4 MINUTES OF IN-CLASS HIGH-INTENSITY INTERVAL ACTIVITY IMPROVES CLASSROOM BEHAVIOUR AND SELECTIVE ATTENTION IN ELEMENTARY SCHOOL CHILDREN

by

Jasmin K. Ma

A thesis submitted to the School of Kinesiology & Health Studies
In conformity with the requirements for
the degree of Master of Science

Queen’s University
Kingston, Ontario, Canada
(July, 2014)

Copyright ©Jasmin Ma, 2014
Abstract

The inclusion of adequate physical activity time within schools is difficult when curriculum time is already saturated with a focus on skills that improve academic achievement. Time-efficient physical activity solutions that demonstrate their impact on academic achievement related outcomes are needed to prioritize physical activity within the school curricula. FUNtervals are 4-minute high-intensity interval activities that use whole body actions to complement a storyline. The purpose of this thesis was four-fold. 1) To develop a resource of classroom appropriate high-intensity interval activities (FUNtervals) 2) to examine the effects of FUNtervals on classroom behaviour and 3) selective attention in elementary school children and lastly 4) to determine whether classroom behaviour predicts changes in selective attention following FUNtervals. Over the past two years, two separate studies have compared FUNtervals (FUN) to No Activity (NA) days using observations of off-task behaviour and administration of the d2 test of attention. Results from the first study showed mean percentages of passive and motor off-task behaviour were significantly decreased in both the grade 2 and 4 classrooms following FUNterval activity (Grade 4: Passive, M_{NA} =29\% \pm 13\% \text{ vs. } M_{FUN} = 25\% \pm 13\%, p<0.05, \text{ ES}= 0.31; \text{ Motor, } M_{NA} =31\% \pm 16\% \text{ vs. } M_{FUN} = 24\% \pm 13\%, p<0.01, \text{ ES}= 0.48); \text{ Grade } 2: \text{ Passive } M_{NA} =23\% \pm 14\% \text{ vs. } M_{FUN} = 14\% \pm 10\%, p<0.01, \text{ ES}= 0.74; \text{ Motor } M_{NA} =29\% \pm 17\% \text{ vs. } M_{FUN} = 14\% \pm 10\%, p<=0.01, \text{ ES}= 1.08) with verbal off-task behaviour decreasing in the grade 2 class only (NA=8\% \pm 8\% \text{ vs. } FUN= 5\% \pm 5\%, p<0.05, \text{ ES}= 0.45). The second study demonstrated that students made fewer errors during the d2 test of attention (% Error; M_{FUN}=3.4\% \pm 0.3\% \text{ vs. } M_{NA}=4.4\% \pm 0.5\%, p= 0.001, \text{ ES}= 0.26) following FUNtervals. Further, a significant relationship between baseline verbal classroom behaviour and changes in selective attention following FUNtervals was observed (E_{Comm}: R=.27, P=0.03; E\%: R=.27, P=0.02; CP: R=.24, P=0.05). In supporting the priority of physical activity inclusion within schools, FUNtervals, a time-efficient and easily implemented physical activity break, can improve both classroom behaviour and selective attention in elementary school children.
Co-Authorship

This thesis presents the work of Jasmin Ma in collaboration with Dr. Brendon Gurd, Dr. Lucy LeMare and Shane Sures.

*FUNtervals: High-intensity, time-efficient breaks for the primary school classroom* is presented according to the guidelines for ACSM’s Journal of Health and Fitness. This manuscript has been submitted to ACSM’s journal of health and Fitness (Submitted July 8, 2014)

*Classroom Based High-Intensity Interval Activity Improves Off-Task Behaviour In Primary School Students* is presented according to the guidelines for Journal of Applied Physiology Nutrition and Metabolism (Submitted June 17, 2014: APNM-2014-0125.R2).

*4 minutes of in-class high-intensity interval activity improves selective attention in 9-11 year olds* is presented according to the guidelines for Journal of Applied Physiology Nutrition and Metabolism.

Jasmin Ma was responsible for researching the literature to develop the research questions, conducting the interventions, performing the data analysis, and drafting all manuscripts. All aspects were a collaborative effort between Jasmin Ma and Dr. Brendon Gurd. In addition, Dr. Lucy Le Mare contributed to the methods formation and review process. Finally, Shane Sures was integral to the data analysis, collection, and review process of *FUNtervals: High-intensity, time-efficient breaks for the primary school classroom.*
Acknowledgements

There are a number of people whom I’d like to thank for their contributions whether those be formally or informally. First and foremost to my supervisor Dr. Brendon Gurd, thank you for your guidance, life chats, and quality humour. Your passion for research is contagious and played an integral role in my decision to continue pursuing a career in research. I also apologize for turning you into a pumpkin throughout this thesis editing process. Also, thank you to LPC (BF and JJ)- who knew our experiences on the grassy knoll and dates with coolio would lead to this? Thank you to all of my volunteer observers for your countless hours spent watching children (MW, MP, TS, DP, DK, LS, MG, KS, TC, LC, KH, MA, JJ) as well as to the Limestone District School Board and participating teachers for letting us enter their property and classrooms to watch children. Thank you to all of my past participants from whom I now own a piece of their vastus lateralis (not including the pre-adolescent participants- ethics wouldn’t give me that one). To my mom and dad for allowing me to grow into the best daughter they could ever ask for (and for fulfilling the role of the best mom/ dad/ role models/ heroes I could ever ask for). Also, thank you for supplying my cupboards with endless amounts of food- you always know the way to my heart. Thanks to my brother for carrying on the Ma PHE/KIN legacy (My PEC picture was bigger for the record). Thank you to the Pyke lab and Angie for allowing my unnecessary FOB access to come do work when the lily pad got lonely. Most certainly a big thank you to the Colborne Cougs (AB, EC, NW... and Ke$ha. We know who really got us through the hard times). Grad school can take its toll, you guys *insert AB accent here* made for a smashing good time. Ain’t no party like a glow stick party (not a euphemism). Also a throw back to my old house, The Princesspoons, and the old trainers, SN, for the great stories I look forward to never telling my children. Lastly, thank you to my PHE/KIN family, it’s unfathomable to be closing this 6 year chapter that was so beautifully/ hilariously/ competitively written, we’ll be reminiscing about these pages and writing new ones for the years to come.
Table of Contents

Abstract ................................................................................................................................. ii
Co-Authorship ....................................................................................................................... iii
Acknowledgements ................................................................................................................ iv
List of Figures ........................................................................................................................... ix
List of Tables .......................................................................................................................... x
List of Abbreviations ........................................................................................................... xi
Chapter 1 Introduction ........................................................................................................ 1
  1.1 General Introduction .................................................................................................... 1
  1.2 Mechanisms linking physical activity to academic performance: ............................... 2
  1.3 FUNtervals, the solution to the problem? ..................................................................... 3
  1.4 Thesis objectives and experimental approach ............................................................. 3
  1.5 Thesis Organization .................................................................................................... 4
  1.6 References .................................................................................................................. 5
Chapter 2 Literature Review ............................................................................................... 7
  2.1 Overview ...................................................................................................................... 7
  2.2 The physical activity and academic performance relationship .................................... 7
  2.3 Mechanistic links between physical activity and academic performance: The importance of classroom behaviour and selective attention .................................................. 9
    2.3.1 The importance of classroom behaviour and selective attention for academic achievement ..... 9
    2.3.2 Linking selective attention and classroom behaviour .............................................. 12
  2.4 The impact of physical activity on behaviour and selective attention .......................... 13
    2.4.1 Physical activity and classroom behaviour ............................................................ 13
    2.4.2 Physical activity and selective attention................................................................. 14
  2.5 High-intensity interval training: Rationale for the FUNterval design .......................... 15
  2.6 Implications for the classroom .................................................................................... 18
  2.7 Thesis Purpose ............................................................................................................ 18
  2.8 Thesis Hypotheses ...................................................................................................... 19
  2.9 References .................................................................................................................. 19
Chapter 3 FUNtervals: High- intensity, time-efficient breaks for the primary school classroom .......................... 27
  3.1 Learning Objective ..................................................................................................... 29
  3.2 Introduction ................................................................................................................ 29
  3.3 What Do We Know About Physical Activity Breaks in School? .................................. 30
Appendix J: Observer Recording Sheet ............................................................. 115
Appendix K: d2 Test of Attention ........................................................................ 116
List of Figures

Figure 1. Proposed mechanisms contributing to the relationship between physical activity and academic performance ................................................................. 13
Figure 2. Sample FUNterval activity .......................................................................................................................... 17
Figure 3. Movements to target when designing FUNtervals .................................................................................... 35
Figure 4. Tips for Leading FUNtervals .................................................................................................................. 36
Figure 5. Representative heart rate data during FUNtervals activities ................................................................. 37
Figure 6. Sample FUNtervals ................................................................................................................................. 38
Figure 7. Box plot and whisper graphs for student participation in FUNterval Activity ............................................. 62
Figure 8. Mean % change in off-task behaviour in the grade 2 classroom ............................................................. 63
Figure 9. Relationship between off-task behaviour in the Control condition and the improvement (% change) following FUNtervals in grade 2 students .................................................................................. 64
Figure 10. Mean % change in off-task behaviour in the grade 4 classroom .......................................................... 65
Figure 11. Overview of study design (Manuscript 3) ............................................................................................... 87
Figure 12. Effects of FUNtervals on d2 test of attention outcomes ....................................................................... 88
Figure 13. Comparison of the highest and lowest quartile of mean off-task verbal behaviour on change in d2 test performance from No Activity Days to FUNterval days ........................................................................ 89
List of Tables

Table 1. Percent of total time (% ± S.D.) for off-task behaviours during desk lesson, carpet lesson, group work and total observation in the grade 2 classroom................................................................. 60
Table 2. Percent of total time (% ± S.D.) for off-task behaviours during teacher reading, writing, read aloud and total observation in the grade 4 classroom. .................................................................................. 61
Table 3 Participant Characteristics. Means ± S.E. of % of off-task behaviour and d2 test performance on No Activity days.............................................................................................................................................. 85
Table 4 Regression R values of average off-task behaviour as a predictor of d2 test performance ........ 86
List of Abbreviations

ACSM- American College of Sports Medicine
ADHD- Attention Deficit Hyperactivity Disorder
BMI- Body Mass Index
BOSS- Behavioral Observation of Students in Schools
CP- Concentration Performance
E- Total errors
EComm- Errors of commission
EOmis- Errors of omission
ES- Effect Size
E%- Percent errors
FUN- FUNtervals
HQ- High Quartile
HIIT- High-intensity Interval Training
HR- Heart Rate
LQ- Low Quartile
M- Mean
NA- No Activity
TN- Total number of characters processed
TN-E- Total number of characters minus total number of errors
VO_{2\text{Peak}}- Peak Volume of Oxygen
Chapter 1

Introduction

1.1 General Introduction

Despite evidence that physical activity has several health benefits (Biddle, Gorely, & Stensel, 2004; Must & Tybor, 2005), only 7% of Canadian youth are meeting physical activity guidelines (Active Healthy Kids Canada, 2014). The significant proportion of time children spend in school implicates the school setting as an important site to address these rising levels of physical inactivity (Colley et al., 2011; Pate et al., 2006; Tomporowski, Lambourne, & Okumura, 2011). However, the perceived lack of time availability (Tsai, Boonpleng, McElmurry, Park, & McCready, 2009) and the belief that physical activity threatens academic achievement (Coe, Pivarnik, Womack, Reeves, & Malina, 2006; Sallis et al., 1999) present as barriers to increasing in-school physical activity. Contrary to this belief, the majority of studies have demonstrated that the addition of physical activity is not detrimental to academic performance with many indicating a beneficial effect of physical activity (Rasberry et al., 2011). In order to support the inclusion of physical activity in schools, the barriers teachers face must be addressed and communication of evidence that elaborate upon the positive relationship between physical activity and academic performance should be a priority. Thus, physical activity interventions that demonstrate improvements in school relevant outcomes through time-efficient strategies are needed to prioritize the inclusion of physical activity in school curricula.
1.2 Mechanisms linking physical activity to academic performance:

While there is support for the positive relationship between physical activity and academic performance, the mechanisms that contribute to this relationship remain unclear (Hillman et al., 2009). For the purpose of prioritizing the inclusion of physical activity in schools, the mechanistic links explored should promote learning and ultimately academic performance. Of the proposed mechanisms, cognitive function encompasses several processes that provide the basic foundation for learning (Tomporowski et al., 2011) while classroom behaviour provides the environment for optimal learning to take place (Doyle, 1986) making these possible mechanistic links appropriate variables to examine in an effort to raise the priority of physical activity to school administrators.

Classroom behaviour, a proposed mechanistic link to physical activity and academic performance, is also an apparent contributor to learning in schools. Specifically, classroom off-task behaviour, classified as behaviour not directed towards the learning task at hand, can be detrimental to the learning environment (Alexander, Entwisle, & Dauber, 1993). To our knowledge, two studies have examined the relationship between acute, academic lesson-related exercise and on-task behaviour in students. Both studies reported that students were more on-task following days where the students had received a physical activity break than days where they did not (Grieco, Jowers, & Bartholomew, 2009; Mahar et al., 2006).

In addition to classroom behaviour, selective attention may also be a mechanistic link to the observed effect of physical activity on academic achievement. Selective attention is a component of executive function that is posited to play a particularly significant role in the
learning process (Yli-krekola, Jaakko, & Valpola, 2009) and is defined as the ability to attend to relevant stimuli while ignoring irrelevant stimuli (Bedard et al., 2003; Carter, Mintun, & Cohen, 1995). Despite its importance to learning, few studies have examined the effects of exercise on selective attention. However, the limited evidence available consistently demonstrates a positive effect of exercise on selective attention (Budde et al., 2012; Budde, Voelcker-Rehage, Pietrabyk-Kendziorra, Ribeiro, & Tidow, 2008). Thus, the evidence supports both classroom behaviour and selective attention in playing an important role for the learning environment (Alexander et al., 1993; Yli-krekola et al., 2009) however, the perceived barrier of time preventing adequate physical activity inclusion within school curricula remains.

1.3 FUNtervals, the solution to the problem?

FUNtervals are activities designed to address the perceived time barrier preventing teachers from increasing in-school physical activity. These activities require four minutes to complete, require no equipment and are easily implemented in the classroom. In exploring whether these classroom feasible activities provide improvements in both classroom behaviour and selective attention, FUNtervals might offer a solution to prioritize in-school physical activity.

1.4 Thesis objectives and experimental approach

An examination of school relevant outcomes using time-efficient strategies is needed to prioritize the inclusion of physical activity in schools. Previous physical activity interventions of longer duration have demonstrated improvements in the school relevant outcomes classroom behaviour and selective attention. By examining FUNtervals’ effect on two potential links of the physical activity and academic performance relationship the purpose of this thesis was four-fold.
1) To develop a resource that that teachers can use to implement FUNtervals in the classroom. A lay article will elaborate upon the rationale, sample activities and implementation instructions for FUNtervals.

2) To examine the impact of FUNtervals on classroom behaviour. To achieve this, alternating over the course of three weeks, off-task classroom behaviour will be compared between No Activity days and FUNterval days.

3) To determine whether selective attention is improved following an acute bout of FUNtervals. This will be examined through the administration of the d2 test of attention and comparing performance following No Activity and FUNtervals.

4) To determine whether classroom behaviour predicts changes in selective attention following FUNtervals. This will be examined by comparing the relationship between baseline off-task behaviour and changes in selective attention from No Activity days to FUNterval days.

1.5 Thesis Organization

In Chapter 2 the reader will find a detailed review of the literature concerning the physical activity and academic performance relationship, and discussing classroom behaviour and selective attention as potential mechanistic factors underlying this relationship. Chapter 3 provides a translational overview of FUNterval activities, and how they can be implemented in the classroom; this manuscript has been submitted to ACSM’s Health and Fitness Journal. Chapter 4 contains a manuscript examining the impact of FUNtervals on off-task classroom behaviour; this manuscript is under review (R2) at Applied Physiology, Nutrition and Metabolism. The manuscript in Chapter 5 examines the impact of FUNtervals’ effects on selective attention. Chapter 6 provides a discussion of the key findings of the thesis as well as
strengths and limitations. Lastly, a detailed appendix is attached to provide more complete details of the items discussed within the thesis.

1.6 References


Chapter 2

Literature Review

2.1 Overview

This literature review will begin by exploring the relationship between physical activity and academic performance. This will be followed by a discussion of classroom behaviour and selective attention as potential mechanisms underlying the physical activity/academic performance relationship. This section will be broken down into a discussion of how these mechanisms are associated with improvements in learning and academic performance and an examination of how exercise affects them. A rationale for the FUNterval program design and implications of the current thesis work for the classroom will conclude chapter 2.

2.2 The physical activity and academic performance relationship

In an attempt to prioritize the inclusion of physical activity in schools, a growing body of literature is extending beyond the relationship between physical activity and health and is examining the relationship between physical activity and academic performance (Castelli, Hillman, Buck, & Erwin, 2007; Chomitz et al., 2009; Coe et al., 2006; Donnelly et al., 2009). This research has demonstrated that, even when done at the expense of regular instruction time, physical activity does not impair academic achievement (Sallis et al., 1999). Contrastingly, time taken from physical education is detrimental to youth health and ultimately does not prove beneficial in improving grades (François Trudeau & Shephard, 2008).
Given the rising rates of physical inactivity and increased focus on school achievement, it is important to consider that high fit children actually perform better than low fit children in standardized testing (Castelli et al., 2007; Chomitz et al., 2009). Even after accounting for sociocultural variables such as age, sex, and poverty index in grade 3-5 students, aerobic capacity has been shown to be positively associated with academic achievement, whereas BMI and academic achievement have a demonstrated negative relationship (Castelli et al., 2007). These findings extend beyond normal, healthy weight children with improvements in academic performance also being observed in previously sedentary, overweight children who undertake an exercise program (Davis et al., 2011).

These fitness-associated improvements in academic achievements may be explained in part by the accumulated effects of acute bouts of physical activity. As an example, following an acute bout of treadmill walking, higher brain activation was seen in comparison to the resting control during tests of executive function (Hillman et al., 2009). In addition, the increased arousal found following exercise may also in part be responsible for changes in cognitive performance (Lambourne & Tomporowski, 2010; Tomporowski, 2003). Over time, these learning associated changes seen following acute activity may accumulate to contribute to the chronic effects of training (i.e. increases in fitness) and academic performance discussed above. Taken together, there is strong support for the positive relationship between physical activity and academic performance warranting further exploration to explain the mechanisms that underlie this relationship and thereby increase school administrator’s prioritization of physical activity (Singh, Twisk, Mechelen, Chinapaw, & Central, 2012).
2.3 Mechanistic links between physical activity and academic performance: The importance of classroom behaviour and selective attention

While a non-detrimental, if not positive, relationship has been firmly established between physical activity and academic performance (Castelli et al., 2007; Chomitz et al., 2009; Coe et al., 2006; Davis et al., 2011; Donnelly et al., 2009; Rasberry et al., 2011), the mechanisms that link physical activity to academic outcomes are not fully understood (Hillman et al., 2009). Among the mechanisms proposed to date, classroom behaviour (Grieco et al., 2009; Mahar et al., 2006) and cognitive function (Best, 2010; Davis et al., 2011; Pesce, Crova, Cereatti, Casella, & Bellucci, 2009), specifically selective attention (Budde et al., 2012; Budde, Voelcker-Rehage, Pietrabyk-Kendziorra, Ribeiro, & Tidow, 2008; Hillman, Snook, & Jerome, 2003; Niemann et al., 2013), have been posited to make significant contributions to the physical activity/academic performance relationship.

2.3.1 The importance of classroom behaviour and selective attention for academic achievement

Poor classroom behaviour, or off-task behaviour, is defined as disengagement from the learning environment and is exhibited through inattention, fidgeting, side conversations, etc. (Rowe, Mcquiggan, Robison, & Lester, 2009). Not surprisingly, poor classroom behaviour has a negative impact upon academic performance. Specifically, students with poor behaviour achieve lower grades than those who conduct positive, socially responsible behaviour (Wentzel, 1991). As another example, females demonstrating poor reading capabilities display higher rates of inattentiveness and anti-social behaviour (Maughan, Pickles, Hagell, Rutter, & Yule, 1996). This type of behaviour is not only detrimental for the individual, but can be distracting to the
individual’s peers creating an unfavourable learning environment (Doyle, 1986). Contrastingly, students who exhibit high levels of classroom engagement typically see higher academic achievement (DiPerne, Volpe, & Elliott, 2001) possibly resulting from enhanced learning and ameliorated teacher-pupil relationships (Alexander et al., 1993). Evidently, the negative implications off-task behaviour has on academic achievement posit it as an important classroom based outcome to examine in an effort to demonstrate the importance of physical activity in schools.

In addition to the proposed role of off-task behaviour in the relationship between physical activity and academic performance, cognitive function is also considered a significant contributor to learning and academic achievement. Of the cognitive functions, executive functions, which are higher order cognitive processes involved in the conscious control of thought and action (Diamond, 2013; Latzman, Elkovich, Young, & Clark, 2010), play a particularly important role in learning. Executive function can be broken down into three core components: cognitive flexibility, working memory, and inhibitory control (Diamond & Lee, 2011; Diamond, 2013; Morton, 2013). Specifically, inhibition (Bull & Scerif, 2001; Rebecca Bull, Johnston, & Roy, 1999) and working memory (Bull & Scerif, 2001; McLean & Hitch, 1999) have been shown to predict math competence, English achievement and reading competence in normal (St Clair-Thompson & Gathercole, 2006) and learning disabled populations (Swanson, Ashbaker, & Lee, 1996). Remarkably, in a study of 141 3 to 5 years olds, executive functions were shown to be a greater predictor for school readiness than intelligence quotient (IQ) (Blair & Razza, 2007; Diamond & Lee, 2011), and problems with executive function are associated with learning disability associated disorders including autism (Russell, Jarrold, & Henry, 1996), attention
deficit hyperactivity disorder and Tourette syndrome (Ozonoff & Jensen, 1999). Thus, interventions that target improvement of executive function may facilitate the improvement of overall academic performance in schools (O’Shaugnessy, Lae, Gresham, & Beebe-frankenberger, 2003). Of particular interest for this thesis is the role of selective attention, a component of inhibitory control (Diamond, 2013), in the physical activity and academic performance relationship.

Selective attention, the ability to attend to relevant stimuli and ignore irrelevant or distractor stimuli (Bedard et al., 2003; Carter et al., 1995), plays an important role in learning (Yli-krekola et al., 2009). This subcomponent of executive function is used in executing goal-directed behaviour, selecting incoming sensory information, encoding information into memory, and transforming information that has been retained or manipulated into working memory (Smith, 1999). In the classroom, students may voluntarily choose to inhibit attention to a particular stimuli and attend to others based on the intention or goal (i.e. attending to the lesson given by the teacher while ignoring a disruptive classmate) (Diamond, 2013; Theeuwes, 2010). This highlights the importance of selective attention in students’ ability to remain focused on the task at hand or follow directions. Selective attention is also important for literacy (Stevens, Lauinger, & Neville, 2009) and mathematics ability, independent of general intelligence (Blair & Razza, 2007). As an example, when learning to read, a child must selectively attend to relevant dimensions of the word while suppressing overlearned responses (Stevens et al., 2009). For instance when encountering the word *peg*, the student must suppress reading the word as the more commonly occurring word *pig*. Mathematic ability can also be improved by implementing strategies that target selective attention, such as highlighting or applying movement to relevant information, in
children with learning disabilities (Kercood & Grskovic, 2009; Lee & Zentall, 2002). The integral role selective attention plays in learning and ultimately, in academic success, posits this executive function as another important classroom based outcome to examine the impact of physical activity upon.

### 2.3.2 Linking selective attention and classroom behaviour

As discussed above, both classroom behaviour and selective attention are associated with learning and academic performance. However, the mechanisms by which behaviour and selective attention impact academic performance may not be independent. For example, several studies have shown that behavioural problems can be linked to attentional dysfunction in children (Barkley, 1997; Hallahan, Lloyd, Kosiewicz, Kauffman, & Graves, 1979), including Attention Deficit Hyperactivity Disorder (ADHD). Specifically, children with ADHD exhibit significantly less on-task behaviour than their typically developing counterparts (Kofler, Rapport, & Alderson, 2008), and have associated problems with selective attention (Satterfield, Schell, Nicholas, Satterfield, & Freese, 1990). In complex environments, such as a school classroom, goal-relevant, or on-task behaviours, require the use of selective attention to target relevant stimuli among irrelevant distractors (Tipper, Weaver, & Houghton, 1994). Consequently, these on-task behaviours may be affected in students with ADHD as a result of poor selective attention. Contrastingly, strategies that target selective attention during learning are associated with improved classroom behaviour during math problem solving sessions (Kercood & Grskovic, 2009). The logical link between behaviour and selective attention in addition to the substantial number of children affected by inattention disorders further supports the study of the impact of physical activity on these variables. Specifically, examining whether there is a relationship between physical activity and selective attention, and whether classroom behaviour predicts
selective attention performance (Figure 1). Elucidating the link between classroom behaviour and selective attention will help to further explain the mechanisms underlying the relationship between physical activity and academic performance.

![Proposed mechanisms contributing to the relationship between physical activity and academic performance.](image)

**Figure 1. Proposed mechanisms contributing to the relationship between physical activity and academic performance.**

### 2.4 The impact of physical activity on behaviour and selective attention

Selective attention and classroom behaviour have been discussed for their importance to academic performance. Completing the discussion to their link as possible mechanisms in the physical activity and academic performance relationship, the effects of physical activity on classroom behaviour and selective attention are discussed below.

#### 2.4.1 Physical activity and classroom behaviour

With the demonstration that recess participation resulted in improved classroom behaviour (Jarrett, Maxwell, Dickerson, Hoge, & Davies, 1998), interest was sparked in understanding the effect of classroom-based physical activity on behaviour. Specifically, two studies to date have examined the effect of acute bouts of classroom activities on on-task classroom behaviour in elementary-aged students. It was found that following 10-15 minute
activity breaks on-task behaviour was significantly improved compared to before the intervention (Grieco et al., 2009; Mahar et al., 2006). Interestingly, the greatest improvements in time on-task following exercise were seen in students with the highest body mass index (Grieco et al., 2009). The most noteworthy finding however, is the evidence which suggests that the greatest benefits of increasing in-school physical activity may be experienced by those students at the highest risk for behaviour associated poor academic performance (Mahar et al., 2006). One limitation of the classroom activity observations by Mahar et al. and Grieco et al. was that the effect of having a break from normal lesson material was not controlled for, nor were the activities conducted independent of learning material (learning material was integrated into the activity). Thus, it is difficult to conclude whether the observed effects in these studies were from physical activity per se. The combination of these limitations and the very limited number of studies having been conducted to date warrants further examination of the effects of physical activity on classroom behaviour. Ultimately, support for the link between classroom based activities and improvements in behaviour may provide additional motivation for teachers to include regular physical activity in their curriculum (Grieco et al., 2009).

2.4.2 Physical activity and selective attention

Similar to the effects of physical activity on classroom behaviour, acute bouts of activity also improve selective attention with both brief, high-intensity and sustained, moderate exercise eliciting enhanced attention in students. Specifically, fit, university aged students saw augmented selective attention following high-intensity sprint interval training (Budde et al., 2012) while coordinative exercise (balance and reaction activities) and a normal sport lesson also improved selective attention in 13-16 year olds, with coordinative exercise showing the greatest improvements (Budde et al., 2008). In younger populations, 12 minutes of moderate (Tine &
Butler, 2012; Tine, 2014) and high-intensity (Niemann et al., 2013) running also improved selective attention. These findings have been supported by neuro-eccentric data demonstrating enhanced concentration following 30 minutes of treadmill running (Hillman et al., 2009). Evidently, several different exercise modalities and protocols are capable of improving selective attention. These findings are particularly important as selective attention plays an integral role in school learning capacity (Tipper et al., 1994). To date no studies have tested the effects of acute bouts of physical activity using interventions appropriate for the classroom setting. Using 4-minute FUNtervals this thesis hopes to examine a classroom feasible approach and its effects on selective attention and contribute to our knowledge of the physical activity and academic performance relationship.

2.5 High-intensity interval training: Rationale for the FUNterval design

The activity intervention used in this study was adapted from a 4-minute high-intensity interval training (HIIT) protocol that has previously been shown to induce fitness improvements in adults (Ma and Scribbans et al., 2013; Mcrae et al., 2012; Tabata et al., 1996). When tested using a bicycle or whole body exercises, improvements in VO_{2peak} (Ma and Scribbans et al., 2013; Mcrae et al., 2012; Tabata et al., 1996), peak and mean power during a sprint test (Ma and Scribbans et al., 2013; Tabata et al., 1996), as well as muscle strength endurance for various body weight exercises (McRae et al., 2012) were observed following these 4-minute training sessions. The observed laboratory fitness improvements were similar to those seen following traditional endurance training protocols but require a fraction of the time (Ma and Scribbans et al., 2013; Mcrae et al., 2012; Tabata et al., 1996). Adapting this protocol to primary student appropriate activities or FUNtervals, the 20 seconds of exercise separated by 10 seconds of rest, repeated 8 times were transformed into intervals that consist of whole body actions which complement a
storyline (Figure 2). These activities are time-efficient, require no equipment and can be done in the classroom setting and were developed in an attempt to provide teachers with activities that can be used to address the barrier of time availability teachers face in implementing physical activity (Tsai et al., 2009).
Camping Trip

Hike, swim, cycle and paddle to get to a secret camping location. Make up stories of your adventure! Rest is used to ‘sleep’ to recuperate. After completing the first set, repeat the actions in a backwards order to return home safely. **These activities are done in a chair**

1. **Hiking:** Marching, swinging arms back and forth while tapping toes and lifting knees.

2. **Swimming:** Alternate moving arms as if doing front crawl while kicking legs in a flutter kick motion.

3. **Cycling:** Hold on to the seat of chair and pedal legs as if riding a bike.

4. **Paddling:** Paddle side to side just like in a kayak.

Repeat steps 1-4

Figure 2. Sample FUNterval activity
2.6 Implications for the classroom

Increasingly, studies have been emerging that support the positive relationship between physical activity and academic performance in children (Rasberry et al., 2011). Along with the support for the physical activity and academic performance relationship is an increased interest in the mechanisms that contribute to this relationship. This thesis considers two such mechanisms, classroom behaviour and selective attention, that have demonstrated importance for learning and academic achievement. Few studies have tested this relationship using interventions appropriate for the classroom environment. The majority of interventions used have required the use of large space (Pesce et al., 2009) or expensive equipment (Coles & Tomporowski, 2008; Ellemberg & St-Louis-Deschênes, 2010; Hillman et al., 2009). Addressing these limitations, FUNterval activities are time-efficient, suitable for the classroom setting and require no equipment. In combination, the potential benefits to school performance related outcomes and feasibility of these activities, makes FUNtervals an important and applicable protocol to examine in an effort to prioritize the inclusion of physical activity within school curricula.

2.7 Thesis Purpose

Greater support for the role of physical activity in schools is needed. Given the evidence provided, it is clear that there is a link between physical activity and academic performance. What is not currently understood are the mechanisms that explain this relationship in a school relevant context, and whether these mechanisms are activated by very brief, high-intensity interval exercise in primary school children. Therefore, the purpose of this thesis is four-fold: 1) to develop a resource that will aid teachers in implementing FUNtervals, the physical activity intervention in question, in the class, 2) to determine whether FUNtervals improve classroom
behaviour and 3) selective attention in elementary school students and 4) whether there is a link between classroom behaviour and changes in selective attention following FUNtervals.

2.8 Thesis Hypotheses

The literature, although limited, is fairly consistent in supporting the positive link between physical activity and improvements in both classroom behaviour and selective attention. Based on the existing literature, it is hypothesized that FUNtervals, a form of high-intensity interval activity will 1) improve classroom behaviour and selective attention and that 2) baseline classroom behaviour will predict changes in selective attention following FUNtervals.

2.9 References


Ma, J. K., Le Mare, L., & Gurd, B. (2014). Classroom based physical activity and the effects on off-task behaviour in primary school students: an intervention study. *Submitted for Publication*.


Chapter 3

FUNtervals: High-Intensity, Time-Efficient Breaks for the Primary School Classroom
Jasmin Ma, BSc Kinesiology, is a master’s student in the School of Kinesiology and Health Studies at Queen’s University where her research focuses on high-intensity interval training and cognitive function in children.

Shane Sures is an undergraduate student in the School of Kinesiology and Health Studies at Queen’s University.

Brendon Gurd, PhD, is an Assistant Professor in the School of Kinesiology and Health Studies at Queen’s University. His research ranges from molecular mechanisms underlying the adaptive response to exercise to exploring the efficacy of high-intensity training in applied settings.

Funding disclosures: The authors declare no conflict of interest and do not have any financial disclosure
3.1 Learning Objective

• To define what FUNtervals are and to discuss the theory and evidence supporting their use.
• To provide examples and tips on how to implement these time-efficient, classroom
  appropriate fit breaks in primary school classrooms.

3.2 Introduction

Physical inactivity in children is increasing and has even been defined by some as a
pandemic (Kohl et al., 2012). These low levels of physical activity may have wide ranging
impact as inactivity in children is associated with inattention, poor classroom behaviour, reduced
cognitive functioning, lower academic achievement, and negative health risks.

While there are many possible venues in which to implement physical activity programs
aimed at increasing physical activity in children, the large portion of time spent in school makes
the classroom an attractive setting for interventions targeting this population. Of particular
importance for educators working in the school setting, beyond the obvious health benefits
associated with increased physical activity, is the positive association between physical activity
and both short-term classroom behaviour (Grieco et al., 2009; Mahar, 2011) and long-term
academic achievement (Rasberry et al., 2011). While the positive effects of physical activity on
academic performance would seem to suggest that the inclusion of physical activity within the
school curriculum would be a good fit, increasing physical activity during the school day can be
difficult when the curriculum is already saturated with academic skills development. A possible
solution to the barrier of time teachers face are FUNtervals; 4-minute high-intensity interval
activities designed to be easily implemented in the classroom.
3.3 What Do We Know About Physical Activity Breaks in School?

Physical activity breaks provide a wide range of benefits for academic performance in primary school students. Anecdotally, many of the teachers we have worked with over the past 3 years have used physical activity breaks when their students are getting fidgety, restless and inattentive. One grade 2 teacher reported that her afternoons were intolerable without a mid-way physical activity break to re-focus her students. While this positive impact of physical activity breaks on behaviour has been documented experimentally (Grieco et al., 2009; Mahar, 2011), what is often overlooked is the fact that beyond improving behaviour, physical activity breaks also improve students’ ability to learn and achieve. More specifically, fitness breaks can improve memory, mathematic skills, literacy skills, goal-directed behaviours, and a wide range of other cognitive functions (Chang, Labban, Gapin, & Etnier, 2012). Importantly, given the time crunch discussed above, there is also strong evidence that the benefits of physical activity on academic achievement are present even when fitness breaks are implemented in place of regular academic instruction time (Rasberry et al., 2011).

3.4 Rationale for Using FUNtervals in Schools

High-intensity interval training (HIIT) is one of today’s hottest fitness trends, taking the number 1 spot in ACSM’s worldwide survey of fitness trends for 2014. HIIT’s popularity has been rising, at least in part, because of its time-efficiency and well-established positive effects on fitness (Gibala & McGee, 2008). FUNtervals have been adapted from a 4-minute HIIT protocol that improves fitness in adults (Ma and Scribans et al., 2013; Mcrae et al., 2012; Tabata et al., 1996). Specifically, this 4-minute protocol, when performed on a bicycle or using whole body exercises (jumping jacks, burpees, mountain climbers, etc.), improves VO$_{2peak}$(Ma and Scribans
et al., 2013; Mcrae et al., 2012; Tabata et al., 1996), peak and mean power during a sprint test (Ma and Scribbans et al., 2013; Tabata et al., 1996), as well as muscle strength endurance for various body weight exercises (McRae et al., 2012). All of these benefits are equivalent or superior to those achieved following traditional endurance training and require only a fraction of the training time (Ma and Scribbans et al., 2013; Mcrae et al., 2012; Tabata et al., 1996). The very brief nature of this HIIT protocol, combined with our demonstration that it can be used effectively with minimal equipment requirements (McRae et al., 2012), position it as an ideal match for the busy school environment.

Notably for schools, FUNtervals offer important implications for improving the learning environment. In 2 separate experiments we have observed 1) improved classroom behaviour and 2) enhanced selective attention, which is vital for following instructions and remaining focused in class. To highlight their efficiency, the aforementioned benefits of these 4-minute activities are similar to those resulting from longer, more disruptive breaks (Budde et al., 2008; Mahar et al., 2006). Beyond the benefits to learning, FUNtervals support the principles of physical literacy most in-class and out of class activities lack. There is full participation from every student throughout the activity, no waiting in line, long instruction time, or competition that singles out students’ abilities. Moreover, during these activities, students demonstrate high levels of participation and enthusiasm in addition to exercise intensities ( ) that are similar to those observed in adults (Ma and Scribbans et al., 2013). For teachers, implementing the activities is simple, as it does not require rearrangement of the classroom, preparation, equipment, and is less than a 10-minute interruption from start to finish.
Considering the potential fitness benefits, improvements and participation in the classroom, and time efficiency, FUNtervals is an ideal option to get kids moving in class.

3.5 How to Design FUNtervals and Implement Them in the Classroom

FUNtervals have been adapted from a HIIT protocol consisting of 20 second intervals separated by 10 seconds of rest (Tabata et al., 1996). For the purposes of FUNtervals, each interval consists of whole body movements that involve as many parts of the body as is possible, and preferably require participants to change levels several times, such as when squatting and jumping. These movements (for examples see Figure 3) are most likely to elicit the high intensities of exercise (that are associated with fitness benefits in adults (McRae et al., 2012) and are the movements that we have used in classrooms where behaviour and attention were improved following FUNterval breaks. In addition to stressing large movements, every movement during activity intervals should be performed with as much speed and enthusiasm as possible (See Figure 4 for tips on leading FUNtervals).

FUNtervals require students to perform actions that complement a storyline. The basic concept is to teach these exercises to children without using exercise terms, for example, instead of instructing children to squat and jump, they are instructed to make popcorn for their entire school by reaching for the top shelf for a bag of popcorn and then placing it into a giant bowl sitting on the ground. Two examples of FUNterval story lines are presented in Figure 6, but we would be happy to provide more activities upon request, and would encourage you to develop your own FUNtervals either on your own or with the help of your students.
When implementing FUNtervals in the classroom have students spread out around the classroom to ensure that each student has enough space to reach out and move without contacting another student. There is no set up in terms of equipment, and in most classrooms we have been able to perform FUNtervals without moving furniture. Once your children are ready, you should provide a simple introduction to the storyline for the activity and then inform the students of the movements they will be performing as you tell them the story (See Figure 6). Before each interval begins (either before you start or during each 10 second break), the actions for that interval should be explained or demonstrated. During each interval, the teacher should also participate with as much speed and enthusiasm as they would like to see exhibited from their students. The greatest success in participation we have observed is when we allow students to contribute to the story (i.e. students were asked which strategies might best accomplish the goal of the story) and the storyline involved a race, a plot, or a challenge.

3.6 Summary

Including physical activity does not have to be a time consuming disruption to the school day. For example, FUNtervals are 4- minute activities that can easily be implemented right in the classroom. In addition to its feasibility of classroom implementation, these brief activities may actually enhance the learning environment by improving classroom behaviour as well as attention. We firmly believe if you play hard, you work hard.

3.7 Condensed Version and Bottom Line

- FUNtervals are a time-efficient classroom activity that improves classroom behaviour and attention.
• FUNtervals are completed using whole body exercises that complement various story lines that require children to work for 20 seconds, rest for 10 seconds and then repeat 8 times.

• Fitting in FUNtervals during the school day can be easy as they don’t require relocation, equipment or much time. FUNtervals can be particularly effective at points of the day where you notice that children are fidgety, losing attention or misbehaving.
Sidebar 1: Movements to Target when designing FUNtervals
Below are examples of key movements that encourage active participation and increased heart rate:

Frog Hops  Jumping Stars  Squat and Jump
Ducking  Cross Country Skier Jumps  High Knees Running

Other movements to target include:

- Scissor kicks
- Jumping jacks
- Squat and reach
- Side lunges
- Shimmying
- Wood choppers
- Tuck jumps
- Jumping front split squats

Figure 3. Movements to target when designing FUNtervals
Sidebar 2: Tips for Leading FUNtervals

- Activities should be done with as much speed as each child is capable. For example, when running on the spot encourage them to move their feet as fast as possible.
- Activities should be done with as much emphasis as each child is capable. For example, when squatting encourage them to bring their bodies as close to the ground as possible and to stand all the way back up.
- Be creative! The story line is what makes these activities fun! Encourage individual competition, modify the storyline to increase speed or participation, ask the students questions and let the students contribute to the story. If you run out of ideas, the students will always fill the gap.

Figure 4. Tips for Leading FUNtervals
Illustration 1: Representative HR data from 2 groups of grade 3-5 students performing a set of FUNtervals consisting of either “Popcorn” or “Rocket”. See illustration 2 for detailed descriptions of these activities.

**Popcorn**

**Rocket**

Figure 5. Representative heart rate data during FUNtervals activities
Illustration 2: Sample FUNtervals

**Popcorn**
Your school’s class has the esteemed duty of making popcorn for the entire school. Aim to make 20 bags of popcorn for your first batch and top that number for the second batch.

1. Reach for popcorn bags from the top shelf and put them in a giant bowl in front of you: Reach up and squat down
2. Pop the popcorn: jumping stars
3. Scoop the popcorn into a giant sack: Squat down and scoop your arms in front of you and toss beside you
4. Deliver the popcorn: Run on the spot to deliver the popcorn to the cafeteria while it’s still hot!

**Rocket**
You’re headed out for a space adventure! First you must prepare your ship, then survive the travel to the moon to collect some delicious cheese. Make it back in time with the cheese for lunch! Grilled cheese sandwiches anyone?

1. Put the crystals into the fuel tank: Reach up and squat down
2. Crush the crystals to activate their energy: Jump up and squat down
3. Run to the driver’s chair before the ship launches: Running on the spot
4. Dodge asteroids: Call out dodge, jump, power jump (squat plus jump) to dodge asteroids while running on the spot. After this you’ve made it to the moon!

Repeat steps 1-4 to get back home. Hurry! Don’t want to be late for lunch!

Figure 6. Sample FUNtervals
3.8 References:


Chapter 4

Classroom Based High-Intensity Interval Activity Improves Off-Task Behaviour In Primary School Students
4.1 Abstract

This study examined the effects of an acute bout of brief, high-intensity interval exercise on off-task classroom behaviour in primary school students. A grade 4 class (n=24) and a grade 2 class (n=20) were exposed to either a no activity break or an active break consisting of ‘FUNtervals’, a high-intensity interval protocol, on alternating days for 3 weeks. No-activity days consisted of a 10-minute inactive break while FUNterval days consisted of a 4-minute FUNterval completed within a 10-minute break from regular class activities. Off-task behaviour was observed for 50 minutes after each no-activity/FUNterval break, with the amount of time students spent off-task (motor, passive and verbal behaviour) being recorded. When comparing no-activity (NA) to FUNtervals (FUN) the grade 4 class demonstrated reductions in both passive (NA= 29±13% vs. FUN= 25±13%, p<0.05, ES= 0.31) and motor (NA= 31±16% vs. FUN= 24±13%, p<0.01, ES= 0.48) off-task behaviour following FUNtervals. Similarly, in the grade 2 class passive (NA=23% ±14% vs. FUN= 14%±10%, p<0.01, ES= 0.74), verbal (NA=8% ± 8% vs. FUN= 5%± 5%, p<0.05, ES= 0.45) and motor (NA=29% ± 17% vs. FUN= 14% ± 10%, p<0.01, ES= 1.076) off-task behaviours were reduced following FUNtervals. In both classrooms the effects of physical activity were greatest in those students demonstrating the highest rates of off-task behavior on no-activity days. These data demonstrate that very brief high-intensity bouts of exercise can improve off-task behaviour in grade 2 and 4 students, particularly in students with high rates of such behaviour.

Key Words: Exercise, Classroom Behaviour, High-Intensity Interval Training, Academic Performance, Off-Task, Students
4.2 Introduction

Physical inactivity is a major risk factor for the development of childhood health problems (Barros et al., 2009) and an increasing number of youth are failing to meet physical activity guidelines (Colley et al., 2011). The significant proportion of children’s time spent in school implicates the school setting as an important site for increased physical activity (Tomporowski et al., 2011), yet, despite substantial evidence to the contrary (Ahamed et al., 2007; Carlson et al., 2008; Murray et al., 2007; Rasberry et al., 2011; Sallis et al., 1999; Trudeau & Shephard, 2008, 2010), the belief that increasing time spent on physical activity will threaten academic achievement remains (Coe et al., 2006; Sallis et al., 1999). Furthermore, teachers struggling with an already demanding curriculum perceive time availability as a major barrier to implementation of daily physical activity (Tsai et al., 2009).

Interestingly, in addition to the known health and fitness benefits associated with regular physical activity (Biddle et al., 2004; Must & Tybor, 2005) there is evidence that acute bouts of physical activity can improve cognitive function (Best, 2010; Budde et al., 2008; Davis et al., 2012; Pesce et al., 2009), concentration (Taras, 2005; Tsai et al., 2009), and academic achievement (Castelli et al., 2007; Chomitz et al., 2009; Coe et al., 2006; Donnelly et al., 2009). To date, few studies have addressed the mechanisms that may explain the positive relationship between physical activity and academic performance (Mahar et al., 2006). In particular, studies examining the impact of physical activity on classroom off-task behavior (behaviour that is disengaged from and unrelated to the learning task at hand), are lacking. This represents an important area of study as classroom behaviour is associated with academic performance (Alexander et al., 1993; Maughan et al., 1996; Mayes et al., 2000; Stanton et al., 1990).
There is some evidence that physical activity breaks that include an academic component can improve time on-task in primary school students (Grieco et al., 2009; Mahar et al., 2006). While these studies suggest that physical activity can improve classroom behaviour, the effects of physical activity alone (i.e., without an accompanying academic component) have not been examined. Further, the efficacy of brief high-intensity interval exercise (an extremely brief exercise modality with known fitness benefits (Ma et al., 2013; Mcrae et al., 2012; Tabata et al., 1996)) for improving classroom behaviour is also unknown. Thus, the purpose of the current study was to examine the effect of brief, high-intensity interval exercise on classroom off-task behaviour, in primary school students. Specifically, off-task behaviour was observed in a grade 2 and a grade 4 classroom following either a no-activity break or an exercise break consisting of a 4 minute set of high-intensity interval exercise (FUNtervals).

4.3 Methods

4.3.1 Participants:

From April to July 2013, recruitment for this study took place in a class of 2nd grade students (n=23) and a class of 4th grade students (n=27) from two different South Eastern Ontario elementary schools. Both schools serviced primarily white, middle class families and none of the students that participated had ministry of education designations. Forty-four out of the total 50 students in the two classes returned permission forms confirming informed consent and were evaluated in the current study (Grade 2, n=20, boys= 15, girls= 5; Grade 4, n=24, boys= 10, girls= 14;). Approval for this study was obtained from the Health Sciences Human Research Ethics Board at Queen’s University and the local district school board.
4.3.2 Study Design:

The current study utilized a single group, repeated cross-over design where each student’s off-task behaviours on no-activity (NA) days were compared to their FUNterval (FUN) days. The intervention in both classrooms lasted a total of 3 weeks and followed the same format. The first week of the intervention was used as familiarization with a two-fold purpose: 1) Researchers were familiarized with the observation process and the observation tool being utilized, and 2) Students were familiarized with both the presence of the researchers in the classroom as well as the no-activity breaks and the FUNterval activities. Student familiarization to the presence of researchers has previously been reported to be important in order to eliminate the reactivity effect on the teacher and students (Mahar et al., 2006). The subsequent two weeks of the intervention were used for data collection.

Across all 3 weeks of the interventions, FUNterval and no-activity days were alternated resulting in classroom observation and data collection in the final 2 weeks of the intervention being completed on a total of 5 FUNterval days and 5 no-activity days in the grade 2 classroom and 5 FUNterval days and 4 no-activity days in the grade 4 classroom (1 observation period was missed due to an all-day assembly). On each observation day, the duration of the intervention break (FUNterval or no-activity) was approximately 10 minutes with the time of day remaining constant throughout the study. For FUNterval breaks this 10 minutes included set-up, the 4 minute activity, and subsequent preparation for returning to regular classroom activities, while the 10 minute no-activity break consisted of a 10 minute lecture. To allow for an adequate separation between the intervention activity and the last recess break, interventions were conducted after at least 20 minutes of normal classroom instruction. In the grade 2 classroom the intervention was
implemented 30 minutes after the lunch break while in the grade 4 classroom, the intervention activities occurred 20 minutes after a 15-minute recess break. Following each intervention activity the research team observed student behaviour for 50 minutes of additional classroom instruction time.

4.3.3 FUNterval activities:

FUNtervals are high-intensity interval activities that required four minutes to complete, were always performed inside the classroom, and required no equipment. The protocol, adapted from the work of Tabata et al. (1996) consists of 20 seconds of high-intensity activity separated by 10 seconds of rest, repeated 8 times. This protocol was adapted for primary school classrooms to complement various story lines, which encourage students to complete large, whole body movement as fast as possible. Movements targeted included squats, jumping jacks, scissor kicks, jumping, and running on the spot. A different FUNterval was implemented on each activity day of the study. A booklet outlining the FUNterval activities utilized in this study, along with many additional activities is available from authors upon request.

Observers rated each child’s participation in FUNterval activities on activity days. Following the completion of the FUNterval observers gave an overall impression score based on the intensity of participation and adherence of the student to the activity. Participation was graded on a scale of 0-3 with 0 representing no participation and 3 representing enthusiastic participation throughout the duration of the exercise.

4.3.4 No Activity Breaks:
To isolate the effects of exercise from the effect of having a break in the lesson material, a 10-minute lecture on a non-lesson related topic was given on no-activity days. Lectures given did not require the students to be physically active in any capacity and included the lead researcher speaking about healthy eating, the importance of physical activity, and the history of sport.

### 4.3.5 Observation:

The grade 2 classroom observations took place during a math period, which consisted of group work, desk lessons, and carpet lessons. In the grade 4 classroom, observations took place during a literature block that included teacher reading with a question and answer period, shared reading and writing, and teacher novel reading. While the order of these instructional activities remained constant throughout the intervention in both classrooms, the proportion of the 50-minute observation period spent on each activity varied slightly from day to day.

Off-task behaviour was identified using the Behavioral Observation of Students in Schools (BOSS) tool (Shapiro, 1996) with off-task behaviour being recorded using the partial interval method (Hintze et al., 2002). While this tool has not been explicitly validated it consistently demonstrates high levels of inter-observer agreement (Ota & DuPaul, 2002) and is able to discriminate between children with different levels of classroom behaviour (DuPaul et al., 2004). During each 50-minute observation period 4 primary observers each observed a different set of 5 to 6 students. The observation schedule included a 30 second observation of a given student followed by a 15 second break during which observations were recorded. Following this break the observer observed their next student with rotating observations continuing for 20 observations before the observer took a 5-minute break. In total each student was observed 10
times on each day for a total observation time of 5 minutes per student per day. During each observation period researchers noted the occurrence and duration of motor (i.e. fidgeting, drawing, restlessness), verbal (i.e. talking to classmate, speaking when not called upon), and passive (i.e. gazing off, not making eye contact to the speaker, head down on the table) off-task behaviour during each 30-second interval (Shapiro, 1996). Duration of any off-task behaviour was recorded as occurring for 1, a short period of time (i.e. 1-4 seconds), 2, some of the time (i.e. 5-25 seconds), or 3, the entire duration of the observation interval.

4.3.6 Observer Training and Inter-observer Reliability:

Prior to the study, the primary and secondary observers were given detailed definitions of the behaviours to be observed. During the familiarization week for both classrooms, all 4 observers plus the primary researcher observed the same 6 students. Observers were given feedback throughout the week where discrepancies arose. During the 2\textsuperscript{nd} and 3\textsuperscript{rd} weeks of the intervention, when data collection was being completed, an additional observer rotated between groups of students to act as a secondary observer. Inter-rater reliability was calculated by dividing the number of agreements by the total number of agreements and disagreements (i.e. the total number of observations). This value was then multiplied by 100 to find percentage of agreement between observers. The mean percentage of agreement for off-task behaviours was 92\% (range= 88-94\%), Kappa= 0.786 in the grade 2 classroom and 90\% (range= 84- 94\%), Kappa= 0.795 in the grade 4 classroom.

4.3.7 Statistical Analysis:

Values for off-task behaviours for each student were obtained by averaging the daily collections in each condition. Paired-samples $t$-tests were used to compare mean off-task behaviour between
FUNterval and no-activity days. Further, a quartile split was conducted on no-activity day data for motor, passive, and verbal off-task behaviour. This resulted in highest quartile cut-off values for motor, passive and verbal behaviour on no-activity days of 42%, 32% and 12% (n=5) respectively in the grade 2 classroom and 38%, 35%, and 10% (n=6), respectively in the grade 4 classroom. Students’ whose rates of off-task behaviour on no-activity days fell within the highest quartile were considered high off-task. Comparisons of behaviour between conditions of the high off-task students were made using paired-samples t-tests. Effect Size (ES) was calculated using Cohen’s delta to demonstrate the size of mean differences. Correlations between off-task and decreases in off-task behaviour and participation scores for FUNterval activities were tested using a Pearson correlation.

4.4 Results

4.4.1 FUNterval Participation

The median value for participation in the FUNterval activities for the grade 2 students was 2.0 with scores ranging from 0.25 to 3 (Figure 7). No significant relationship was observed between the participation scores for FUNterval activity and the decrease in off-task behaviour observed following FUNtervals.

In the grade 4 classroom, the median value for participation in the FUNterval activities was 2.2 with scores ranging from 1.2 to 3 (Figure 7). As in the grade 2 students, no significant relationship was observed between the participation scores for FUNterval activity and the decrease in off-task behaviour observed following FUNtervals. A significant correlation was observed between the participation scores for FUNterval activity and decreases in motor off-task
behaviour only (r=0.46, p<0.05).

### 4.4.2 Off-task Behaviour

Mean percentages of all off-task behaviours were significantly lower following the FUNterval intervention (FUN) compared to the no-activity condition (NA) in the grade 2 classroom (Figure 8). Passive off-task behaviour decreased 9% (NA=23% +/- 14% vs. FUN= 14% +/- 10%, p<0.01, ES= 0.74), verbal off- task behaviour decreased by 3% (NA=8% +/- 8% vs. FUN= 5% +/- 5%, p<0.05, ES= 0.45) while motor off-task behaviour decreased by 15% (NA=29% +/- 17% vs. FUN= 14% +/- 10%, p<0.01, ES= 1.076). When excluding the high off-task students in the analysis, decreases in the off-task passive and motor behaviour were still significant (Table 1). There were no significant differences between boys and girls in off-task behaviour on no-activity days, however, only the boys demonstrated significantly decreased passive and motor behaviour following FUNtervals (Table 1). The effects of the activity intervention were greatest in those students in the highest quartile of off-task behaviour on no-activity days (Table 1). Significant correlations were also observed between the amount of off-task behaviour observed on no-activity days and the decrease in motor (r=.72 p<0.001), verbal (r=.82, p<0.001), and passive (r=.81, p<0.001) off-task behaviour following FUNtervals (Figure 9).

In the grade 4 classroom, the mean percentages of passive and motor off-task behaviour only were significantly decreased following FUNterval activity (Passive, NA=29% +/- 13% vs. FUN= 25% +/- 13%, p<0.05, ES= 0.31; Motor, NA=31% +/- 16% vs. FUN= 24% +/- 13%, p<0.01, ES= 0.48) (Figure 10). As in the grade 2 classroom, the effects of FUNterval activity were greatest
in those students in the highest quartile for off-task behaviour on the no-activity days (Table 2). Small, however significant correlations were observed between the no-activity day off-task passive and motor behaviour and the decrease in off-task behaviour following FUNtervals ($R_{\text{motor}}=0.36, p<0.05; R_{\text{verbal}}=0.091, p=0.34; R_{\text{passive}}=0.142, p<0.05$). The decrease in passive behaviour was greater in boys than girls with significant reductions in off-task passive and motor behaviour only observed in boys (Table 2).

4.5 Discussion

Despite evidence that physical inactivity is a major risk factor for the development of health problems, youth participation in physical activity is well below national guidelines (Colley et al., 2011). In schools, time allocated to physical activity is decreasing (Coe et al., 2006; Sallis et al., 1999) despite considerable evidence that regular participation in physical activity is beneficial for both health and fitness (Biddle et al., 2004; Must & Tybor, 2005), academic performance and cognitive function (Best, 2010; Budde et al., 2008; Castelli et al., 2007; Chomitz et al., 2009; Coe et al., 2006; Davis et al., 2012; Donnelly et al., 2009; Pesce et al., 2009). In the present study we have demonstrated that brief, high-intensity interval exercise can decrease off-task classroom behaviour in both grade 2 and grade 4 students. This effect was most apparent in those students with the greatest off-task behaviour on no-activity days. These results support that decreased off-task behaviour may contribute to the well-documented link between physical activity and academic performance (Castelli et al., 2007; Chomitz et al., 2009; Coe et al., 2006; Donnelly et al., 2009) in addition to highlighting the feasibility of implementing this time efficient exercise protocol in primary school classrooms.

4.5.1 Physical activity, classroom behaviour and academic performance
Previous studies have demonstrated that on-task behaviour increases following a physical activity break that includes an academic component (Grieco et al., 2009; Mahar et al., 2006). The present study extends these results by demonstrating that 4 minutes of high-intensity physical activity (the shortest protocol studied to date) is adequate to decrease off-task behaviour. While there is some indication that a cognitive component may be required for physical activity mediated improvements in attention and recall (Budde et al., 2008; Pesce et al., 2009), the current results suggest that at least some of the improved on-task behaviour previously observed following academically linked physical activity (Grieco et al., 2009; Mahar et al., 2006) results from physical activity *per se*. Specifically, our results demonstrate that high-intensity physical activity is capable of decreasing motor (i.e. fidgeting, drawing, restlessness), and to a lesser extent, passive (i.e. gazing off, not making eye contact to the speaker, head down on the table) off-task behaviour. It is worth highlighting that a greater effect on off-task behaviour was observed in grade 2s than in grade 4s, an effect that may be explained by differences in the learning environment (the grade 2 classroom participated mainly in group work while the grade 4 classroom performed individual desk work) and/or the gender composition (grade 2s, 75% male; grade 4s, 42% male) of the classes studied. A weak positive correlation between FUNterval participation and decrease in motor behaviour in grade 4 students was also observed, indicating that exercise intensity may also impact the effectiveness of the activity intervention.

In addition to the overall improvements observed, students demonstrating the highest off-task behaviour on no-activity days demonstrated the greatest improvements in behaviour following FUNtervals. This finding is consistent with previous observations following academically linked physical activity (Mahar et al., 2006). As has been previously suggested (Grieco et al., 2009), the
finding that physical activity improves off-task behaviour, especially in the students with highest amounts of off-task behaviour, may provide additional motivation for teachers to include regular physical activity in their curriculum.

While evidence is available linking classroom behaviour to academic performance (Alexander et al., 1993; Maughan et al., 1996; Mayes et al., 2000; Stanton et al., 1990) the mechanisms underlying this relationship are poorly understood. Interestingly, similar academic performance is observed when physical activity is added at the expense of academic lesson time (Trudeau & Shephard, 2008) suggesting that learning may actually be improved when it takes place following physical activity. Our results, combined with other reports illustrating the beneficial effects of physical activity on classroom behaviour (Grieco et al., 2009; Jarrett et al., 1998; Mahar et al., 2006) suggest that improved on-task behaviour may provide a mechanistic link between physical activity and academic performance. At present however, this hypothesis remains speculative and represents an important direction for future research.

4.5.2 Implications for classroom time and student fitness

In a recent publication presenting teacher evaluations of the “TAKE 10” physical activity/nutritional intervention program, teachers reported time and class interruption as the major barriers to implementing daily physical activity into their curriculum (Tsai et al., 2009). The FUNterval protocol used in the current study was easily implemented in both the grade 2 and grade 4 classrooms and required less than 10 minutes of class disruption. Our demonstration of decreased post-FUNterval off-task behaviour is important, however, perhaps equally important is the demonstration that this time efficient high-intensity protocol was easily implemented in a
classroom setting, suggesting that the incorporation of FUNtervals into primary school classrooms is feasible.

In addition to its improvements in off-task classroom behaviour, implementing the FUNterval protocol on a regular basis may improve student fitness. FUNterval activities were adapted from a high-intensity interval protocol that has repeatedly been demonstrated to improve aerobic fitness in young adults (Ma et al., 2013; Mcrae et al., 2012; Tabata et al., 1996). Importantly, while there is evidence available that high-intensity exercise is safe, and even encouraged, in healthy children (Corbin et al., 1994; Janssen & Leblanc, 2010) it should be noted that in children with chronic health conditions medical clearance should be sought before participation in high-intensity interval exercise is undertaken (Maron et al., 2004; Philpott et al., 2010). While the ability of FUNtervals to improve fitness in primary school children has not been confirmed, the observed decrease in off-task behaviour combined with the apparent feasibility of implementation suggests that further studies examining the efficacy of FUNtervals for improving fitness are warranted.

4.5.3 Limitations and Future Directions

Among the limitations imposed by working within an operating classroom was an inability to blind our classroom observers to the activity that preceded their observation. The issues associated with attempting to blind observers to classroom activity have been discussed in detail previously (Mahar et al., 2006), however, our primary hurdle was disguising the fairly obvious physical signs of participation in high-intensity exercise. It is important to note that our inter-rater reliability scores (~90% agreement) provides confidence in the precision of observations (Mahar et al., 2006) and although inter-rater reliability does not eliminate the
possibility of bias, it does support the accuracy of our measure of off-task behaviour across conditions (Mahar et al., 2006). Another limitation of the current study is the limited scope of the analyses we were able to perform owing to a relatively small sample size. The positive effects of the current study highlight the importance of performing future work on larger, more diverse samples as we attempt to further understand the mechanism(s) linking physical activity with academic performance. Future work should also examine the appropriateness of FUNterval activities for use with non-able-bodied and overweight/obese populations and the efficacy of FUNtervals for decreasing off-task behaviour in these populations.

4.6 Conclusion

The major finding of the current study was that performance of FUNtervals, a brief high-intensity interval protocol, in grade 2 and grade 4 classrooms results in decreased off-task behaviour. This effect was most robust in those students demonstrating the most off-task behaviours on non-activity days. These results demonstrate that this brief, high-intensity exercise protocol was easily implemented into primary school classrooms while also demonstrating the efficacy of an extremely brief physical activity break for decreasing off-task classroom behaviour.

4.7 Acknowledgements

Jasmin Ma is funded by OGS.

Dr. Brendon Gurd is funded by NSERC.

Dr. Lucy LeMare is funded by the Hospital for Sick Children Foundation, an SFU SSHRC Small Grant, and Health Canada.
4.8 References


Table 1. Percent of total time (% ± S.D.) for off-task behaviours during desk lesson, carpet lesson, group work and total observation in the grade 2 classroom.

<table>
<thead>
<tr>
<th></th>
<th>Passive</th>
<th>Verbal</th>
<th>Motor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NA</td>
<td>A</td>
<td>NA</td>
</tr>
<tr>
<td>Total Off-Task</td>
<td>23±14</td>
<td>14±10*</td>
<td>8±8</td>
</tr>
<tr>
<td>Desk Lesson</td>
<td>19±19</td>
<td>24±22</td>
<td>4±7</td>
</tr>
<tr>
<td>Carpet Lesson</td>
<td>27±19</td>
<td>17±17*</td>
<td>4±6</td>
</tr>
<tr>
<td>Group Work</td>
<td>28±20</td>
<td>11±8*</td>
<td>14±19</td>
</tr>
<tr>
<td>High off-task†</td>
<td>41±6</td>
<td>21±8*</td>
<td>19±7</td>
</tr>
<tr>
<td>Excluding High off-task‡</td>
<td>17±7</td>
<td>11±6*</td>
<td>4±3</td>
</tr>
<tr>
<td>Girls (n=5)</td>
<td>16±8</td>
<td>12±11</td>
<td>6±6</td>
</tr>
<tr>
<td>Boys (n=15)</td>
<td>25±15</td>
<td>14±9*</td>
<td>9±9</td>
</tr>
</tbody>
</table>

NA= No-Activity  A= FUNterval Activity.
† Includes only the student from the highest quartile for off-task behaviours on days.
‡ All students except those in the highest quartile for no-activity day off-task behaviour.
* Significant differences from no-activity (p<0.05).
Table 2. Percent of total time (% ± S.D.) for off-task behaviours during teacher reading, writing, read aloud and total observation in the grade 4 classroom.

<table>
<thead>
<tr>
<th></th>
<th>Passive</th>
<th></th>
<th>Verbal</th>
<th></th>
<th>Motor</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NA</td>
<td>A</td>
<td>NA</td>
<td>A</td>
<td>NA</td>
<td>A</td>
</tr>
<tr>
<td>Total Off-Task</td>
<td>29±13</td>
<td>25±13*</td>
<td>7±5</td>
<td>6±5</td>
<td>31±16</td>
<td>24±13*</td>
</tr>
<tr>
<td>Teacher Reading</td>
<td>40±17</td>
<td>25±18*</td>
<td>5±5</td>
<td>5±5</td>
<td>43±18</td>
<td>28±16*</td>
</tr>
<tr>
<td>Writing</td>
<td>20±16</td>
<td>19±12</td>
<td>10±11</td>
<td>9±7</td>
<td>23±16</td>
<td>17±12*</td>
</tr>
<tr>
<td>Read Aloud</td>
<td>27±17</td>
<td>41±18*</td>
<td>7±5</td>
<td>6±5</td>
<td>27±18</td>
<td>36±16*</td>
</tr>
<tr>
<td>High off-task†</td>
<td>46±7</td>
<td>33±13*</td>
<td>15±4</td>
<td>9±6</td>
<td>55±7</td>
<td>37±13*</td>
</tr>
<tr>
<td>Excluding High off-task‡</td>
<td>24±9</td>
<td>22±12</td>
<td>7±2</td>
<td>6±4</td>
<td>23±9</td>
<td>19±9*</td>
</tr>
<tr>
<td>Girls (n=14)</td>
<td>31±9</td>
<td>29±12δ</td>
<td>8±5</td>
<td>6±4</td>
<td>31±10</td>
<td>23±9</td>
</tr>
<tr>
<td>Boys (n=10)</td>
<td>28±17</td>
<td>19±12δ</td>
<td>6±5</td>
<td>5±5</td>
<td>31±24</td>
<td>24±17</td>
</tr>
</tbody>
</table>

NA= No-Activity A= FUNterval Activity.  
† Includes only the student from the highest quartile for off-task behaviours on no-activity days.  
‡ All students except those in the highest quartile for no-activity day off-task behaviour.  
* Significant differences from no-activity (p<0.05).  
δ Significant differences between boys and girls (p<0.05).
Figure 7. Box plot and whisper graphs for student participation in FUNterval Activity

Box plot and whisper graphs for student participation in FUNterval Activity in grade 2 and grade 4 classrooms. The median, 25\textsuperscript{th} and 75\textsuperscript{th} percentile are presented with maximum and minimum values included as error bars. Participation was evaluated based on intensity and adherence to activity with 0 representing no participation and 3 representing enthusiastic participation throughout the entire duration of the FUNterval session.
Figure 8. Mean % change in off-task behaviour in the grade 2 classroom

Mean % changes in passive, verbal, and motor off-task behaviours in the grade 2 classroom.

* Indicates significant difference (p<0.05) from No Activity.
Figure 9. Relationship between off-task behaviour in the No Activity condition and the improvement (% change) following FUNtervals in grade 2 students.

Relationship between off-task behaviour in the No Activity condition and the improvement (% change) following FUNtervals in grade 2 students. Data for passive (A), verbal (B) and motor (C) off-task behaviour is shown.
Mean % changes in passive, verbal, and motor off-task behaviours in the grade 4 classroom.

* Indicates significant difference (p<0.05) from No Activity.

Figure 10. Mean % change in off-task behaviour in the grade 4 classroom
Chapter 5

4 Minutes of In-Class High-Intensity Interval Activity Improves Selective Attention in 9-11 Year Olds
5.1 Abstract

The inclusion of adequate physical activity time within schools is difficult when curriculum time is already saturated with a focus on skills that improve academic achievement. Time-efficient physical activity solutions that demonstrate their impact on academic achievement related outcomes are needed to prioritize physical activity within the school curricula. FUNtervals are 4-minute high-intensity interval activities that use whole body actions to complement a storyline. The purpose of this study was two-fold. 1) To explore whether FUNtervals can improve selective attention, an executive function posited to be essential for learning and academic success. 2) To examine whether this relationship is predicted by students’ classroom off-task behaviour. 7 grade 3-5 classes (n=88) were exposed to a single group, repeated cross-over design where each student’s selective attention on No Activity (NA) days was compared to FUNtervals (FUN) days. In week 1, students were familiarized with the d2 test of attention, FUNterval activities, and baseline off-task behaviour was observed. In both week 2 and week 3 students completed the d2 test of attention following either a FUNterval break or a No Activity break. The order of these breaks was randomized in week 2 and then repeated in the opposite order in week 3. Neither motor or passive off-task behaviour predicted changes in selective attention following FUNtervals however a weak relationship was observed for verbal off-task behaviour and improvements in d2 test performance. More importantly, students made fewer errors during the d2 test (% Error; $M_{\text{FUN}}=3.4\% \pm 0.3\%$ vs. $M_{\text{NA}}=4.4\% \pm 0.5\%$, $p=0.001$, ES= 0.26) following FUNtervals. In supporting the priority of physical activity inclusion within schools, FUNtervals, a time-efficient and easily implemented physical activity break, can improve selective attention through improved accuracy, quality of work and a higher degree of carefulness in elementary school children.
5.2 Introduction

Despite evidence that physical activity promotes health in children (Biddle et al., 2004; Must & Tybor, 2005), only 7% of Canadian youth are meeting the physical activity guidelines (Active Healthy Kids Canada, 2014). While schools appear to represent an ideal site for increasing youth physical activity (Colley et al., 2011; Pate et al., 2006; Tomporowski et al., 2011) the perception that physical activity threatens academic achievement (Coe et al., 2006; Sallis et al., 1999), and the perceived lack of time available for physical activity (Tsai et al., 2009) have contributed to a lack of physical activity programming in schools. Contrary to these perceptions, time spent participating in physical activity in place of regular instruction time does not impair academic performance (Rasberry et al., 2011), while time taken from physical education is detrimental to youth health and ultimately does not improve academic performance (François Trudeau & Shephard, 2008). Not only does the literature support that time spent on physical activity does not negatively affect academic performance, there is extensive evidence that physical activity actually improves academic outcomes (Ahamed et al., 2007; Carlson et al., 2008; Murray et al., 2007; Rasberry et al., 2011; Sallis et al., 1999; F. Trudeau & Shephard, 2010; François Trudeau & Shephard, 2008).

To address the barrier of time and the associated threat to academic performance teachers perceive, we (Chapter 4) and others (Grieco et al., 2009; Mahar et al., 2006; Tsai et al., 2009) have developed brief exercise breaks designed to be time-efficient and feasibly implemented in the classroom. To further support the inclusion of physical activity in schools an emerging body of literature has begun to examine the impact of classroom exercise breaks on outcomes linked to learning and academic performance (Chapter 4; Grieco et al., 2009; Mahar et al., 2006; Tsai et al.,
In particular, the impact of exercise on selective attention, a cognitive function linked to learning (Yli-krekola et al., 2009), has received recent interest.

Selective attention, the ability to attend to relevant stimuli and ignore irrelevant or distractor stimuli (Bedard et al., 2003; Carter et al., 1995), is an important determinant of literacy (Stevens et al., 2009) and mathematics ability (Blair & Razza, 2007). There is limited evidence that exercise has positive effects on selective attention with coordinative exercises such as balancing and reaction exercises (Budde et al., 2008), sports (Budde et al., 2008), and sustained moderate to high-intensity exercise (Niemann et al., 2013; Tine & Butler, 2012) enhancing selective attention in elementary aged children. However, the effect of brief, high-intensity, classroom-based physical activity on selective attention has yet to be examined.

We have previously demonstrated that a 4-minute high-intensity interval protocol, FUNtervals, are easily implemented in primary school classrooms and reduce off-task behaviour (i.e. disengagement from the learning task at hand) in grade 2 and grade 4 students (Chapter 4). In this study the greatest improvements in off-task behaviour following FUNtervals were seen in those students demonstrating the highest off-task behaviour on No Activity days. Interestingly, there is some evidence that changes in off-task behaviour and selective attention may not occur independently. For example, children with ADHD exhibit significantly less on-task behaviour than their typically developing counterparts (Kofler et al., 2008), and have associated problems with selective attention (Satterfield et al., 1990). Given this potential relationship, and our previous observation that improvements in off-task behaviour were correlated with baseline off-
task behaviour, it seems reasonable to hypothesize that improvements in selective attention following exercise may be predicted by off-task behaviour.

Therefore, the purpose of this study is two-fold. 1) To examine the effects of brief, high-intensity interval exercise (FUNtervals) on selective attention, a cognitive function essential for learning, and 2) To determine whether classroom off-task behaviour predicts any changes in selective attention observed following exercise.

5.3 Methods

5.3.1 Participants:

Participants were recruited from 7 classes consisting of grade 3-5 students (grade 3/4, 2 classes; grade 4, 2 classes; grade 4/5, 3 classes) from 5 different South Eastern Ontario elementary schools. Schools serviced primarily white, middle class families with 12 students having ministry of education designations. 168 out of the total 170 students (99%) returned permission forms confirming informed consent. Any students that did not contain a full data set (5 days of testing), absences, students with dyslexia or severe learning disabilities and the exclusion of one class whose teacher intervened during an intervention as a result of excessively poor behaviour on a No Activity day, a total of 88 students (male n=44, female n=44) were included in the final data analysis. Approval for this study was obtained from the General Research Ethics Board at Queen’s University and the Limestone District School Board.

5.3.2 Study Design:

The current study utilized a single group, repeated cross-over design where each student’s selective attention on No Activity (NA) days was compared to their FUNterval (FUN)
days. Off-task behaviour for each student was also evaluated on 2 occasions during the first week of the study. The intervention totaled 3 weeks in duration with all data collection being conducted in the classroom. In week 1, students were familiarized with the d2 test of attention and FUNterval activities, and off-task behaviour was assessed. In both week 2 and week 3 students completed the d2 test of attention following either a FUNterval break or a No Activity break. The order of these breaks was randomized in week 2 and then repeated in the opposite order in week 3.

5.3.3 Familiarization and Quantification of Off-Task Behaviour

The first day of week 1 was used as familiarization to both FUNterval activities and the d2 test of attention. 50 minutes of observation of off-task behaviour was also completed on day 1 with the dual purpose of familiarizing the researchers with the observation tool, and familiarizing students with the presence of researchers in the classroom. Student familiarization to the presence of researchers has previously been reported to be important in order to eliminate the reactivity effect on the teacher and students (Mahar et al., 2006). Data collected during the familiarization day was not used in subsequent analysis.

Days 2 and 3 of week 1 were used to quantify student off-task behaviour on No Activity days. Both of these days consisted of 50 minutes of classroom observation following a 10-minute lecture break delivered by the primary researcher. The 10-minute, No Activity break was separated from recess by at least 20 minutes on both days.

5.3.4 FUNterval and No Activity Interventions
During weeks 2 and 3, FUNterval and No Activity break interventions were delivered on 2 separate days in randomized order (FUNterval intervention on day 1 n= 53; No Activity intervention on day 1 n= 35). The order that these breaks were delivered in week 3 was opposite from the order that they were delivered in week 2. On each experimental day, the duration of the intervention break (FUNterval or No Activity) was approximately 10 minutes and was separated from recess by at least 20 minutes of normal classroom instruction. Every intervention break was followed by another 10-minute No Activity break, during which the researcher delivered a non-class related lecture, before the d2 test of attention was administered. The d2 test of attention was administered 10 minutes post-intervention as previous research has demonstrated that this is the time period at which the greatest effects of physical activity on executive function are present (Chang et al., 2012). Intervention days within a given week were separated by at least 24 hours and the last visit of week 2 and the first of week three were separated by at least 5 days. Ideally a week separation occurred between weeks 2 and 3 in an attempt to reduce the learning effect on the d2 test (Budde et al., 2012), however this scheduling commitment was not always feasible for teachers. A detailed schematic of the experimental design is presented in Figure 11.

5.3.5 FUNterval Activity Intervention:

FUNtervals are high-intensity interval activities that require four minutes to complete, are always performed inside the classroom, and require no equipment. The protocol, adapted from the work of Tabata et al. (1996) consists of 20 seconds of high-intensity activity separated by 10 seconds of rest, repeated 8 times. This protocol was adapted for primary school classrooms to complement various storylines, which encourage students to complete large, whole body movement as fast as possible. Movements targeted included squats, jumping jacks, scissor kicks, jumping, and running on the spot. A different FUNterval was implemented on each activity day.
of the study. A booklet outlining the FUNterval activities utilized in this study, along with many additional activities is available from authors upon request. Although other physical activity breaks that are effective for school use are available (Melicia Whitt-Glover, Porter, & Yancey, 2013) FUNtervals is unique for its physical activity-specific break (no associated academic component), requirement of less than 10 minutes of class disruption, and no equipment or relocation from the classroom.

5.3.6 No Activity Intervention:

To isolate the effects of exercise from the effect of having a break in the lesson material, a lecture on a non-lesson related topic was given on No Activity days. Lectures given did not require the students to be physically active in any capacity and included the primary researcher speaking about topics related to the field of kinesiology.

5.3.7 Observation:

Classroom observation took place during regular classroom instruction. Teachers were instructed to avoid group work and have students participate in the lecture from their desks. Although the proportion of time each class spent in each lesson activity varied, classroom lessons during the observation period consisted of either students completing independent worksheets and/or oral lectures followed by a question and answer period.

Off-task behaviour was identified using the Behavioral Observation of Students in Schools (BOSS) tool (Shapiro, 1996) with off-task behaviour being recorded using the partial interval method (Hintze et al., 2002) as we have described previously (Please see Chapter 4). Briefly, a rotating observation schedule allowed for a total observation time of 5 minutes per
student per day. During each observation interval researchers noted the occurrence and duration of motor (i.e. fidgeting, drawing, restlessness), verbal (i.e. talking to classmate, speaking when not called upon), and passive (i.e. gazing off, not making eye contact to the speaker, head down on the table) off-task behaviour for 30-seconds (Hintze et al., 1997; Mahar, 2011). Reliability of this observation technique was previously tested in grade 4’s and found to be high 90% (range=84-94%), Kappa= 0.795 (Chapter 4).

5.3.8 d2 Test of Attention:

The d2 is a standardized pen and paper assessment of individual attention and concentration that is related to academic performance (Brickenkamp, 2002). The test consists of 14 lines of 47 characters (658 total items) composed of the letters “p” and “d” with 1-4 dashes arranged individually or in pairs above or below the character. The students are required to scan the characters and mark all “d”s with two dashes either above or below. Students were given 20 seconds per line, or a total of 4 minutes and 40 seconds to complete the test and the tests were scored for the total number of worked symbols (sum of total characters processed for each line; TN), errors of omission (the number of mistakes made by missing relevant symbols; $E_{Omis}$), errors of commission (the number of mistakes made by including irrelevant symbols; $E_{Comm}$), the percentage of errors (the proportion of both errors of commission and omission made within all of the processed items; $E\%$), the total number of items scanned minus error scores (TN-E), and concentration performance (number of correctly crossed out relevant items minus errors of commission; CP) (Brickenkamp & Zillmer, 2002). The test retest internal reliability of the d2 test has been reported to be high (0.9-0.95) for all parameters (Brickenkamp, 2002) with test values for criterion, construct, and predictive validity remaining stable over a period of up to 23 months after initial testing (Brickenkamp, 2002). The d2 test of attention has been used to measure
selective attention in previous childhood studies (Budde et al., 2008; Niemann et al., 2013; Tine & Butler, 2012) and was selected as its short time for completion and set up make it minimally disruptive for the classroom.

5.3.9 Statistical Analysis:

Values for d2 test performance for each student were obtained by averaging the daily collections in each condition. Repeated measures 2 way ANOVA’s were used to compare d2 performance scores between No Activity and FUNterval days. Where the assumption of sphericity was violated, the Greenhouse Geyser adjustment was reported. Unpaired samples t-tests were used to determine differences in d2 test performance between genders. Effect Sizes (ES) were calculated using Cohen’s delta to demonstrate the size of mean differences. Classroom off-task behaviour was averaged over the two days and linear regression analysis was used to examine each individual component of classroom off-task behaviour as a predictor of mean changes in selective attention. Unpaired t-tests were used to compare off-task behaviour in males and females.

5.4 Results

5.4.1 Participant Characteristics

A comparison of the d2 test performance on No Activity days demonstrated that males made a higher number of Total Errors and Errors of Omission than females (Table 3). Males were also found to participate in a greater percentage of passive off-task behaviour than females (Table 3).

5.4.2 d2 Test of Attention
Repeated measures ANOVAs revealed no interaction effects of gender or week on intervention, but a significant (p<0.05) main effect of intervention (i.e. FUNtervals) was observed on d2 test performance. Specifically, No Activity days resulted in greater Total Number of Characters Processed (TN; NA= 370, FUN=361, p=0.04, ES=0.12; Figure 12 A) while FUNtervals resulted in fewer Total Errors (E; NA= 15, FUN=11, p<0.01, ES=0.29), Errors of Omission (E_{Omis}; NA= 9, FUN=6, p=0.01, ES=0.18; Figure 12 B), Errors of Commission (E_{Comm}; NA= 7, FUN=5, p=0.03, ES=0.16; Figure 12 C), and Percentage of Errors (E%; NA= 4.4%, FUN=3.4%, p<0.01, ES=0.23; Figure 12 D). All measures of the d2 test were improved from week 1 to week 2 (p<0.05). A significant effect of test day order was also found from day 1 to day 2 in all d2 test outcomes as well as between days 3 and 4 for Total Errors, Errors of Omission, and Percentage of Errors (Data not shown).

5.4.3 Off-Task Behaviour and Selective Attention

Neither mean passive nor motor off-task behaviour was found to predict the change in d2 test outcomes in linear regression tests (p>0.05; Table 4). However, a weak relationship between mean verbal off-task behaviour and change in E_{Comm} (R=.27, P=0.03), E% (R=.27, P=0.02), and CP (R=.24, P=0.05) as well as a weak relationship between mean verbal off-task behaviour and No Activity E_{Comm} (R=0.06, P=0.04; not shown in data) were observed (Table 4). Similar to the regression analysis, the improvement in selective attention following FUNtervals was not significantly different between the highest quartile (HQ) and lowest quartile (LQ) of motor or passive off-task behaviour (data not shown), however, the highest quartile (HQ) for verbal off-task behaviour demonstrated a significantly greater improvement following FUNtervals than the lowest quartile (LQ) for E (HQ=-7.7, LQ=-2.0, p=0.04), E_{Comm} (HQ=-2.6, LQ=-0.3, p=0.03), E% (HQ=-2.2, LQ=-0.5, p=0.04), and CP (HQ=7.8, LQ=-1.3, p=0.01; Figure 13).
5.5 Discussion

The present study examined the acute effects of brief, high-intensity interval activities, or FUNtervals, on selective attention in grades 3-5 students. Whether the impact of exercise on selective attention could be predicted by classroom behaviour was also examined. The major findings of the current study were: 1) brief, high-intensity interval exercise (FUNtervals) improves selective attention in 9-11 years olds, and 2) verbal off-task classroom behaviour weakly predicted the changes in selective attention induced by FUNtervals but a similar relationship was not observed for either passive or motor off-task behaviour. These results demonstrate that FUNtervals are both easily implemented in primary school classrooms, and can increase performance on a selective attention test, suggesting that they may also improve the in-class learning environment.

5.5.1 FUNtervals and Selective Attention

The most important finding of the current study is the observation that 4-minutes of high-intensity interval activity improves selective attention in elementary school children (Figure 12). The observation that fewer errors were made during the d2 test following FUNtervals is consistent with improved accuracy, quality of work and degree of carefulness compared to No Activity days. Performance on the d2 test is also predictive of academic performance (Brickenkamp & Zillmer, 2002) suggesting that the observed improvements on the d2 test following FUNtervals may be associated with improvements in academic achievement were FUNtervals to be implemented on a long term basis. These results are speculative however and further research is needed to confirm the long-term effects of regular participation in FUNtervals activities on academic achievement.
Our observations are consistent with previous studies demonstrating positive acute effects of exercise on selective attention. For example, running at both moderate (Tine & Butler, 2012) and high intensities (Niemann et al., 2013) resulted in greater d2 test performance with this effect being particularly strong in students from low-income families (Tine & Butler, 2012). Additionally, both coordinative exercises and normal sport lessons improve concentration performance (CP), with greater effects seen following coordinative exercises (Budde et al., 2008). Unlike the latter study, where a counterbalanced order, no activity control was absent, the current study utilized a randomized within-subject repeated crossover design, which provides greater confidence that the observation of improved selective attention was an effect of exercise per se, rather than an effect of learning. Further, after exclusion of students with incomplete data sets (see methods for details), a greater percentage of students participated in an order of conditions that would favour improvements in the No Activity condition in week 1 (60% completed the FUNterval condition first during the first week of testing) as test taking strategies may be developed when the test is repeated from day to day. This may explain the observation that No Activity days resulted in a slightly higher number of characters processed than FUNterval days and suggests that the positive effects of FUNtervals reported may actually have been underestimated in the current data set. In summary, FUNtervals are an extremely brief physical activity break with benefits extending beyond their ease of implementation to the classroom learning environment through improved selective attention.

5.5.2 Selective Attention and Off-Task Behaviour Relationship

The second purpose of this study was to examine whether baseline off-task classroom behaviour predicted changes in selective attention following FUNtervals. Previous studies have observed that students with the highest off-task behaviour benefited the most from physical
activity interventions (Chapter 4; Mahar et al., 2006). Based on these observations, and the proposed mechanistic links between behaviour and selective attention (Kercood & Grskovic, 2009), we hypothesized a positive correlation between baseline off-task behaviour and the change in selective attention induced by exercise. Contrary to our hypothesis, neither passive nor motor off-task behaviour predicted the change in d2 test performance following FUNtervals (Table 4), and while a statistically significant correlation was observed between verbal off-task behaviour and improvements in d2 test performance (Concentration Performance, % Errors and Errors of Commission; Table 4) this effect was weak (r ~ 0.25). To our knowledge, no study to date has specifically tested the relationship between classroom off-task behaviour and selective attention in children of normal learning ability, but behaviour and selective attention have been linked in children with attentional dysfunction (Barkley, 1997; Hallahan et al., 1979). There is also evidence that strategies targeted to improve selective attention also result in improved classroom behaviour in students with attention disorders (Kercood & Grskovic, 2009). Our data provides preliminary evidence that verbal off-task behaviour is associated with selective attention improvements, however further research evaluating children with normal learning abilities using randomized control trials are needed to better understand the classroom behaviour and selective attention relationship.

5.5.3 Limitations and Future Directions

In an effort to encourage teacher participation, the current study was designed to be as minimally disruptive to normal class activities as possible, and thus the primary researcher led the activity interventions in classrooms. To better generalize the feasibility of FUNtervals, future studies should involve teachers in the activity implementation. Additionally, although the d2 Test of Attention is shown to be related to academic outcomes (Brickenkamp, 2002), we have not been
able to demonstrate an effect of FUNtervals on academic performance. Future research should test the long-term effects of FUNtervals on academic performance and achievement by assessing the impact of regular participation in FUNtervals on standardized test results or grade point average. Finally, while the protocol used in FUNtervals has consistently demonstrated improvements in adult fitness when done on a bicycle (Ma and Scribans et al., 2013; Tabata et al., 1996) or using whole body movements (McRae et al., 2012) the efficacy of FUNtervals specifically for improving fitness in children is currently not known. Most importantly, future work needs to focus on translating these activities out of research studies and into classrooms. This process can begin with the dissemination of the resource to school boards accompanied by training teachers to implement FUNtervals in their own classrooms.

5.6 Conclusion

FUNtervals address both the barrier of time teachers face and supports the positive role activity breaks play in the learning environment. Further, we have demonstrated that verbal off-task behaviour weakly predicts changes in d2 test performance following FUNtervals, and more importantly, that d2 test performance (i.e. selective attention) is improved by participation in 4 minutes of high-intensity, classroom based, interval activity. This study is the first to examine the effect of physical activity on selective attention using an intervention that is appropriate for the classroom and therefore demonstrates the feasibility and utility of short physical activity breaks in the classroom. It is hoped that these results will be utilized to help prioritize the inclusion of physical activity within school curricula.
5.7 References


Ma, J. K., Le Mare, L., & Gurd, B. (2014). Classroom based physical activity and the effects on off-task behaviour in primary school students: an intervention study. *Submitted for Publication.*


Tables and Figures

Table 3 Participant Characteristics. Means ± S.E. of % of off-task behaviour and d2 test performance on No Activity days. *Indicates significant (p<0.05) differences between males and females.

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behaviour</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Passive</td>
<td>29 ± 3</td>
<td>19 ± 2</td>
<td>&lt;0.01*</td>
</tr>
<tr>
<td>% Motor</td>
<td>25 ± 3</td>
<td>18 ± 2</td>
<td>0.13</td>
</tr>
<tr>
<td>% Verbal</td>
<td>5 ± 1</td>
<td>5 ± 1</td>
<td>0.97</td>
</tr>
<tr>
<td>Selective Attention</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TN</td>
<td>381 ± 13</td>
<td>359 ± 13</td>
<td>0.21</td>
</tr>
<tr>
<td>E</td>
<td>19 ± 2</td>
<td>12 ± 2</td>
<td>0.03*</td>
</tr>
<tr>
<td>EOmis</td>
<td>12 ± 2</td>
<td>6 ± 2</td>
<td>0.01*</td>
</tr>
<tr>
<td>EComm</td>
<td>7 ± 1</td>
<td>6 ± 1</td>
<td>0.70</td>
</tr>
<tr>
<td>E%</td>
<td>5.0 ± 0.6</td>
<td>3.8 ± 0.6</td>
<td>0.18</td>
</tr>
<tr>
<td>TN-E</td>
<td>362 ± 13</td>
<td>347 ± 13</td>
<td>0.39</td>
</tr>
<tr>
<td>CP</td>
<td>143 ± 6</td>
<td>140 ± 6</td>
<td>0.65</td>
</tr>
</tbody>
</table>

TN= Total number of characters processed, E= Total errors, EOmis= Errors of omission, EComm= Errors of commission, E%= Percent errors, TN-E= Total number of characters minus total number of errors, CP= Concentration Performance
Table 4 Regression R values of average off-task behaviour as a predictor of d2 test performance.
*Indicates significant (p<0.05) correlation.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>TN</td>
<td>R 0.05</td>
<td>0.09</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td>P value 0.70</td>
<td>0.47</td>
<td>0.65</td>
</tr>
<tr>
<td>E</td>
<td>R 0.01</td>
<td>0.11</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>P value 0.91</td>
<td>0.38</td>
<td>0.10</td>
</tr>
<tr>
<td>E_{Omis}</td>
<td>R 0.00</td>
<td>0.08</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>P value 0.99</td>
<td>0.52</td>
<td>0.32</td>
</tr>
<tr>
<td>E_{Comm}</td>
<td>R 0.05</td>
<td>0.10</td>
<td><strong>0.26</strong></td>
</tr>
<tr>
<td></td>
<td>P value 0.72</td>
<td>0.42</td>
<td><strong>0.03</strong>*</td>
</tr>
<tr>
<td>E%</td>
<td>R 0.03</td>
<td>0.10</td>
<td><strong>0.27</strong></td>
</tr>
<tr>
<td></td>
<td>P value 0.81</td>
<td>0.41</td>
<td><strong>0.02</strong>*</td>
</tr>
<tr>
<td>TN-E</td>
<td>R 0.06</td>
<td>0.13</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>P value 0.66</td>
<td>0.29</td>
<td>0.31</td>
</tr>
<tr>
<td>CP</td>
<td>R 0.06</td>
<td>0.17</td>
<td><strong>0.24</strong></td>
</tr>
<tr>
<td></td>
<td>P value 0.65</td>
<td>0.17</td>
<td><strong>0.05</strong>*</td>
</tr>
</tbody>
</table>

TN= Total number of characters processed, E= Total errors, E_{Omis}= Errors of omission, E_{Comm}= Errors of commission, E%= Percent errors, TN-E= Total number of characters minus total number of errors, CP= Concentration Performance
Figure 11. Overview of study design. The order of interventions in weeks 2 and 3 was randomized and counterbalanced.
Figure 12. Effects of FUNtervals on d2 test of attention outcomes. Comparison of FUNterval to No Activity days in males and females on total number of items processed (TN; A), errors of omission (E\textsubscript{Omis}; B), errors of commission (E\textsubscript{Comm}; C) and % errors (E%; D).

*Indicates a significant (p<0.05) main effect of intervention.
Figure 13. Comparison of the highest and lowest quartile of mean off-task verbal behaviour on change in d2 test performance from No Activity Days to FUNterval days. A greater negative change is desirable for Total Errors (E), Errors of Commission (E_{Comm}), and % Errors (E%), while a greater positive change is desirable for Concentration Performance (CP).

*Indicates significantly different from the highest quartile (p<0.05)
Chapter 6

General Discussion

6.1 Summary of Key Findings

The current thesis has provided three important findings that contribute to the physical activity in schools literature. 1) Supporting our hypothesis, acute bouts of high-intensity interval activities, or FUNtervals, improve classroom behaviour in students in grades 2 and 4. Specifically, when compared to No Activity days, students exhibited less off-task behaviour following FUNtervals. Our results extend previous findings that academic lesson related activity breaks improve on-task behaviour (Grieco et al., 2009; Mahar et al., 2006) and demonstrate for the first time that physical activity alone improves classroom behaviour. 2) Also in line with our hypothesis, FUNtervals improve selective attention in students in grades 3-5. When compared to No Activity days students produced a smaller percentage of errors during the d2 test of attention following FUNtervals. These findings are also consistent with previous examinations of acute bouts of physical activity on selective attention (Budde et al., 2008; Niemann et al., 2013; Tine & Butler, 2012), however, this is the first study to use an intervention that is appropriate for classroom use. 3) Contrary to our hypothesis, only verbal off-task behaviour predicted changes in selective attention following FUNtervals with the relationship observed being significant but weak (r ~0.25). To our knowledge, no study has examined this relationship experimentally in children with normal learning abilities and further research is required to understand whether this relationship extends beyond children with attention deficit disorders.
6.2 Thesis Strengths

In Chapter 3, the novelty of the FUNterval protocol is discussed. Although other physical activity breaks that are effective for school use are available (Melicia Whitt-Glover, Porter, & Yancey, 2013) FUNtervals is the first to encompass all attributes of having a physical activity-specific break (no associated academic component), requiring less than 10 minutes of class disruption, and no equipment or relocation from the classroom.

In Chapter 4, observation measures were conducted over five days for each condition increasing the confidence in our observed effects. In addition, previous studies used activity interventions in conjunction with learning material and compared behaviour following activity to behaviour following regular class instruction. In chapter 4 we used a non-academic physical activity intervention with activity being compared to no activity breaks (in order to control for changes resulting from simply having a break from lesson material). This strengthens the conclusion that improvements in behaviour were a result of physical activity per se. In combination, Chapter 4 demonstrates the first of two school relevant outcomes to support the utility of these time-efficient physical activity breaks in schools.

In Chapter 5, the rigour of the repeated measures cross-over design in the current study addresses both the limitations of individual variability (Niemann et al., 2013; Tine & Butler, 2012) as well as the potentially confounding effect of learning (Budde et al., 2008) that previous studies faced. Lastly, to our knowledge, this is the first study to examine the acute effects of exercise on selective attention using an intervention that can be directly translated for classroom
use. Together, Chapters 4 and 5 extend the use of physical activity breaks to demonstrate their importance in the classroom, improving both behaviour and attention using a classroom feasible intervention.

6.3 Study Limitations

Although careful consideration of the study design was taken, a few limitations are worthy of discussion. First, it is possible that the No Activity condition could have had negative effects on d2 test performance and may not have been experienced as a ‘break’ by some students. However, student responses to the No Activity lectures were very positive and did accomplish providing a break from their regular teacher’s instruction. Other types of no activity breaks, such as watching a movie or playing card games may be explored in the future. Next, our inter-rater reliability scores (~90% agreement) provide confidence in the precision of observations in both studies, however using video observation would provide greater certainty in eliminating observer bias. Despite our efforts, videotaping was not possible for the present studies due to ethical constraints. Likewise, administration of the d2 test following either FUNterval or control conditions should be blinded in future studies. However, best efforts were made by the primary investigator to avoid bias by following a script provided by the publishers of the d2 test when administered. Limitations to the d2 test of attention are the confounding effects of learning and motivation. Other tests of cognition were considered for this study such as the Stroop test (Stroop, 1935) and Flanker task (Eriksen & Eriksen, 1974). These were not chosen in an effort to avoid reading ability as a limitation to student performance as well as the use of technology and equipment in order to minimize disruption in the classroom. Lastly, although the d2 test and classroom behaviour are related to academic performance, this study did not test for improvements in academic achievement specifically.
6.4 Future Directions

Further supporting the role of FUNtervals in schools, FUNtervals’ chronic effects on academic performance should be tested by assessing the impact of regular participation in FUNtervals on grade point average or standardized test results. Additionally, as a complement to the improvements of cognitive function seen in Chapter 5, neuro-imaging data would be useful to discern the mechanisms through which this relationship is achieved (Hillman et al., 2009). Most importantly, the next step for FUNtervals is to translate the research into practice. Dissemination of the resource to school boards is integral to accomplishing the true purpose of this research. Highlighting the uptake of the activities thus far, FUNtervals are now a part of the university curriculum, are being distributed to all schools in the Kingston and area through Public Health endorsement, as well as anecdotally have received very positive feedback from participating teachers and students. In addition, Chapter 3 has been submitted to ACSM’s popular Fitness and Health journal to continue extending the reach of this resource to potential users. By providing activities that are easily implemented in the classroom and are accompanied by improvements necessary for optimal learning, we hope to facilitate the inclusion of physical activity in schools as a priority within the curriculum.

6.5 MSc. Research Experience

The past two years as a graduate student have offered opportunities that have provided me with both theoretical and practical knowledge. From the theoretical perspective, I have developed a greater understanding of physiological mechanisms associated with exercise both in the sites of the muscle and brain. From a practical perspective, I have gained tools in exercise training and laboratory fitness testing, behaviour observation and cognitive testing techniques, in
addition to lecturing skills to various age groups. Beyond the learned educational content, my experience has also brought forth a great deal of personal growth. Having completed 4 projects throughout my master’s I’ve honed skills in time management, experienced the importance of networking and most importantly understood the value of critical thinking. The opportunity to work with a diverse set of colleagues, and particularly the guidance of Dr. Gurd who fostered my interest in research, despite my avenues that expanded outside of his area of expertise, has allowed me the opportunity of a very meaningful research experience. Scratching the surface of the crossroads between basic and applied research, I hope to continue working in an area of research that brings knowledge into practice.

6.6 Conclusions

Including physical activity within the school curriculum can be difficult when academic achievement is the primary priority for schools. This thesis provides important evidence demonstrating the role of physical activity in improving classroom-based outcomes that contribute to schools’ central focus. The exercise intervention examined in this thesis, FUNtervals 1) Improve both classroom behaviour and 2) selective attention in elementary school children. Lastly, 3) preliminary findings show that verbal off-task classroom behaviour predicts changes in selective attention following acute bouts of high-intensity interval activities, or FUNtervals. Importantly, these time-efficient and classroom feasible activities extend the role of physical activity to an effective strategy for bettering the learning environment and prioritizing the inclusion of physical activity in school curricula.
6.7 References


Appendix A: Research Ethics Board- Letter of Informed Consent

Impact of Acute Exercise on Attention and Behaviour in Elementary School Students

Parental Letter of Information and Informed Consent/ Letter of Assent

Your son/daughter is being asked to participate in a research project conducted by Jasmin Ma and Dr. Brendon Gurd of Queen’s University in collaboration with Limestone District School Board teachers, Myra MacDonald and Laural Matthews. The project aims to examine the impact of exercise prior to instructional class on attention and behaviour. Participation in this study is voluntary and will involve your son/daughter to complete three different exercise conditions that will run daily for two weeks at a time for a total of six weeks. Measures of attention and behaviour will be taken at the beginning of each week with the addition of one final survey once you’ve finished. These measures will include short surveys and classroom observation.

Exercise Conditions:
Your son/daughter will participate in three different exercise conditions, each daily for 2 weeks. Exercise will be scheduled during normal class hours and should last no longer than 20 minutes each day. In the ‘no exercise before class’ condition, your son/daughter will continue participation in your regular Daily Physical Activity (DPA). In the third week, your son/daughter will exercise at a continuous, moderate effort for twenty minutes. As an example, your son/daughter will participate in a game of small field soccer or other running exercises. Intensity may be measured using a non-invasive personal heart rate monitor that straps around your son/daughter’s chest. In the last condition your son/daughter will complete games that require a great amount of effort for four minutes prior to class. This may include running, jumping, squatting, skipping. We are interested in knowing if incorporating exercise prior to class will improve students’ classroom behaviour and attention. Should your son/daughter not wish to participate in the exercise, they are free to partake in the alternative activities their teacher provides them with when they do not wish to partake in their regular DPA.

**Behaviour and Attention Surveys:**

A short survey will be distributed at the beginning of each week with the addition of one final survey once your son/daughter has finished for a total of 7 surveys. The surveys should take no longer than five to ten minutes to complete during class and will show how your son/daughter felt about his/her class behaviour and attention that day, i.e. ability to concentrate, speaking only when called upon, fidgeting, etc.

**Classroom Observation:**

Observation will be used to document behaviour, specifically regarding attention and focus during class (i.e. interrupting, talking, ability to keep on-task). This will entail two trained Queen’s University observers recording behaviour with a pen and paper for the duration of a class on six separate occasions. The students will be instructed to ignore the research members’ presence and researchers will not interact with the children as to minimize disturbances to the class. The principal investigator will then analyze the recordings in order to observe differences in behaviour between classes.
Risks and Confidentiality:

While there are risks associated with exercise (i.e. fatigue, accidental minor injury, shortness of breath due to exertion, etc.), these risks are very slight in young adolescents. If you have any concerns that your child is not healthy enough to participate in regular physical activity please contact your homeroom teacher or one of the study coordinators (contact information is provided below). There is neither compensation nor penalty for participating or not participating in this project.

All data that is collected during the course of this study will be stored using initials and identification numbers. As the students will not be expected to remember their respective subject ID number, a digital list with their name and corresponding subject number will be kept on a password protected lab computer and accessed by only Jasmin Ma and Dr. Brendon Gurd. At no point will the full names of the participants be released or used for any other purpose other than subject identification by the primary researchers. As such, individual results will only be viewed by the researchers directly involved in this study (Dr. Brendon Gurd and Ms. Jasmin Ma) and results will always be presented anonymously and as group means. Should your son/daughter wish to discontinue participation at any point, he/she is free to do so without any penalty. If participants wish to withdraw from the study they will be able to do so by informing their teacher or a member of the research team at any time. Withdrawal from the study will simply mean that data will not be collected from that participant moving forward and all data previously collected will be deleted. There is no penalty for withdrawal.
If at any point you have questions or concerns regarding your child’s involvement in this study you can contact either your home-room teacher or any of the individuals below:

This study has been granted clearance according to the recommended principles of Canadian ethics guidelines, and Queen’s policies.

Any questions about study participation may be directed to Dr. Brendon Gurd at gurdb@queensu.ca or the student researcher, Jasmin Ma at 8jkm@queensu.ca. Any ethical concerns about the study may be directed to the Chair of the General Research Ethics Board at chair.GREB@queensu.ca or 613-533-6081.

Ms. Jasmin Ma  
Primary Graduate Student Investigator  
8jkm@queensu.ca

Dr. Brendon Gurd  
Study Supervisor  
Assistant Professor in the School of Kinesiology and Health Studies at Queen’s University  
gurdb@queensu.ca  
(613 533 6000 extension 79023)

Myra MacDonald  
Teacher Contact  
mmacdonald1@cogeco.ca

Laural Matthews  
Teacher Contact  
matthewsl@limestone.on.ca

Dr. Joan Stevenson  
Chair of the General Research Ethics Board at Queen’s University
By signing this document I and my son or daughter acknowledge the following:

- I and my son or daughter have read the form above and have any questions answered to my satisfaction.
- I and my son or daughter have read the form, understand the study and are aware of the voluntary nature of the study.
- I and my son or daughter understand that participation in this study is voluntary and that they or I may remove themselves/myself from the study at any time without any negative repercussions.
- I and my son or daughter are aware that if I have any questions I understand who to contact, under what circumstances, and that at any point I can contact the individuals listed above.
- I and my son or daughter understand the confidentiality measures taken in the study.
- I grant permission for the video recording of my son or daughter.

You are encouraged to keep a copy of the letter of information for your own records.

I grant permission for my son/daughter to participate in the following:

- [ ] Exercise Conditions
- [ ] Surveys
- [ ] Classroom Observation

Name of Volunteer  _______________________________________________________________

Name of Parent/Guardian  ____________________________________________________________

Signature/Date  ____________________________________________________________
Appendix B: Research Ethics Board- Letter of Informed Consent

School of Kinesiology and Health Studies
Department of Exercise Physiology
28 Division St., Kingston, Ontario
Canada, K7L 3N6

Impact of Acute Exercise on Attention and Behaviour in Elementary School Students

Parental Letter of Information and Informed Consent/ Letter of Assent

Your son/daughter is being asked to participate in a research project conducted by Jasmin Ma and Dr. Brendon Gurd of Queen’s University in collaboration with Limestone District School Board teacher, Lise Doutre. The project aims to examine the impact of exercise prior to instructional class on attention and behaviour. Participation in this study is voluntary and will involve your son/daughter to complete short physical activities. Measures of attention and behaviour will be taken daily. These measures will include observation, and short, written tests of attention. Heart rate data will also be collected to measure exercise intensity.

Exercise:

Exercise will be scheduled during normal class hours and should last no longer than 4 minutes each day. Your son/daughter will complete games that require a great amount of effort, this
may include running on the spot, jumping, squatting, skipping. Heart rate will be taken using non-invasive detectors attached at the chest underneath the clothing using adjustable straps. The primary researcher will aid with heart rate monitor placement in a private area of the classroom under teacher supervision. In the ‘no exercise before class’ condition, your son/daughter will continue participation in your regular Daily Physical Activity (DPA). We are interested in knowing if incorporating exercise prior to class will improve students’ classroom behaviour and attention. Should your son/daughter not wish to participate in the exercise, they are free to partake in the alternative activities their teacher provides them with when they do not wish to partake in their regular DPA.

Test of Attention:

A short, written test of attention will be distributed daily for the duration of the study. The test will require your son/daughter to identify, on a piece of paper, specific characters within a string of varying characters. The test will take no longer than five to ten minutes to complete during class and will show the level of attention your son/daughter has at that time.

Classroom Observation:

Observation will be used to document behaviour, specifically regarding attention and focus during class (i.e. interrupting, talking, ability to keep on-task). This will entail trained Queen’s University observers recording behaviour with a pen and paper for the duration of a class on six separate occasions. The students will be instructed to ignore the research members’ presence and researchers will not interact with the children as to minimize disturbances to the class. The principal investigator will then analyze the recordings in order to observe differences in behaviour between classes.

Risks and Confidentiality:

While there are risks associated with exercise (i.e. fatigue, accidental minor injury, shortness of breath due to exertion, etc.), these risks are very slight in young adolescents. If you have any
concerns that your child is not healthy enough to participate in regular physical activity please contact your homeroom teacher or one of the study coordinators (contact information is provided below). There is neither compensation nor penalty for participating or not participating in this project.

All data that is collected during the course of this study will be stored using initials and identification numbers. As the students will not be expected to remember their respective subject ID number, a digital list with their name and corresponding subject number will be kept on a password protected lab computer and accessed by only Jasmin Ma and Dr. Brendon Gurd. At no point will the full names of the participants be released or used for any other purpose other than subject identification by the primary researchers. As such, individual results will only be viewed by the researchers directly involved in this study (Dr. Brendon Gurd and Ms. Jasmin Ma) and results will always be presented anonymously and as group means. Should your son/daughter wish to discontinue participation at any point, he/she is free to do so without any penalty. If participants wish to withdraw from the study they will be able to do so by informing their teacher or a member of the research team at any time. Withdrawal from the study will simply mean that data will not be collected from that participant moving forward and all data previously collected will be deleted. There is no penalty for withdrawal.
If at any point you have questions or concerns regarding your child’s involvement in this study you can contact either your home-room teacher or any of the individuals below:

This study has been granted clearance according to the recommended principles of Canadian ethics guidelines, and Queen’s policies.

Any questions about study participation may be directed to Dr. Brendon Gurd at gurdb@queensu.ca or the student researcher, Jasmin Ma at 8jkm@queensu.ca. Any ethical concerns about the study may be directed to the Chair of the General Research Ethics Board at chair.GREB@queensu.ca or 613-533-6081.

Ms. Jasmin Ma
Primary Graduate Student Investigator
8jkm@queensu.ca

Dr. Brendon Gurd
Study Supervisor
Assistant Professor in the School of Kinesiology and Health Studies at Queen’s University
gurdb@queensu.ca
(613 533 6000 extension 79023)

Lise Doutre
Teacher Contact
doutrel@limestone.on.ca

Anita Dannenberg
Principal
dannenberg@limestone.on.ca

Dr. Joan Stevenson
Chair of the General Research Ethics Board at Queen’s University
By signing this document I and my son or daughter acknowledge the following:

- I and my son or daughter has read the form above and have any questions answered to my satisfaction.
- I and my son or daughter have read the form, understand the study and are aware of the voluntary nature of the study.
- I and my son or daughter understands that participation in this study is voluntary and that they or I may remove themselves/myself from the study at any time without any negative repercussions.
- I and my son or daughter are aware that if I have any questions I understand who to contact, under what circumstances, and that at any point I can contact the individuals listed above.
- I and my son or daughter understand the confidentiality measures taken in the study.
- I grant permission for the video recording of my son or daughter.

You are encouraged to keep a copy of the letter of information for your own records.

I grant permission for my son/ daughter to participate in the following:

- Exercise
- D2 Test of Attention
- Classroom Observation
- Heart Rate

Name of Volunteer  ______________________________________________________

Name of Parent/Guardian  ________________________________________________

Signature/Date  __________________________________________________________

105
February 05, 2013

Ms. Jasmin Ma
Master’s Student
School of Kinesiology and Health Studies
Queen's University
28 Division Street
Kingston, ON K7L 3N6

GREB Ref #: GPHE-137-12; Romeo # 6007573
Title: "GPHE-137-12 Impact of acute exercise on attention, behaviour and self- efficacy in grade 8 students"

Dear Ms. Ma:

The General Research Ethics Board (GREB), by means of a delegated board review, has cleared your proposal entitled "GPHE-137-12 Impact of acute exercise on attention, behaviour and self- efficacy in grade 8 students" for ethical compliance with the Tri-Council Guidelines (TCPS) and Queen's ethics policies. In accordance with the Tri-Council Guidelines (article D.1.6) and Senate Terms of Reference (article G), your project has been cleared for one year. At the end of each year, the GREB will ask if your project has been completed and if not, what changes have occurred or will occur in the next year.

You are reminded of your obligation to advise the GREB, with a copy to your unit REB, of any adverse event(s) that occur during this one year period (access this form at https://eservices.queensu.ca/romeo_researcher/ and click Events - GREB Adverse Event Report). An adverse event includes, but is not limited to, a complaint, a change or unexpected event that alters the level of risk for the researcher or participants or situation that requires a substantial change in approach to a participant(s). You are also advised that all adverse events must be reported to the GREB within 48 hours.

You are also reminded that all changes that might affect human participants must be cleared by the GREB. For example you must report changes to the level of risk, applicant characteristics, and implementation of new procedures. To make an amendment, access the application at https://eservices.queensu.ca/romeo_researcher/ and click Events - GREB Amendment to Approved Study Form. These changes will automatically be sent to the Ethics Coordinator, Gail Irving, at the Office of Research Services or irvingg@queensu.ca for further review and clearance by the GREB or GREB Chair.

On behalf of the General Research Ethics Board, I wish you continued success in your research.

Yours sincerely,
John Freeman, Ph.D.
Professor and Acting Chair
General Research Ethics Board

cc: Dr. Brendon Gurd, Faculty Supervisor
Dr. Spencer Moore, Chair, Unit REB
Josie Birchall, Dept. Admin.
Appendix D: Research Ethics Board- Renewal of Clearance

January 17, 2014

Ms. Jasmin Ma  
Master’s Student  
School of Kinesiology and Health Studies Queen’s University  
28 Division Street  
Kingston, ON, K7L 3N6

GREB Romeo #: 6007573  
Title: "GPHE-137-12 Impact of Acute Exercise on Attention, Behaviour and Self-Efficacy in Elementary Students"

Dear Ms. Ma:

The General Research Ethics Board (GREB) has reviewed and approved your request for renewal of ethics clearance for the above-named study. This renewal is valid for one year from February 5, 2014. Prior to the next renewal date you will be sent a reminder memo and the link to ROMEO to renew for another year.

You are reminded of your obligation to advise the GREB of any adverse event(s) that occur during this one year period. An adverse event includes, but is not limited to, a complaint, a change or unexpected event that alters the level of risk for the researcher or participants or situation that requires a substantial change in approach to a participant(s). You are also advised that all adverse events must be reported to the GREB within 48 hours. Report to GREB through either ROMEO Event Report or Adverse Event Report Form at http://www.queensu.ca/ors/researchethics/GeneralREB/forms.html.

You are also reminded that all changes that might affect human participants must be cleared by the GREB. For example you must report changes in study procedures or implementation of new aspects into the study procedures. Your request for protocol changes will be forwarded to the appropriate GREB reviewers and/or the GREB Chair. Please report changes to GREB through either ROMEO Event Reports or the Ethics Change Form at http://www.queensu.ca/ors/researchethics/GeneralREB/forms.html.

On behalf of the General Research Ethics Board, I wish you continued success in your research.

Yours sincerely,

Joan Stevenson, Ph.D.  
Chair  
General Research Ethics Board
c.: Dr. Brendon Gurd, Faculty Supervisor
Dr. Michael Tschakovsky, Chair, Unit REB
Appendix E: Research Ethics Board- Amendment Approval

January 17, 2014

Ms. Jasmin Ma
Master’s Student
School of Kinesiology and Health Studies
Queen's University
28 Division Street
Kingston, ON, K7L 3N6

Dear Ms. Ma:

RE: Amendment for your study entitled: GPHE-137-12 Impact of Acute Exercise on Attention, Behaviour and Self-Efficacy in Elementary Students; ROMEO# 6007573

Thank you for submitting your amendment requesting the following changes:

1) To change the title from “Impact of Acute Exercise on Attention, Behaviour and Self-Efficacy in Grade 8 Students” to “Impact of Acute Exercise on Attention, Behaviour and Self-Efficacy in Elementary Students”;

2) To change the participant population to Grade 4’s;

3) To add and administer the outcome measure: the D2 Test of Attention;

4) Letter of Information / Letter of Assent;

5) D2 Test;

6) Instructions for D2 Test.

By this letter you have ethics clearance for these changes. Good luck with your research.

Sincerely,

Joan Stevenson, Ph.D.
Chair
General Research Ethics Board
c.: Dr. Brendon Gurd, Faculty Supervisor
Appendix F: Research Ethics Board- Amendment Approval

May 12, 2014

Ms. Jasmin Ma
Master’s Student
School of Kinesiology and Health Studies
Queen's University
28 Division Street
Kingston, ON, K7L 3N6

Dear Ms. Ma:

RE: Amendment for your study entitled: **GPHE-137-12 Impact of Acute Exercise on Attention, Behaviour and Self-Efficacy in Elementary Students**; ROMEO# 6007573

Thank you for submitting your amendment requesting the following changes:

1) To take heart rate using a non-I evasive detector (Polar heart rate monitors);

2) Letter of Information – 2014 Heart Rate (v. 2014/05/12).

By this letter you have ethics clearance for these changes. Good luck with your research.

Sincerely,

Joan Stevenson, Ph.D.

Chair General Research Ethics Board

c.: Dr. Brendon Gurd, Faculty Supervisor
Appendix G: Limestone District School Board Approval

LIMESTONE DISTRICT SCHOOL BOARD
Postal Bag 610, 220 Portmanteau Ave., Kingston, ON, K7L 4X4
T: (613) 544-0920 | Toll Free: 1-800-267-9935 | TTY: (613) 542-8526 | F: (613) 544 6804

February 14, 2013

Ms. Jasmin Ma
Master’s Student
School of Kinesiology and Health Studies
Queen’s University
25 Division Street
Kingston, Ontario K7L 3N6

Dear Ms. Ma:

This letter will acknowledge receipt of your research proposal entitled, “Impact of acute exercise on attention, behaviour and self-efficacy in grade 4 and 8 students.”

You have submitted the following components required as part of the Limestone District School Board Administrative Procedure regarding External Research:

- written commitment to ensure anonymity of Board, schools, staff and students
- abstract of the research proposal
- copies of questionnaires, schedules
- parental consent form
- official ethics review

May I emphasize that it is understood that for all research projects, the name of the District School Board, the name of the school, participants, principals, teachers and students would not be identified in your final report and participants would have a right to opt out of this project at any time.

Approval is granted for you to contact Mary Ellen Card, Principal of Lancaster Drive PS and Steve Hedderson, Principal of Ecole Sir John A. Macdonald PS. Following the completion of your project, a copy of your report is required to be submitted to the Limestone District School Board.

Sincerely,

Barb Fraser-Stiff
Superintendent

cc: Mary Ellen Card – Principal – Lancaster Drive Public School
Steve Hedderson – Principal – Ecole Sir John A. Macdonald Public School
Senior staff

Helen Chadwick - Chair | Brenda Hunter - Director of Education and Secretary | Roger H. Richard – Treasurer

Our Students, Our Future
Appendix H: Limestone District School Board Approval

LIMESTONE DISTRICT SCHOOL BOARD

Postal Bag 610, 220 Portsmouth Ave., Kingston, ON, K7L 4X4
www.limestone.on.ca

February 13, 2014

Ms. Jasmin Ma
Master's Student
School of Kinesiology and Health Services
Queen's University
28 Division Street
Kingston, Ontario
K7L 3N6

Dear Ms. Ma:

This letter will acknowledge receipt of your research proposal amendment entitled, “Impact of Acute Exercise on Attention, Behaviour and Self-Efficacy in Elementary Students.”

You have submitted the following components required as part of the Limestone District School Board Administrative Procedure regarding External Research:

- written commitment to ensure anonymity of Board, schools, staff and students
- abstract of the research proposal
- copies of questionnaires, schedules
- principal consent form
- official ethics review

May I emphasize that it is understood that for all research projects, the name of the District School Board, the name of the school, participants, teachers and students would not be identified in your final report and participants would have a right to opt out of this project at any time.

Approval is granted for you to contact Principals within the Board. Following the completion of your project, a copy of your report is required to be submitted to the Limestone District School Board.

Sincerely,

Barb Fraser-Stiff
Superintendent

cc: Principals
    Senior Staff

Our Students, Our Future
Appendix I: Limestone District School Board - Amendment Clearance

February 13, 2014

Ms. Jasmin Ma
Master’s Student
School of Kinesiology and Health Services
Queen’s University
28 Division Street
Kingston, Ontario
K7L 3N6

Dear Ms. Ma:

Re: Impact of acute exercise on attention, behaviour and self-efficacy in elementary students: Amendment

This letter will acknowledge your amendment to the above-noted study. Approval is granted for you to use heart rate monitors during exercise to the previously approved study examining exercise and attention.

Sincerely,

Barb Fraser-Stiff
Superintendent

cc: Principals
Senior Staff

Laurie French – Chair | Brenda Hunter - Director of Education and Secretary | Paul Babine – Treasurer

Our Students, Our Future
### Appendix J: Observer Recording Sheet

**FUNterval Observation Date:** __________  **Observer:** __________

<table>
<thead>
<tr>
<th>Student</th>
<th>Student</th>
<th>Student</th>
<th>Student</th>
<th>Student</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Behaviour: M I II III</td>
<td>Behaviour: M I II III</td>
<td>Behaviour: M I II III</td>
<td>Behaviour: M I III</td>
</tr>
<tr>
<td>2</td>
<td>V I II III</td>
<td>V I II III</td>
<td>V I II III</td>
<td>V I II III</td>
</tr>
<tr>
<td>3</td>
<td>P I II III</td>
<td>P I II III</td>
<td>P I II III</td>
<td>P I II III</td>
</tr>
<tr>
<td>4</td>
<td>Comments:</td>
<td>Comments:</td>
<td>Comments:</td>
<td>Comments:</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>Behaviour: M I II III</td>
<td>Behaviour: M I II III</td>
<td>Behaviour: M I II III</td>
<td>Behaviour: M I III</td>
</tr>
<tr>
<td>7</td>
<td>V I II III</td>
<td>V I II III</td>
<td>V I II III</td>
<td>V I II III</td>
</tr>
<tr>
<td>8</td>
<td>P I II III</td>
<td>P I II III</td>
<td>P I II III</td>
<td>P I II III</td>
</tr>
<tr>
<td>9</td>
<td>Comments:</td>
<td>Comments:</td>
<td>Comments:</td>
<td>Comments:</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>11</td>
<td>Behaviour: M I II III</td>
<td>Behaviour: M I II III</td>
<td>Behaviour: M I II III</td>
<td>Behaviour: M I III</td>
</tr>
<tr>
<td>12</td>
<td>V I II III</td>
<td>V I II III</td>
<td>V I II III</td>
<td>V I II III</td>
</tr>
<tr>
<td>13</td>
<td>P I II III</td>
<td>P I II III</td>
<td>P I II III</td>
<td>P I II III</td>
</tr>
<tr>
<td>14</td>
<td>Comments:</td>
<td>Comments:</td>
<td>Comments:</td>
<td>Comments:</td>
</tr>
<tr>
<td>15</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>16</td>
<td>Behaviour: M I II III</td>
<td>Behaviour: M I II III</td>
<td>Behaviour: M I II III</td>
<td>Behaviour: M I III</td>
</tr>
<tr>
<td>17</td>
<td>V I II III</td>
<td>V I II III</td>
<td>V I II III</td>
<td>V I II III</td>
</tr>
<tr>
<td>18</td>
<td>P I II III</td>
<td>P I II III</td>
<td>P I II III</td>
<td>P I II III</td>
</tr>
<tr>
<td>19</td>
<td>Comments:</td>
<td>Comments:</td>
<td>Comments:</td>
<td>Comments:</td>
</tr>
<tr>
<td>20</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

20 ➔ Cover Overall Impression
### d2 Test of Attention

**Rolf Brickenkamp & Eric A. Zillmer**

**Appendix K: d2 Test of Attention**

Name: ____________________________

Age: _______ Sex: □ male □ female

Handedness: □ L □ R

Years of education: ____________________

Occupation: ____________________________

Examiner: ____________________ Date: __________

#### Example:

```
  d  d  i
```

#### Practice line:

```
  d  p  d  d  d  d  p  d  d  d  d  d  p  d  d  d  p  d  d  d  p  d  d  i
  1  2  3  4  5  6  7  8  9 10  11 12 13 14 15 16 17 18 19 20 21 22
```

<table>
<thead>
<tr>
<th></th>
<th>Raw Score</th>
<th>Percentage</th>
<th>Percentile Rank</th>
<th>Standard Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>TN</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(total number)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Omissions: E1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commissions: E2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E (errors)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TN-E</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(total-errors)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CP (concentration performance)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FR (fluctuation rate)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

S-Syndrome: □

---

Copyright © 1998 by Hogrefe & Huber Publishers. No part of this work may be reproduced, stored in a retrieval system or copied by any means, electronic, mechanical, photocopying, microfilming, recording, or otherwise, without the written permission of the publisher.
<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
</table>

117