAB are taking place, which does not allow for knowledge to be gained regarding the number of activity breaks or what time of day implementing a CAB would have the most beneficial influence on physical activity levels and on-task behaviour.

There has been one study to our knowledge that investigated the idea of timing and dose of physical activity on selective attention in children (Altenburg et al. 2016). Specifically, selective attention was examined in response to one or two bouts of moderate-intensity physical

activity in the morning. One group of children underwent one bout of physical activity after 110 min of sitting, whereas another group participated in one bout first thing in the morning, and then again after 110 min of sitting. Analysis of the entire morning indicated that two bouts were more beneficial than one for improving selective attention (Altenburg et al. 2016). Interestingly, the improvement in attention following the first bout of activity was sustained for 90 min, or until the following bout of activity took place (Altenburg et al. 2016). Although this provides some insight to an optimal dose and timing of a bout of physical activity, it has limited applicability to CAB and on-task behaviour. Additionally, both bouts of activity took place in the morning, therefore the gap in the research regarding optimal timing of CAB is far from filled.

Purpose

It is clear that CAB have the potential to be a feasible and effective intervention to improve children's physical activity levels as well have a positive influence on children's behaviour in the classroom. However, before CAB are recommended to teachers and school boards as an effective intervention, more needs to be learned regarding when and how often they should be implemented to have the greatest effects. Therefore, the purpose of the present study will be to compare the effects of CAB at different times of day on on-task behaviour and physical activity levels in children. Overall, results from the proposed research will assist in determining the optimal timing and frequency of CAB during the school day for improving on-task behaviour and physical activity levels in children.

Hypotheses

We hypothesize that CAB in the morning and afternoon periods will be equally successful in improving students' on-task behaviour in the classroom. Although there is limited research examining the effect of CAB at different times of day on on-task behaviour upon which to base this hypothesis, research reviews and meta-analyses show consistent improvements in on-task behaviour following CAB, despite them occurring at various times of day across studies (Daly-Smith et al. 2018; Watson et al. 2014). Further, we hypothesize that performing a CAB both in the morning and afternoon on the same day will induce even greater improvements in on-task behaviour than performing just one CAB either in the morning or afternoon. Finally, we hypothesize that performing at least one CAB will lead to increases in student MVPA. Previous research has been successful in showing an increase in physical activity levels, either through MVPA or number of steps, following the performance of a similar CAB (Bershwinger and Brusseau 2013; Erwin et al. 2011). Additionally, the type of CAB performed in the present study is adapted from a type of high-intensity interval training that is designed to be moderate-vigorous in nature (Ma et al. 2014).

CHAPTER 2

The influence of classroom physical activity breaks at different times of day on off-task behaviour and physical activity levels in primary school children

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Introduction

Primary school children are at a critical age for developing habits that will impact both their health and academic achievement throughout their life. Two factors that play an important role in influencing these outcomes are physical activity and classroom behaviour. In terms of physical activity, Canada's "24 h Movement Guidelines for Children and Youth" currently suggests that children between the ages of 5-17 y should participate in 60 min of moderate-vigorous physical activity (MVPA) per day in order to experience health benefits (Tremblay et al. 2016). However, the 2018 ParticipACTION Report Card on Physical Activity for Children and Youth found that only 35% of Canadian children 5-17 y are meeting the physical activity guidelines, achieving a grade of D+ for overall physical activity (Barnes et al. 2018; ParticipACTION 2018). This is problematic because in addition to physical activity having benefits for physical health, it also has important cognitive benefits such as improvements in memory, attention, and academic achievement (Castelli et al. 2007; Chu et al. 2016; Davis et al. 2011; Kao et al. 2017; Pesce et al. 2009; Rasberry et al. 2011).

Classroom behaviour is also important to consider because behavioural regulation such as being attentive, following instructions, and inhibiting inappropriate actions (McClelland et al. 2007), and has been shown to predict academic achievement (Owen et al. 2016). Specifically, on-task behaviour can be defined as behaviour that is engaged in, and related to, the learning task at hand (Ma et al. 2014). Conversely, off-task behaviour can be defined as behaviour that is disengaged from, and unrelated, to the learning task at hang (Ma et al. 2014) and can be divided into three categories – verbal (ie. talking to a classmate, speaking when not asked), motor (ie. fidgeting, walking around the room), and passive (ie. gazing off, day dreaming) (Ma et al. 2014). Importantly, physical activity has shown positive associations with on- and off-task behaviour in

classroom settings (Carlson et al. 2015; Howie et al. 2014; Ma et al. 2014; Mahar et al. 2006; Szabo-Reed et al. 2017; Webster et al. 2015b). For example, incorporating physical activity into classroom lessons improved on-task behaviour for observations ranging from 5 (Szabo-Reed et al. 2017) – 50 min (Ma et al. 2014) following the activity.

It is important to consider on-task behaviour and physical activity within the school day because children spend a large amount of time at school. Currently, scheduling for recess and physical education class is a low priority for schools, therefore most of the school day is spent in the classroom during lessons (Weaver et al. 2016). This is problematic, as children typically spend less than 60% of the time on-task in regular education classrooms (Fischer et al. 1980; Lee et al. 1999; Godwin et al. 2016), and 64% of a child's total daily sedentary time occurs within the classroom (Bailey et al. 2012). Consequently, children are only participating in 15-30 min of MVPA during the school day (Carlson et al. 2013). Therefore, because children spend a lot of time in the classroom, and this time is largely off-task and sedentary, the classroom is an ideal place for an intervention aimed at improving both on-task behaviour and physical activity levels.

Classroom activity breaks (CAB) are a type of physical activity intervention for children that are gaining popularity within schools and the research field for improving on-task behaviour and physical activity levels. CAB can be defined as "short bouts of physical activity, often moderate to vigorous in nature, between periods of academic instruction" (Daly-Smith et al. 2018). There are various forms of CAB throughout literature using a variety of formats and exercises, however one specific example of interest is the "FUNtervals" CAB implemented by Ma and colleagues (Ma et al. 2014). FUNtervals consisted of performing large, whole body movements along with a fun story line to keep children engaged. Exercises were performed in a Tabata format,

which involved 20 sec of exercise interspersed by 10 sec of rest, repeated eight times, resulting in a 4 min workout (Ma et al. 2014).

The high intensity nature of CAB allow them to be time efficient, as they range from 4 to 10 min (Bershwinger et al. 2013; Carlson et al. 2015; Erwin et al. 2011; Ma et al. 2014; Ma et al. 2015; Murtagh et al. 2013; Watson et al. 2019) in duration. Additionally, they often involve no additional equipment (Beemer et al. 2018; Erwin et al. 2011; Ma et al. 2014; Murtagh et al. 2013) and therefore set up and clean up prior to and following the activity break is minimal and quick. Therefore, since CAB are time efficient and require little equipment, they may be a feasible intervention for improving children's physical activity levels (Erwin et al. 2011).

Research has begun to reveal a positive association between CAB and physical activity levels in children (Carlson et al. 2015; Daly-Smith et al. 2018; Watson et al. 2017). Specifically, students of teachers who reported holding CAB at any point throughout a 6 week intervention were 75% more likely to meet MVPA guidelines, and consequently 11% more students met the guidelines than students of teachers who never implemented CAB (Carlson et al. 2015). Further, CAB can increase number of steps and minutes of MVPA during the school day by 18% and 26%, respectively (Bershwinger and Brusseau 2013).

In addition to physical activity, CAB have also been shown to be beneficial in improving on-task behaviour (Daly-Smith et al. 2018; Watson et al. 2017). To date, most of the research has implemented physically active lessons, while fewer studies have examined the effects of CAB (Daly-Smith et al. 2018; Watson et al. 2017) (Table 2). However, of the few studies that have investigated CAB and on-task behaviour, results consistently show that CAB are associated with improvements in on-task behaviour (Howie et al. 2014; Ma et al. 2014; Webster et al. 2015b), with an average improvement in on-task behaviour of 16.5% (Howie et al. 2014; Ma et al. 2014;

Webster et al. 2015b). Some CAB were teacher led (Webster et al. 2015b), whereas others were researcher led (Howie et al. 2014; Ma et al. 2014), however the improvement in on-task behaviour remained consistent, indicating that adequately trained teachers can successfully implement CAB.

Although CAB are capable of inducing an improvement in on-task behaviour and physical activity levels following the CAB, current research is limited by a general lack of standardization as to when CAB take place during the school day. This prevents knowledge to be gained regarding what time of day CAB would have the most beneficial influence on physical activity levels and on-task behaviour. Therefore, the purpose of the present study was to compare the effects of CAB at different times of day on on-task behaviour and physical activity levels in children.

Methods

Participants

Thirty-five primary school children (grade 1-3) were recruited across five different classrooms to participate in this study. The experimental procedures were explained fully to the classroom teacher, the students, and the parents. Students were physically healthy as indicated by the Get Active Questionnaire (GAQ), which was completed by the child's parent or guardian. Written informed consent was obtained from the child's parent/guardian and informed assent was subsequently obtained verbally from the children. Only children whose parent/guardian provided written informed consent were included in data collection, however all students within the classroom participated in the CAB, as they were all physically capable to do so. Additionally, a demographic questionnaire regarding information such as age and physical activity habits was completed by the child's parent/guardian. Teachers of each classroom also consented to completing an exit survey regarding their thoughts and perceptions toward physical activity in the

classroom following the completion of the fourth experimental session. The Research Ethics Board at Wilfrid Laurier University approved this study in accordance with the ethical standards of the *1964 Declaration of Helsinki*.

Study Design

Each classroom participated in one familiarization day and four experimental sessions during which physical activity and on- and off-task behaviour were measured. Experimental sessions consisted of CAB in four different conditions – CAB in the: 1) morning (AM); 2) afternoon (PM); 3) both morning and afternoon (BOTH); 4) or a no activity break control (CTRL). The order of these sessions was randomized and systematically rotated between classrooms. The day of the week in which the experimental sessions were conducted was standardized within classrooms, and never occurred on a day where the classroom had physical education class. Classrooms were classified as either "traditional" or "balanced," based on their nutrition and recess break schedule. Traditional classrooms had a morning recess, a lunch hour, and an afternoon recess, whereas balanced classrooms had two longer recesses – one in the morning and one in the afternoon.

Pre-Experimental Procedures

All classrooms underwent a familiarization session one week prior to data collection. The familiarization consisted of the participants wearing accelerometers, being exposed to the researcher being in the classroom for the entire school day, and participating in the type of CAB that was used during each experimental session. The familiarization session was important to eliminate the reactivity effect of students to both the accelerometers and the presence of the researcher in the classroom (Ma et al. 2014; Mahar et al. 2006).

Experimental Sessions

Experimental sessions spanned across 24 h (Figure 2). At the beginning of the school day, participants were fitted with accelerometers for the continuous measurement of physical activity throughout the subsequent 24 h. Classrooms underwent their normal classroom routine other than the implementation of the CAB. During the AM condition, the CAB took place 30 min after the start of the school day. Due to the differences in recess breaks between the two school day schedules, the scheduling of the CAB in the PM condition was slightly different between them. In the traditional school day, the afternoon CAB took place 30 min after the lunch break. In the balanced day, it took place 30 min after the second nutrition break. During the BOTH condition, both the morning and afternoon CAB were performed in the same day. During the CTRL condition, there was no CAB and the classroom underwent their normal routine for the entire day. On- and off-task behaviour measurement took place during observation periods that began 35 min after the beginning of the school day (Morn Obs) while the afternoon (Aft Obs) was 35 min after lunch (traditional) or the afternoon recess (balanced) and continued for the remainder of the school period, with the duration of the observation ranging from 45-140 min depending on the classroom schedule. Morning and afternoon observation periods took place in all conditions regardless of whether or not a CAB was performed prior. Accelerometers were then collected the following morning at the beginning of the school day.

Classroom Activity Break

The CAB consisted of FUNterval activities, which are in the form of high-intensity interval training (Ma et al. 2014). FUNtervals were always performed in the classroom with no additional equipment required, and followed a Tabata protocol (Tabata et al. 1996), which consisted of 20 sec of high-intensity activity separated by 10 sec of rest, repeated 8 times for a total of 4 min.

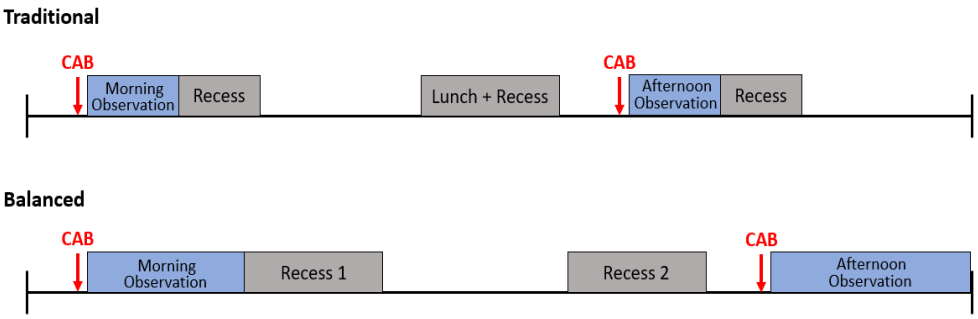

Figure 2: experimental session timeline

Students were instructed to perform large, whole body movements as fast as possible along with a fun story line to keep students engaged (Appendix A). The specific FUNterval activity and storyline was standardized based on condition (Appendix B), and no FUNterval was repeated within a classroom. Four out of five FUNterval activities used were developed by Ma and colleagues (2014), whereas one was originally developed by the primary researcher (AAB) to use for this project. FUNterval activities were led by the researcher (AAB) following tips from the original creatures (Ma et al. 2015) to ensure instructions were appropriate and consistent across classrooms. Observers rated each child's participation in the FUNterval activities based on the intensity of participation and adherence to the activity. Participation was graded on a scale of 0-3, with a 0 representing no participation, and a 3 representing enthusiastic participation throughout the entire duration of the FUNterval activity.

FUNtervals were chosen as opposed to any other type of CAB found in the literature primarily due to it being one of the highest intensity and shortest duration CAB developed. There is evidence to suggest that the effectiveness of the CAB to improve off-task behaviour is intensity-dependent (Daly-Smith et al. 2018), therefore choosing a CAB of high-intensity is more likely to yield positive results. Additionally, the high-intensity nature is more likely to be classified as

MVPA, which we were interested in improving. Finally, the various exercises included in the CAB follow a fun story line, which is more likely to keep children of this age interested in participating in the activity to their greatest ability. This is necessary in order to have the greatest influence on their on- and off-task behaviour and physical activity levels.

Physical Activity Levels

Physical activity was measured using activPAL accelerometers which were secured along the midline of the anterior thigh of each student with a waterproof adhesive (Tegaderm) and worn for the entire 24 h duration of the experimental sessions. Data concerning limb position was recorded according to manufacturer settings and subsequently analyzed using a custom R package (Lyden et al. 2018). The R package analyzed activPAL "events" files to determine minutes spent in various activities based on MET values: sedentary behaviour (>1.5 MET), LPA (1.5-2.99 MET), and MVPA (>3 MET). Classification accuracy for the MET values and their respective activity has been previously shown to be acceptable using activPAL accelerometers (Van Loo et al. 2016). Additionally, activPAL accelerometers have been shown to be a valid and reliable measurement of physical activity in children in classroom and free-living settings (Davies et al. 2012; Janssen et al. 2014; Ridley et al. 2016), and children have shown good compliance with wearing the accelerometers for a 7-day period (Davies et al. 2012).

Behaviour Observations

On- and off-task behaviour was measured via systematic time sampling observation performed by the primary researcher (AAB) for all data collection, as well as a secondary researcher which varied across classrooms. This method has been used previously in research (Howie et al. 2014; Ma et al. 2014; Mahar et al. 2006) and consists of a group of 5-6 students being observed in a systematic manner. The observation schedule included a 20 sec observation of a

given student, followed by a 10 sec break before moving to the next student. Rotating observations within these 5-6 students continued for a 10 min period before a 2.5 min break, resulting in each student being observed 3-4 times, for a total of 60-80 sec, within a 10 min period of observation. During observations, the duration and occurrence of on-task behaviour, as well as motor, verbal, and passive off-task behaviour were recorded. Both researchers observed the same 5-6 students in the same order, and observations were compared to ensure reliability.

Observations were recorded on a custom smartphone app developed specifically for the present study (Appendix C). Many apps currently available for download on smartphones (either free or paid) utilize partial or whole interval recording, where only one behaviour can be recorded during an observation interval. The current study measured four different behaviours, and therefore if more than one behaviour occurred during an interval, they would be unaccounted for using this method. Additionally, this method does not allow for duration of behaviour to be recorded and therefore percentage of time spent in the four different behaviours being measured would be inaccurate. The custom app had observers select buttons corresponding with each behaviour in real-time as the student was exhibiting that behaviour, and allowed for multiple behaviours to be recorded within an observation interval. Additionally, the duration of each behaviour was recorded, and could be expressed in seconds or as a percentage of total time observed. Overall, the development and use of this custom smartphone app allowed for a more detailed and accurate representation of the time each student spent in the four behaviours being measured.

Observer Training and Inter-Observer Reliability

Prior to data collection, all observers were given detailed definitions and examples of each behaviour that would be observed and recorded, which were obtained from the Behavioural

Observation of Students in Schools (BOSS) tool (Shapiro 1996). Observers first practiced observations on pre-recorded videos of primary school children in a classroom setting. Practice continued until an inter-observer reliability of >90% was consistently achieved. Additionally, inter-observer reliability was calculated following each data collection session to ensure that observations and reliability were consistent throughout the duration of the study. Inter-observer reliability continued to remain >90% throughout all data collection sessions.

Statistical Analysis

Students were grouped based on the schedule of their school day (TSD vs BSD), and a two-way repeated measures ANOVA (condition (4) x school schedule (2)) was conducted to examine potential differences in on-task behaviour between school day schedule. No differences between students with a traditional schedule and those with a balanced schedule were noted for changes in on-task behaviour or physical activity levels (consistent with previous literature; see Clark et al. 2019; Vanderloo & Tucker 2016). Therefore, all participants were analyzed as a single group for all measures included in the results section of this document.

On-task behaviour was first averaged across both the morning and afternoon observation periods to get a total on-task behaviour percentage of the entire school day for each student. A one-way repeated measures ANOVA was conducted to determine differences between conditions. Observations were also averaged within both the morning and afternoon observation period to get a percentage of time spent in on-task, off-task motor, off-task passive, and off-task verbal behaviour for each student in the morning and afternoon. A two-way (condition (4) x observation period (2)) repeated measures ANOVA was used to examine differences in on-task and off-task behaviour between conditions and observation periods.

Additionally, a quartile split was conducted on control day data for off-task behaviour, and students whose rates of off-task behaviour fall into the highest quartile were considered low on-task students. A three-way mixed ANOVA (condition (4) x observation period (2) x amount on-task (2)) was conducted to examine potential differences in high vs low on-task students across conditions and observation periods. Additionally, a correlation analysis was conducted between off-task behaviour on the control day and amount of decrease in off-task behaviour following a CAB both in the morning and afternoon.

In terms of physical activity, a one-way repeated measures ANOVA was used to determine differences in both 24 h MVPA and number of steps between conditions. Additionally, MVPA and number of steps during just the school day were also analyzed using a one-way repeated measure ANOVA between conditions.

All statistical analyses were performed on SPSS statistics software (IBM Software, Armonk, NY), and Bonferonni post hoc analyses were used when necessary. Significance was set at $p<0.05$, and all data is presented as means±SD. Cohen's *f* was used to calculate effect sizes for ANOVA tests, where 0.04 indicated a small effect size, 0.25 indicated a medium effect size, and 0.64 indicated a large effect size. Cohen's *d* was used to calculate effect sizes for post hoc comparisons, where 0.2 indicated a small effect size, 0.5 indicated a medium effect size, and 0.8 indicated a large effect size. Figures were created using Prism (GraphPad Software, San Diego, CA).

Results

Participants

Thirty-five grade 1-3 (grade 1: n=18, grade 2: n=16, grade 3: n=1) students aged 6.25±1 y were recruited from four local private schools to participate in the current study. Students and their parents had the option to select which portion of data collection they wished to participate in (on-task behaviour observations and/or physical activity measurement), and consequently 34 students are included in on-task behaviour data and 26 in physical activity data.

Participation in CAB

Average participation in the CAB was 2.5, 2.4, 2.7, and 2.4 for AM, PM, BOTH (morning), and BOTH (afternoon), respectively. Therefore, children were actively participating in all CAB.

On-task Behaviour

When on-task behaviour was averaged across both observation periods, the AM (58.3±8.2%), PM (58.2±8.5%), and BOTH (61.9±9.2%) conditions were greater (p<0.001, f=0.778, large) than CTRL (47.9±11.4%) (Figure 3a). Additionally, there was a condition x time interaction (p<0.001, f=0.628, medium) for on-task behaviour (Figure 3b), where in the morning observation period, the AM (65.4±12.9%) and BOTH (63.3±14.5%) conditions were greater (p<0.017, d>0.39, small) than PM (55.9±9.6%) and CTRL (50.6±13.6%). In the afternoon observation period, AM (51.4±8.2%), PM (60.8±9.8%), and BOTH (60.5±9.3%) conditions were greater (p<0.010, d>0.49, small) than CTRL (45.4±13.0%), whereas PM (60.8±9.8%) and BOTH (60.5±9.3%) were also greater (p<0.001, d>0.70, medium) than AM (51.4±8.2%). Additionally, on-task behaviour in the afternoon observation period was lower (p<0.036, d>0.43, small) than the morning observation period in CTRL (45.4±13.0% vs 50.6±13.6%) and AM (51.4±8.2% vs

65.4±12.9%), though greater (p=0.004, d=0.34, small) in the afternoon observation period than the morning observation period in PM (60.8±9.8% vs 55.9±9.6%). There was no difference in on-task behaviour between the morning and afternoon observation periods for the BOTH condition (63.3±14.5% vs 60.5±9.3%, p=0.306, d=0.05, no effect).

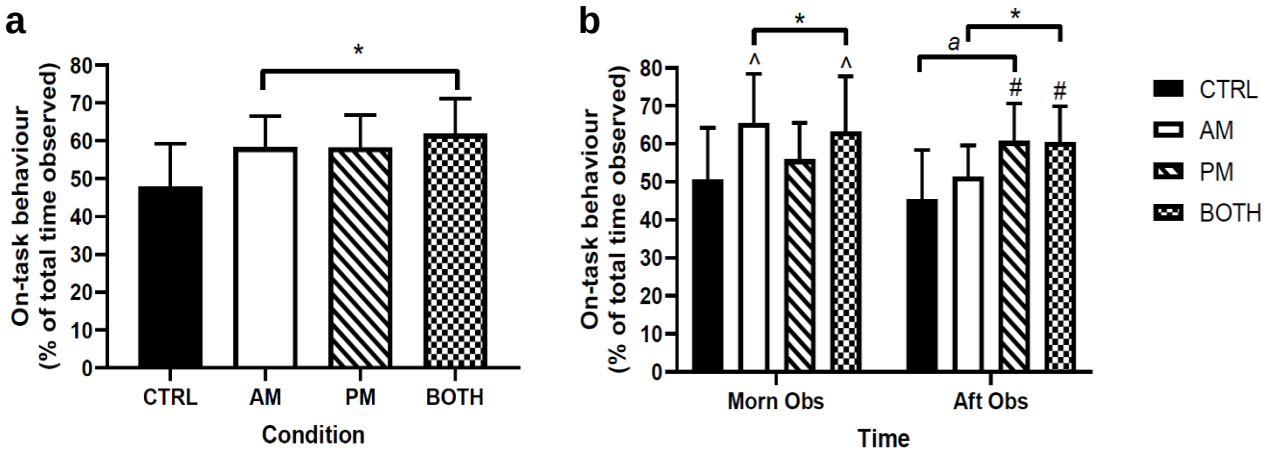

Figure 3: **a** – total on-task behaviour across both observation periods, between conditions. *, significantly greater than CTRL. **b** – on-task behaviour across observation period (time) and condition. *, significantly greater than CTRL. ^, significantly greater than PM. #, significantly greater than AM. *a*, significantly different than Morn Obs.

High vs Low On-Task Students

Students in the highest quartile for off-task behaviour were classified as low on-task and were on-task less than 45% of the time during the CTRL condition. There was no three-way interaction for condition x observation period x amount on-task (p=0.111, f=0.256, medium). There was also no observation period x amount on-task interaction (p=0.388, f=0.116, small). However, there was a condition x amount on-task interaction (p=0.012, f=0.424, medium) (Figure 4), where the AM (low: 52.6±2.7%, high: 60.2±1.5%), PM (low: 54.1±3.0%, high: 59.6±1.6%), and BOTH (low: 56.1±3.1%, high: 63.7±1.7%) conditions were greater (p<0.001) than CTRL (low: 33.4±2.9%, high: 52.4±1.6%) in both the high (d>0.89, large) and low (d>1.55, large) on-

task students. Additionally, on-task behaviour was greater (p<0.040) in the high on-task students during the CTRL (low: 33.4±2.9%, high: 52.4±1.6%), AM (low: 52.6±2.7%, high: 60.2±1.5%), and BOTH (low: 56.1±3.1%, high: 63.7±1.7%) conditions, with no difference (p=0.113) between high and low on-task students in the PM (low: 54.1±3.0%, high: 59.6±1.6%) condition.

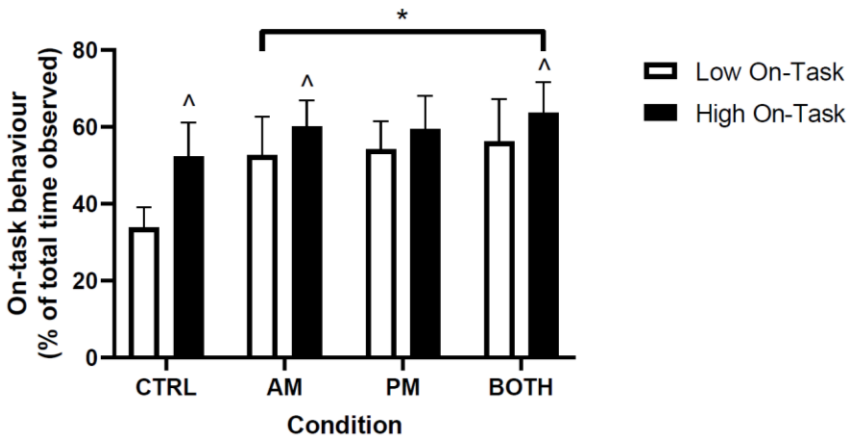

Figure 4: significant interaction effect for on-task behaviour across condition and amount on-task. *, significantly greater than CTRL. ^, significantly greater than low on-task

Additionally, there was a strong positive correlation (r = 0.67, p<0.001) for the relationship between total off-task behaviour in the CTRL condition and the amount of decrease in off-task behaviour following a CAB in the morning observation period (Figure 5a). Similarly, there was a strong positive correlation (r = 0.74, p<0.001) for the relationship between total off-task behaviour in the CTRL condition and the amount of decrease in off-task behaviour following a CAB in the afternoon observation period (Figure 5b). Together, this shows that the more off-task a student was without a CAB, the greater improvement in off-task behaviour they experienced following a CAB in both the morning and afternoon.

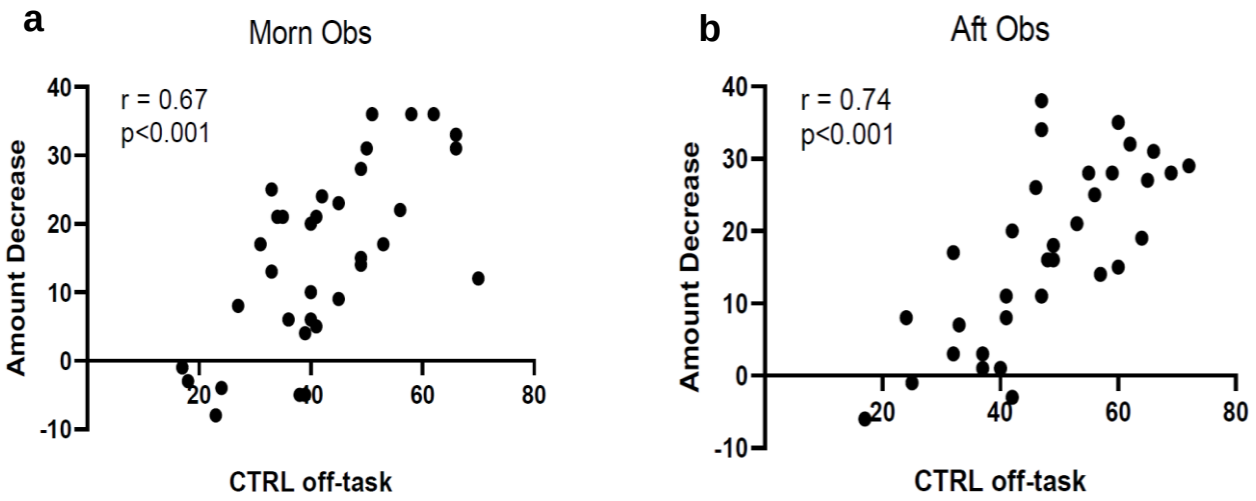

Figure 5: a – strong, significant correlation for amount of off-task behaviour during the morning observation period in CTRL condition, and the amount of decrease in off-task behaviour following a classroom activity break in the morning. *b* – strong, significant correlation for amount of off-task behaviour during the afternoon observation period in CTRL condition, and the amount of decrease in off-task behaviour following a classroom

Off-task Behaviour

Off-task Behaviour - Motor

There was a condition x time interaction (p<0.001, f=0.453, medium) for off-task motor behaviour (Figure 6a), where in the morning observation period the AM (9.4±1.3%) and BOTH (7.9±1.1%) conditions were lower (p<0.014, d>0.40, small) than CTRL (15.4±1.6%) and PM (13.6±1.5%). In the afternoon observation period, the PM (13.0±1.2%) condition was lower (p<0.024, d>0.40, small) than CTRL (16.2±1.5%) and AM (13.6±1.5%), while BOTH (13.7±1.6%) was lower (p=0.036, d=0.42, small) than AM (18.0±1.3%). Additionally, off-task motor behaviour in the afternoon observation period was greater (p<0.003, d>0.49, small) than the morning observation period in the AM (18.0±1.3% vs 9.4±1.3%) and BOTH (13.7±1.6% vs 7.9±1.1%) conditions, while there was no difference (p>0.663, d<0.07, no effect) between the morning and afternoon

observation periods for the CTRL (16.2±1.5% vs 15.4±1.6%) and PM (13.0±1.2% vs 13.6±1.5%) conditions.

Off-task Behaviour - Passive

There was a condition x time interaction (p=0.004, f=0.380, medium) for off-task passive behaviour (Figure 6b), where in the morning observation period the AM (16.0±1.9%) condition was lower (p=0.003, d=0.45, small) than CTRL (22.8±2.0%). In the afternoon observation period, the AM (19.4±1.3%), PM (14.1±1.6%), and BOTH (14.3±1.2%) conditions were lower (p<0.028, d>0.43, small) than CTRL (23.9±1.7%), while PM (14.1±1.6%) and BOTH (14.3±1.2%) were also lower (p<0.014, d>0.32, small) than AM (19.4±1.3%). Additionally, off-task passive behaviour in the afternoon observation period was lower (p<0.032, d>0.36, small) than the morning observation period in the PM (14.1±1.8% vs 19.8±1.6%) and BOTH (14.3±1.2% vs 19.1±1.9%) conditions, while there was no difference (p>0.129, d<0.23, small) between observation periods for CTRL (23.9±1.7% vs 22.8±2.0%) and AM (19.4±1.3% vs 16.0±1.9%).

Off-task Behaviour - Verbal

There was no condition x time interaction (p=0.432, f=0.167, small) for off-task verbal behaviour (Figure 6c), however there was a main effect of condition (p<0.001, f=0.671, large) where the AM (3.0±0.3%) and BOTH (3.1±0.3%) conditions were lower (p<0.001, d>0.82, large) than CTRL (5.9±0.6%) and PM (5.4±0.5%). Additionally, there was a main effect of observation period (p<0.001, f=0.761, large) where the morning observation period (3.3±0.3%) was lower than the afternoon observation period (5.4±0.5%).

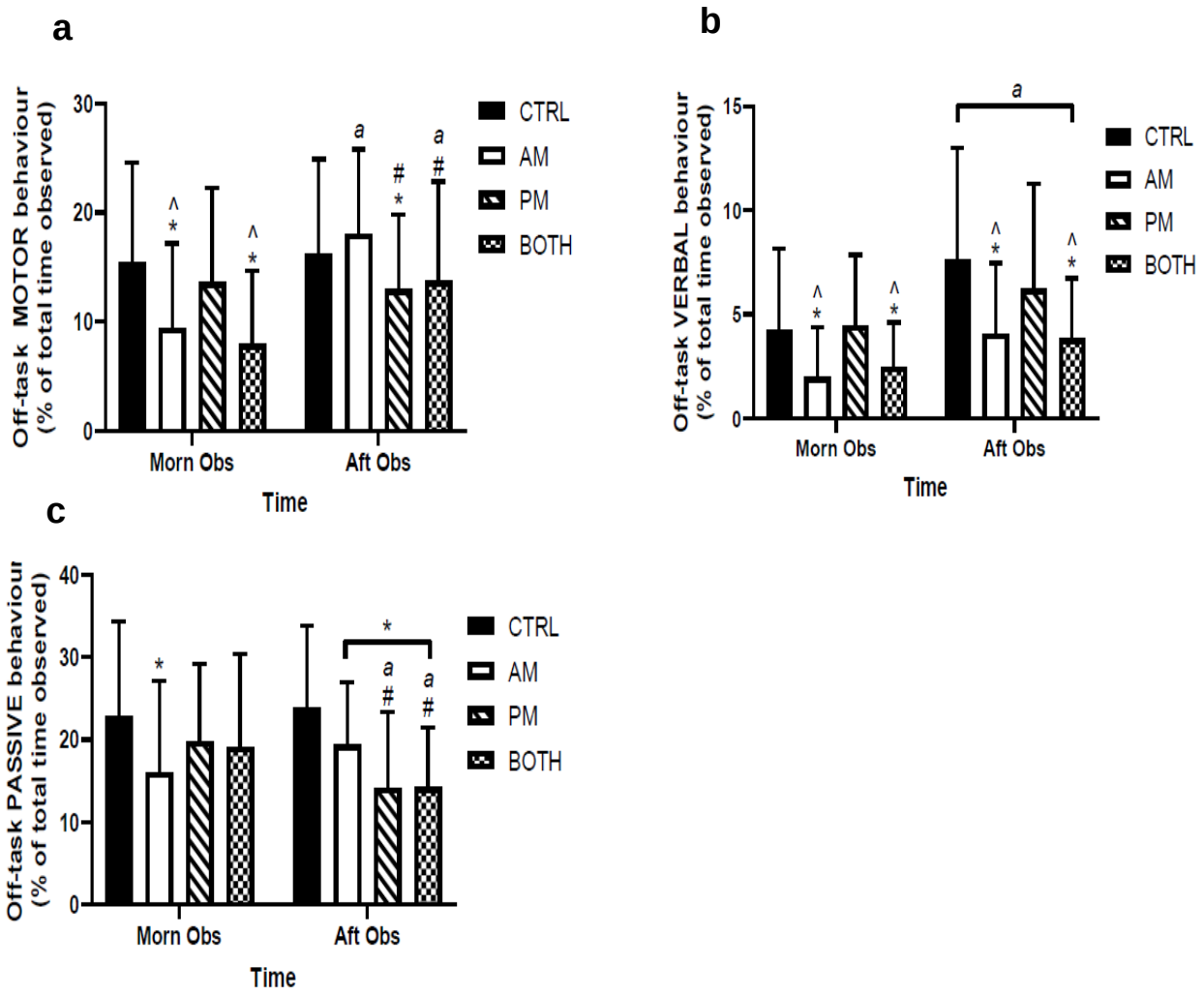

Figure 6: a – significant interaction effect for off-task motor behaviour across observation period (time) and condition. *b* – significant interaction effect for off-task passive behaviour across observation period (time) and condition. *c* – significantly main effect of condition and observation period (time) for off-task verbal behaviour.
*, significantly lower than CTRL. ^, significantly lower than PM. #, significantly lower than AM. a, significantly different than Morn Obs.

Physical Activity

MVPA across the entire 24 h period (Figure 7a) was greater (p<0.001, f=0.485, medium) in PM (68.7±2.0 min) compared to CTRL (56.5±1.6 min). Although the AM (64.9±3.1 min) and BOTH (62.8±2.0 min) conditions were not significantly greater than CTRL (56.5±1.6 min), they

were approaching significance at p=0.07 (d=0.93, large) and p=0.09 (d=0.47, small) respectively. There were no other differences in MVPA between conditions for the 24 h period. Additionally, there was no effect of condition on MVPA during the school day (p=0.177, f=0.061, small).

Number of steps across the 24 h period (Figure 7b) was greater (p=0.001, f=0.196, small) in PM (11530±362 steps) compared to CTRL (9615±314 steps), and BOTH (10727±288 steps) was approaching significance at p=0.07, d=0.45 (small), while AM (11055±580 steps) was not different (p=0.142, d=0.48, small). Additionally, number of steps during just the school (Figure 7c) day were greater (p<0.009. f=0.660, large) in AM (9788±519 steps), PM (9935±290 steps), and BOTH (9516±267 steps) compared to CTRL (7739±356 steps).

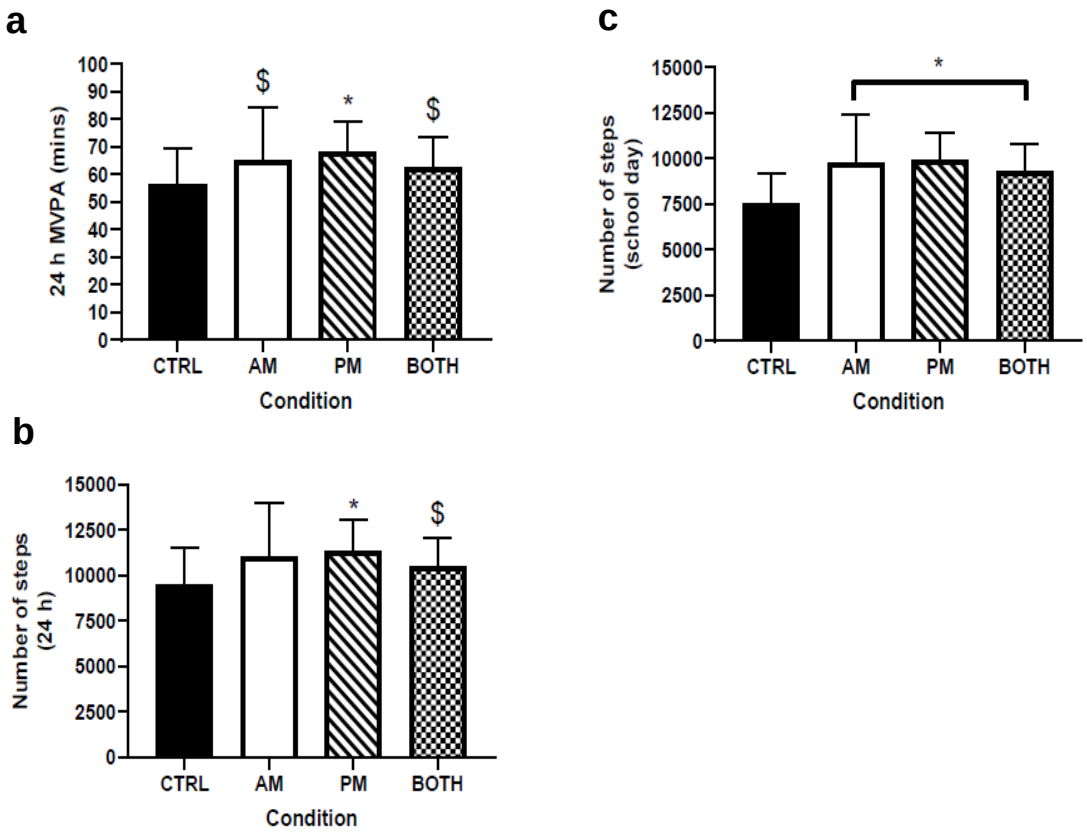

Figure 7: a – MVPA during the full 24 h period, across condition. *b* – number of steps taken during the 24 h period, across condition. *c* – number of steps taken during the school day, across condition.
*, significantly greater than CTRL. $, approaching significance to be greater than CTRL.

Teacher Perceptions

The exit surveys provided to all teachers was only completed by two of five teachers. Generally, these two teachers believed that CAB are beneficial for students, subjectively observed more focused behaviour in their students after a CAB had been performed, and believed that they would be willing/able to implement CAB 2-3 times per week.

Discussion

The present study revealed that classroom physical activity breaks (CAB) of 4 min in duration performed either in the morning or afternoon are capable of improving on-task behaviour in primary school students. However, slight differences were found in the type of off-task behaviour reduced as a CAB in the morning reduced off-task motor and verbal behaviour whereas a CAB in the afternoon reduced off-task passive behaviour. Therefore, it seems that performing two CAB – one in the morning and one in the afternoon – would have benefit as all types of off-task behaviours would be reduced across the school day. Finally, CAB both in the morning and afternoon were found to have a positive influence on important physical activity measures such as MVPA and number of steps taken.

On-Task Behaviour

On-task behaviour across the entire school day was improved when at least one CAB was implemented, regardless of time of day. Compared to control, CAB improved overall on-task behaviour by 10.4%, 10.5%, and 14% in AM, PM, and BOTH, respectively (11.6% average across all conditions). However, this average is across an entire school day and in order to examine potential differences based on time of day, morning and afternoon observation periods must be considered independently.

On-task behaviour was lower in the afternoon than the morning during CTRL (45.4% vs 50.5%), which coincides with previous research (Godwin et al. 2016; Martin et al. 2015; Muyskens and Ysseldyke 1998). Improvements in on-task behaviour where seen following a CAB in the morning (12.7%) and in the afternoon (15.1%) demonstrating the timing of a CAB is less important than actually performing a CAB, as the morning and afternoon CAB are equally successful in improving on-task behaviour. Additionally, there was a carry-over effect as a morning CAB improved on-task behaviour in the afternoon by 6%, suggesting that if a teacher only has time to perform a single CAB, in the morning may be the best approach. Moreover, our increases in on-task behaviour are comparable to previous research (8-27%), further supporting the efficacy of a CAB (Howie et al. 2014; Ma et al. 2014; Mahar et al. 2006; Webster et al. 2015). Of note, the present study was conducted in private schools rather than public schools suggesting that the benefits of CAB may transcend any major differences that may exist between schools such as class size, socioeconomic status, and family dynamics. Thus, it appears all students can benefit from more physical activity in the classroom.

Regarding the effects of biological sex, it is well-known that girls spend more time on-task than boys (Daly-Smith et al. 2018; Ma et al. 2014; Mahar et al. 2019; Masini et al. 2019). The present results support this, as girls spent ~7% more time on-task than boys during CTRL and 7 out of 8 low on-task students were boys. However, following a CAB either in the morning or afternoon, on-task behaviour was similar between boys and girls demonstrating a CAB may reduce any inherent biological sex differences for on-task behaviour.

Off-Task Behaviour

Off-task Behaviour - Motor

While the improvement in on-task behaviour was not different following a morning versus afternoon CAB, there were some differences noted in the reduction of off-task behaviour. Conditions in which a morning CAB was performed consistently exhibited a 6.5% average decrease in off-task motor behaviour, indicating that a CAB in the morning is successful at reducing off-task motor behaviour. On the other hand, performing an afternoon CAB led to a 4% average reduction in off-task motor behaviour though this reduction was only observed in the PM condition and not the BOTH condition, despite both conditions performing an afternoon CAB. This observation, together with a smaller average reduction following an afternoon CAB compared to a morning CAB, suggests that an afternoon CAB is only somewhat successful at reducing off-task motor behaviour.

The overall 5% reduction in off-task motor behaviour following a CAB was lower than the 15% reduction observed in previous research (Ma et al. 2014). Although this may seem like a large difference, it is important to note that average off-task motor behaviour following a CAB was similar between the current study (11%) and previous research (14%) suggesting the difference in magnitude is due to a difference in "baseline" off-task motor behaviour without a CAB (15% vs 29%). This may have important implications as classroom factors such as class size, socioeconomic status, teaching style, etc. may influence the amount of off-task motor behaviour students exhibit, and that performing a CAB may help mitigate these differences.

Off-task Behaviour - Passive

Interestingly, results for off-task passive behaviour show opposite trends to that of off-task motor behaviour. Performing a morning CAB led to an average 7% reduction in off-task passive behaviour only observed in the AM condition and not the BOTH condition, despite both conditions performing a morning CAB. This suggests a morning CAB may not be consistently successful for reducing off-task passive behaviour. On the other hand, conditions in which an afternoon CAB was performed consistently showed an average 9% reduction in off-task passive behaviour, indicating that a CAB in the afternoon is successful at reducing off-task passive behaviour. Additionally, reductions in off-task passive behaviour in the afternoon were slightly larger than those in the morning. Together, these findings suggest that an afternoon CAB may be more beneficial for reducing off-task passive behaviour than a morning CAB. Again, a carry-over effect was observed where performing a morning CAB reduced off-task passive behaviour in the afternoon by 4.5%, further supporting the idea that if only one CAB can be performed per day, a morning CAB might be the best option. The overall 7% reduction in off-task passive behaviour following a CAB was similar to the 9% reduction observed in previous research (Ma et al. 2014) suggesting that the amount of off-task passive behaviour students exhibit is fairly consistent across various classrooms.

Off-task Behaviour - Verbal

Although results for off-task verbal behaviour did not show an interaction effect, the main effect of condition and main effect of observation period reveal a similar story to off-task motor behaviour. Off-task verbal behaviour across the entire school day was reduced in the AM and BOTH conditions by 3% compared to the CTRL and PM

conditions. Additionally, off-task verbal behaviour was found to be 2% lower in the morning observation period than the afternoon. Together, this indicates that a morning CAB may be more successful in reducing off-task verbal behaviour than an afternoon CAB. The overall 2% reduction in off-task verbal behaviour following a CAB was similar to the 3% reduction observed in previous research (Ma et al. 2014) suggesting the amount of off-task verbal behaviour students exhibit is fairly consistent across various classrooms.

Overall, the changes in off-task behaviour in the morning and afternoon observation periods indicate that a morning CAB might be most beneficial for reducing off-task motor and off-task verbal behaviour, whereas an afternoon CAB might be more beneficial for reducing off-task passive behaviour. In this sense, conducting a CAB in both the morning and afternoon would have value, as all off-task behaviours would be reduced at some point across the school day. Due to this being the first study to examine changes in off-task behaviours across the school day, the reasons behind the pattern observed are unknown. However, it is logical to hypothesize that children have an abundance of energy in the morning that may be translated into increased off-task motor and verbal behaviour, thus 'burning this energy off' through a CAB may help to reduce these behaviours. On the other hand, later in the day children may feel 'fatigued' or 'burnt out' from spending the day at school leading to off-task passive behaviours such as daydreaming, thus performing a CAB provides them a means to get back on-task for the remainder of the afternoon.

The current study observed no differences between boys and girls, except for a 3.5% greater reduction in off-task passive behaviour in boys which is in line with the only other previous study to examine this (Ma et al. 2014), who demonstrated no differences between boys and girls except only boys reduced off-task motor and off-task passive behaviour following the CAB (Ma et al. 2014). These slight differences between studies could be due to the children in the present study

spending ~16% less time in off-task motor behaviour without a CABy (Ma et al. 2014). Therefore, it is possible that any potential sex differences in off-task motor behaviour were not exposed in the current study due to having less room for improvement following a CAB.

High vs. Low On-Task Students

The present results combined with previous research demonstrate a clear benefit of performing a CAB for improving on-task behaviour and reducing off-task behaviour in primary school students. However, previous research has indicated that these effects are most robust in students who are least on-task within the classroom (Ma et al. 2014; Mahar et al. 2019; Webster et al. 2015). In the present study, both high and low on-task students saw improvements in on-task behaviour in the AM, PM, and BOTH conditions compared to CTRL, which indicates that all students benefit from CAB both in the morning and afternoon. However, following a CAB, the low on-task students improved to a greater extent as there was a strong positive correlation between the amount of time spent off-task and the amount of improvement with a CAB. Specifically, high on-task students showed an 8.7% increase in on-task behaviour following a CAB, while low on-task students showed a 20.6% increase. These robust improvements in low on-task students may have significant practical applications considering students participating in off-task behaviours have the potential to cause classroom disruption. Therefore, inducing a large increase in on-task behaviour in low on-task students through a CAB may inadvertently benefit high on-task students as well, having a benefit on classroom behaviour as a whole.

Physical Activity

Our MVPA results on during CTRL confirm that children are not meeting Canada's 24 h Movement Guidelines for Children and Youth, in line with previous research (Colley et al. 2017). However, having children perform a CAB increased MVPA by 9 min, thus reaching the 60 min

per day guidelines and indicating that, on average, students met the guidelines when a CAB was performed. Interestingly the increase in MVPA was not seen during the actual school day and could be due to the activPAL accelerometers not classifying participation in the FUNterval as MVPA. The ActivPAL software uses an equation based on step cadence to estimate MET values during physical activity, and subsequently a cut point of >3 METs was used to classify activities as MVPA. It is important to note that many exercises during FUNtervals do not involve stepping, and therefore may not have been accurately classified. Although we do not have specific physical activity data for the 4 min spent participating in FUNtervals, we observed a high-level of child participation during the CAB suggesting the students were actively participating. It is possible that this participation in the CAB could have prompted students to also be more active after school, as exhibited in 24 h MVPA, coinciding with the activity synergy hypothesis (Goodman et al. 2011). On the other hand, the number of steps during the school day increased by an average 2007 steps (26%), indicating that CAB may be beneficial for increasing physical activity through number of steps taken. However, there were no changes in the number of steps taken across the 24 h period. This may imply that children compensate for increased steps during the school day by taking fewer steps after school, as suggested by the activitystat hypothesis (Gomersall et al. 2013), however it is important to note that the sample size for 24 h physical activity was smaller than school day physical activity, thus the main issue is likely lack of power rather than a physical activity compensation *per se*.

The mixed physical activity results observed in the current study reflect the inconsistent findings regarding the effects of CAB on physical activity throughout the literature which are likely due to differences in the type of physical activity variable measured, as variables include number of steps (Carlson et al. 2015; Erwin et al. 2011), sedentary time (Riley et al. 2013), light

physical activity (Whitt-Glover et al. 2011), and MVPA (Bershwinger and Brusseau 2013). Research suggests a CAB has a more consistent benefit on the number of steps (Masini et al. 2019), whereas research examining MVPA is much less consistent (Masini et al. 2019) and in line with our present results.

Overall, CAB in both the morning and afternoon were successful in improving physical activity levels through 24 h MVPA and number of steps during the school day, two important variables of consideration. Specifically, 24 h MVPA is the variable of interest within Canada's 24 h Movement Guidelines, thus seeing an improvement here is important. Additionally, number of steps can be measured through pedometers, which are easily accessible to individuals in the general public wishing to monitor their physical activity levels. Therefore, schools or teachers looking to implement a CAB intervention will be able to detect positive influences on their students' physical activity levels.

It is well-known that boys are typically more physically active than girls in terms of both MVPA and number of steps (Brusseau et al. 2011; Nettlefold et al. 2011; ParticipACTION 2018; Tudor-Locke et al. 2006; Tudor-Locke et al. 2011), however there were no sex differences noted for MVPA or number of steps in any of the four conditions in the present study. This may be due to the low sample size of girls included in physical activity data (girls: n=8, boys: n=19), or that data was collected from students attending private school, who likely have higher socioeconomic status and thus more opportunities for physical activity than the general population. Regardless, a positive improvement in MVPA and steps was noted for both boys and girls, thus supporting the effectiveness of CAB for improving physical activity levels.

Practical Applications

Although the benefits of CAB are clear, they have yet to be widely accepted by school boards and teachers. Teachers state that they believe implementing physical activity into the classroom is beneficial (Campbell & Lassiter 2020), however the major barrier preventing them from doing so is lack of time (Campbell & Lassiter 2020; Cothran et al. 2010; Gately et al. 2013; Goh et al. 2013). It is important to highlight that the CAB implemented in the current study was only 4 min long, and should be regarded by teachers as an investment, in which the return is large. For example, classroom periods in the BSD are 100 min long – if a teacher invests 4 min to perform a CAB, our research shows that students will consequently achieve 12% more time on-task, which equates to 12 min. Therefore, the net gain of learning time is an additional 8 min per 100 min period, which would undoubtedly have a positive influence on learning and academic achievement (supported by the teachers' exit survey where teachers acknowledged the positive influence of the CAB on children's behaviour in the classroom).

In order to promote the implementation of CAB to teachers, there are important factors that should be taken into consideration. Teachers spend a significant amount of time planning lessons (Gately et al. 2013), therefore CAB provided to teachers should come in a "ready to use" format. Specifically, FUNtervals (Ma et al. 2014) are readily available, easy to use, and require no additional equipment or training, making them a feasible intervention for teachers to implement. Overall, in order to increase the uptake of CAB throughout schools worldwide, communication between researchers and teachers is vital. It is the duty of researchers to demonstrate the benefits of performing these CAB to teachers a format that is understandable, meaningful, and feasible to meet the teacher's needs in their classroom. In this regard, FUNtervals have the potential to check

all the boxes and should be promoted to teachers and school boards to improve student health and academic achievement.

Strengths

The main strength of the present study is that it is the first to directly compare the effects of CAB at different times within the school day. To our knowledge, there are no previous studies directly investigating potential differences between morning and afternoon CAB in terms of their effects on physical activity levels and on-task behaviour. However, in order to do this, behaviour observations had to occur during different periods of the school day, resulting in different subjects and lessons being included in data collection. In this sense, there is an inherent lack of control in the present study and we believe this to be a study strength. Observing improvements in on-task behaviour in light of this classroom variability demonstrates the potential for CAB to benefit primary school classroom environments on a whole.

Limitations

Although the present study is innovative and has many strengths, it is not without its limitations. Most limitations in the present study are related to the collection and analysis of physical activity data. The activPAL accelerometer has yet to be fully validated in a primary age population such as the one in the current study (Janssen et al. 2014), as it has been shown to underestimate METs for activities classified as MVPA (Van Loo et al. 2016). The R package used to estimate minutes of MVPA uses an algorithm based on MET values provided by the activPAL software, and therefore could be underestimated as well. Additionally, activPAL uses an equation based on step cadence to estimate MET values for various activities, and therefore it is possible that activities during the FUNtervals not involving steps (i.e. squats) may not be assigned an appropriate MET value. Overall, we are unable to tell if the CAB implemented in the current study

was classified as MVPA by the activPAL accelerometers or the R package used to analyze the data.

Additionally, a few other unavoidable limitations in the present study should be noted. Data collection, for both physical activity and on-task behaviour, spanned across the entire school day and was therefore affected by the occasional occurrence of indoor recesses due to inclement weather. Specifically, indoor recesses occurred on four experimental sessions (1 CTRL, 3 AM, and 1 PM) and though there were no notable differences for on- or off-task behaviour between days with outdoor vs indoor recesses, the variability within the AM session due to a high incidence of indoor recesses may affect the ability to detect meaningful changes in physical activity. Another limitation was the inability to blind the researchers conducting the behaviour observations and while potential issues related to attempting to blind researchers to classroom activity have been detailed previously (Mahar et al. 2006), it would have been difficult to disguise the fairly obvious physical signs of participation in high-intensity exercise (Ma et al. 2014). Although inter-rater reliability does not eliminate the possibility of bias, it is important to note that our high inter-rater reliability (>90%) supports the accuracy of our observation across conditions.

Future Directions

Although the impact of CAB for on- and off-task behaviour is clearly illustrated through the current study and previous literature, there are many nuances within this relationship that have yet to be investigated. Specifically, there were some factors not controlled for in the present study that would be of interest and importance to investigate further, such as lesson type and indoor recesses. Controlling for not only subject but lesson type as well (i.e. group work, carpet lesson, individual desk work, etc.) will allow researchers to examine whether there are certain types of activities in the classroom that are prone to lower levels of on-task behaviour, and if CAB

implemented during these activities can help improve this. Additionally, the occurrence of indoor recess is sometimes unpredictable, however it would be of interest to directly compare on-task behaviour during a classroom period immediately following an outdoor vs indoor recess to determine whether CAB may be more useful following either type. Together, this could help provide valuable information for researchers and teachers regarding the optimal implementation strategy of CAB to influence students' on-task behaviour.

Conclusion

The present study found that a high-intensity classroom activity break (CAB) was equally successful in improving on-task behaviour in both the morning and afternoon of a school day. Further, performing a CAB in both the morning and the afternoon in the same day led to slightly more on-task behaviour across the school day than doing either alone, indicating that performing two CAB in one day is beneficial. Interestingly, a CAB in the morning was more beneficial for reducing off-task motor and off-task verbal behaviour, whereas a CAB in the afternoon was more beneficial for reducing off-task passive behaviour – therefore performing both a morning and afternoon CAB would, again, be most beneficial. However, if unable to perform two CAB in one day, carry over effects from a CAB performed in the morning for on-task and off-task passive behaviour indicate that a morning CAB might be the best choice. These effects observed for on- and off-task behaviours were most robust in those students that were the least on-task when no activity breaks were implemented, however even those students who were most on-task still demonstrated important improvements. Although the effects of the classroom activity break on physical activity levels were less robust than those for on-task behaviour, results show that the type of classroom activity break performed in the present study is capable of inducing an increase

in physical activity levels through 24 h MVPA and number of steps during the school day. Overall, results demonstrate that just 4 min of physical activity within the classroom period has significant effects on classroom behaviour and physical activity in primary school children.

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CHAPTER 3

Knowledge Translation

Hello,

We would like to sincerely thank you for choosing to have your school/classroom/child participate in our research project. Your participation and cooperation were invaluable in the completion of this project, and the project would not have turned out as successful as it did without your help. Attached is an infographic displaying the general results of the project, and you will find more detailed information on the findings below. If you have any questions, please don't hesitate to contact me (broa6880@mylaurier.ca).

Canadian physical activity guidelines state that children age 5-17 years should participate in 60 min of physical activity every day. However, Canada's ParticipACTION report card graded the physical activity levels of Canadian children as a D+ as only 35% of children meet these guidelines. This lack of physical activity has important health implications, and has also been shown to impact children's behaviour within the classroom. Specifically, an increase in physical activity has been associated with more on-task behaviour – meaning children are better able to focus on appropriate tasks while at school. Considering children spend the majority of their time at school, the classroom would be an ideal setting to improve physical activity levels.

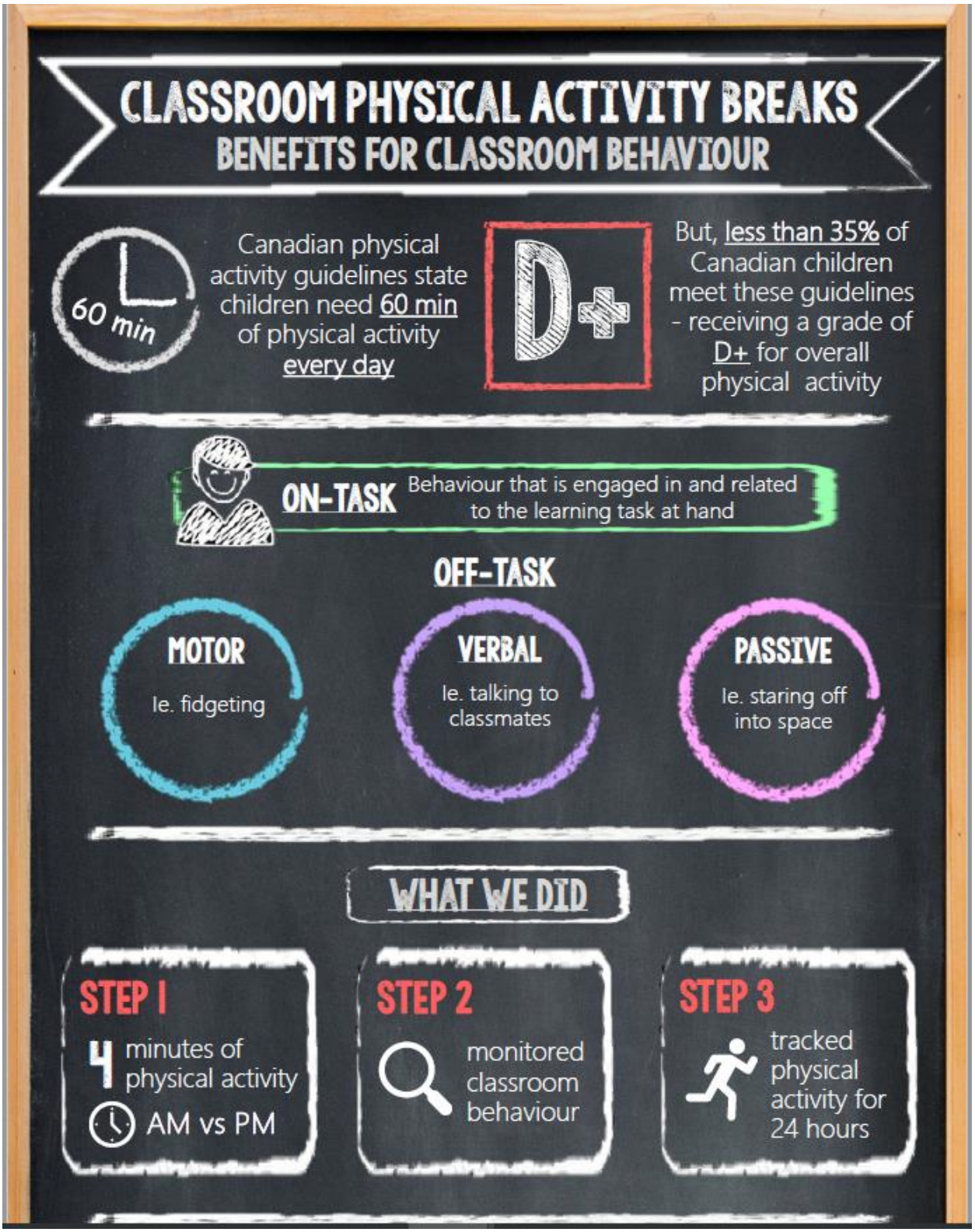
Classroom physical activity breaks (CAB) are a great way to implement more physical activity at school, as they are short in duration and require no additional equipment. Not only do CAB increase physical activity, but they have also been shown to improve student's on-task behaviour in the classroom by up to 27%! However, we were interested in whether there is a specific time during the school day that these CAB would be most beneficial. Specifically, we conducted a 4 min CAB either in the morning, in the afternoon, or both morning and afternoon, and examined the effects on on-task behaviour and physical activity levels. The CAB was termed "FUNtervals" and consisted of whole-body movements that followed a fun story line to keep children engaged.

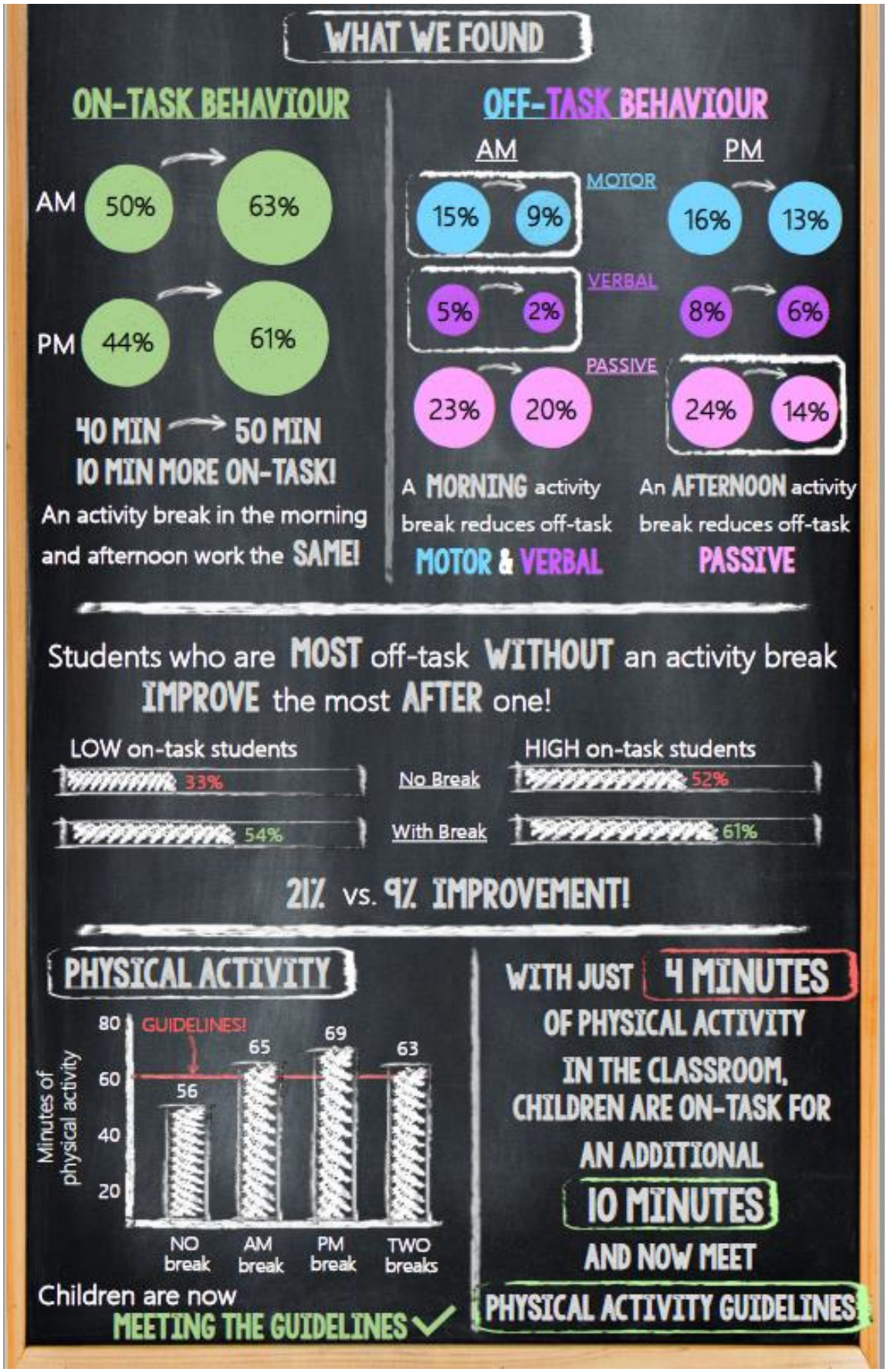
Overall, we found that on-task behaviour across the school day improved by ~10% after a morning CAB, ~11% after an afternoon CAB, and ~14% when both CAB were performed. This shows that a CAB in the morning and afternoon are equally beneficial, while performing both CAB is slightly more beneficial than performing just one. We did find some differences when we examined the three different types of off-task behaviour. Off-task behaviour can be either motor (ie. fidgeting), verbal (ie. speaking out), or passive (ie. day dreaming), and we found that a CAB in the morning reduced off-task motor and verbal behaviour, whereas a CAB in the afternoon reduced off-task passive behaviour. Therefore, performing both CAB would again be most beneficial, as all types of off-task behaviour would be reduced at some point in the school day. However, if a teacher finds they are unable to perform two CAB, then a CAB in the morning might be their best option, as some of the benefits observed following a morning CAB actually carried over into the afternoon!

In terms of physical activity, we found that without a CAB, most children were not meeting the guidelines of 60 min in a 24-hour period. However, when a CAB was performed in the morning children achieved 65 min of physical activity, when a CAB was performed in the afternoon they achieved 69 min of physical activity, and when two CAB were performed they achieved 63 min of physical activity. Therefore, by performing at least one CAB, children were then able to meet the physical activity guidelines! Additionally, we saw the number of steps taken throughout the school day increase by ~2000 steps.

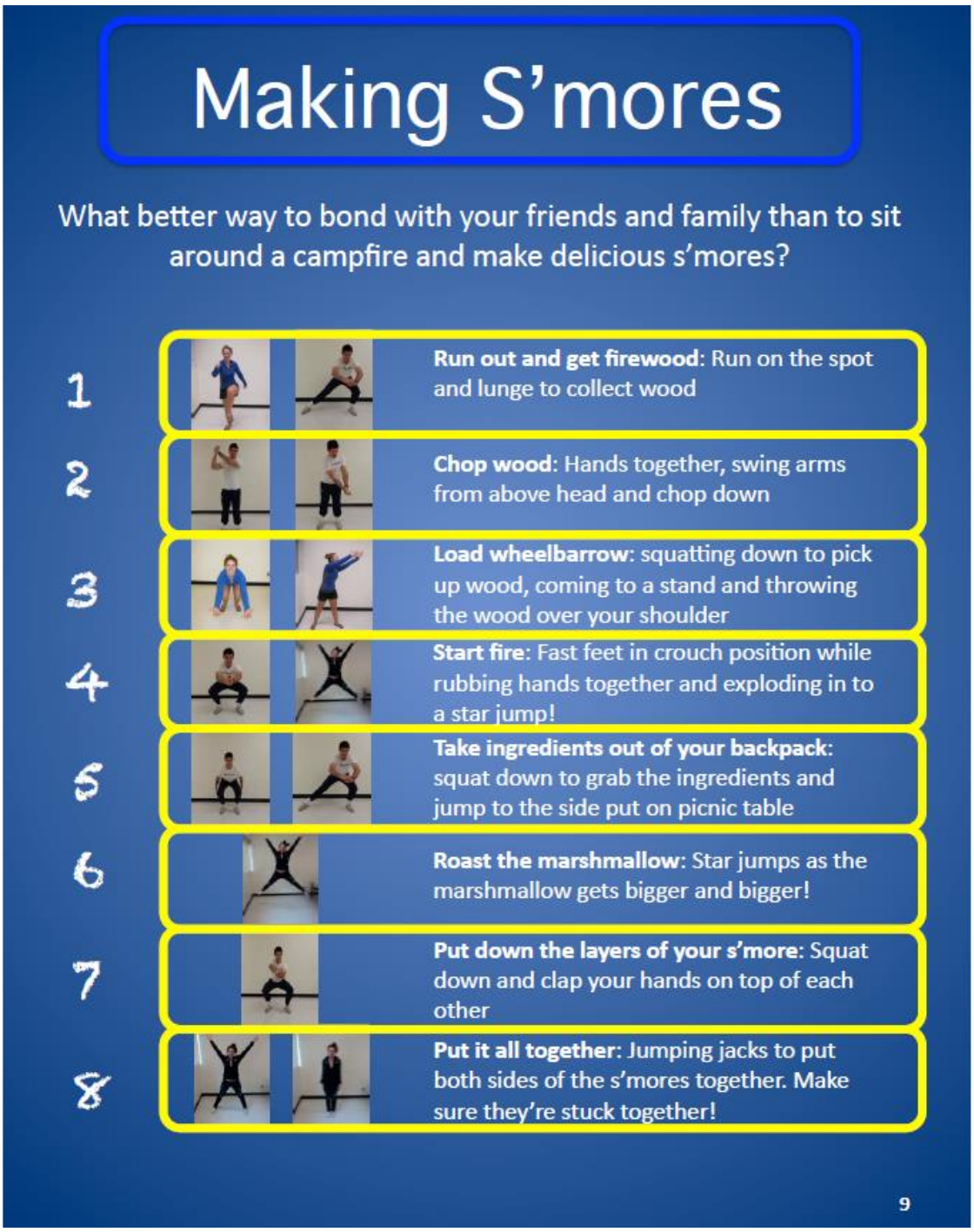
Overall, we believe our results make a compelling case for the implementation of CAB. Understandably, teachers struggle to find time within the school day to implement physical activity in the classroom. However, the CAB we conducted were just 4 min, and led students to be on-task for an additional 10 min, showing that the time spent on CAB is made up for by the amount of time students will spend being on-task afterwards. The increase in physical activity provided by the CAB has the potential to benefit children's health, and the increase in on-task behaviour can benefit their academic achievement, therefore all schools and teachers should consider conducting CAB within their classrooms.

Sincerely,
Abigail A. Broad, MKin, Wilfrid Laurier University
Tom J. Hazell, PhD, Wilfrid Laurier University


CLASSROOM PHYSICAL ACTIVITY BREAKS
BENEFITS FOR CLASSROOM BEHAVIOUR
60 min
Canadian physical activity guidelines state children need 60 min of physical activity every day
D+
But, less than 35% of Canadian children meet these guidelines - receiving a grade of D+ for overall physical activity
ON-TASK
Behaviour that is engaged in and related to the learning task at hand
OFF-TASK
MOTOR
Ie. fidgeting
VERBAL
Ie. talking to classmates
PASSIVE
Ie. staring off into space
WHAT WE DID
STEP 1
4 minutes of physical activity
AM vs PM
STEP 2
monitored classroom behaviour
STEP 3
tracked physical activity for 24 hours


WHAT WE FOUND
ON-TASK BEHAVIOUR
AM
50%
63%
PM
44%
61%
40 MIN → 50 MIN
10 MIN MORE ON-TASK!
An activity break in the morning and afternoon work the SAME!
OFF-TASK BEHAVIOUR
AM
PM
MOTOR
15%
9%
16%
13%
VERBAL
5%
2%
8%
6%
PASSIVE
23%
20%
24%
14%
A MORNING activity break reduces off-task MOTOR & VERBAL
An AFTERNOON activity break reduces off-task PASSIVE
Students who are MOST off-task WITHOUT an activity break IMPROVE the most AFTER one!
LOW on-task students
No Break
33%
With Break
54%
HIGH on-task students
No Break
52%
With Break
61%
21% vs. 9% IMPROVEMENT!
PHYSICAL ACTIVITY
Minutes of physical activity
80
60
40
20
GUIDELINES!
56
65
69
63
NO break
AM break
PM break
TWO breaks
Children are now MEETING THE GUIDELINES ✓
WITH JUST 4 MINUTES OF PHYSICAL ACTIVITY IN THE CLASSROOM, CHILDREN ARE ON-TASK FOR AN ADDITIONAL 10 MINUTES AND NOW MEET PHYSICAL ACTIVITY GUIDELINES

Appendix A – Example of FUNterval Activity



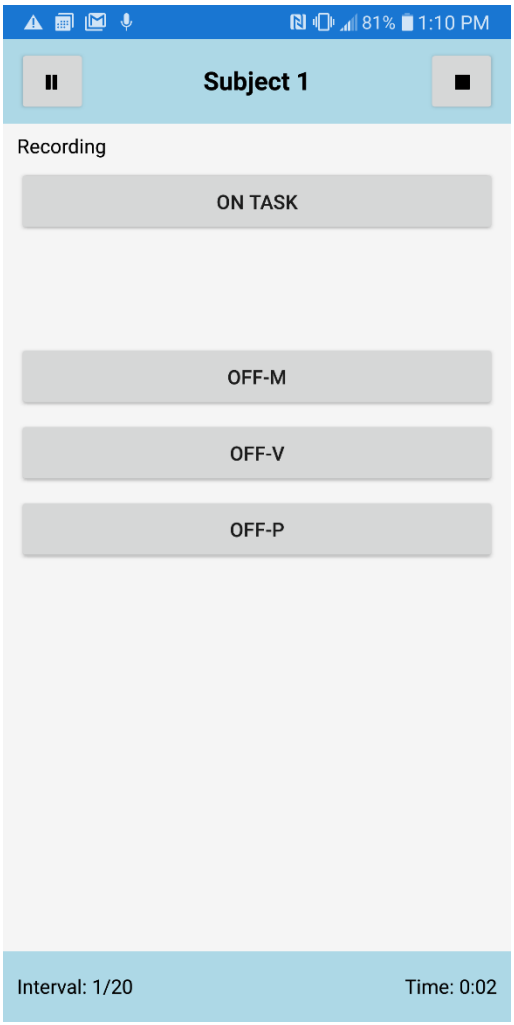
Appendix B – Standardized Classroom Activity Break Schedule

Condition	***FUNterval Performed***
CTRL (control)	None
Familiarization (one CAB done in the morning)	Popcorn
AM (morning CAB)	Making S'mores
PM (afternoon CAB)	Pizza Day
BOTH1 (morning CAB in BOTH condition)	Winter X Games
BOTH2 (afternoon CAB in BOTH condition)	Hunting for Treasure*

* denotes FUNterval designed by primary researcher (AAB) for this project

Appendix C – Behaviour Observation App

Screen capture of behaviour observation app during data collection



Screen capture of behaviour observation app results following data collection interval