"WHAT ARE THE BENEFITS OF EXERCISE?" EXAMINING THE EFFECTS OF ACUTE EXERCISE ON COGNITIVE FUNCTIONING IN SCHOOL-AGE CHILDREN AND YOUTH.

by

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ABSTRACT

The present study examined the benefits of exercising and the direct effects of acute exercising on students' cognitive functioning in the classroom. The researcher was interested to find out if short bouts of exercise have a positive effect on concentration and cognitive performance in the classroom. Furthermore, the researcher was interested to find out if acute exercise results in an increase of learning. It is important to understand the benefits of physical exercise especially for students who are easily distracted or students who experience challenges with learning and academic performance. The study aimed to answer three questions: (1) Do students perform better on a cognitive test after a period of acute exercising? (2) Does acute exercise increase attention, memory, response time and processing speed? (3) Are students more motivated and engaged in the classroom after having exercised? First, it was hypothesized that exercising increases cognitive functioning. Second, it was predicted that acute exercise contributes positively to memory, attention, processing speed and response time. Last, it was hypothesized that student's level of motivation and engagement increases while participating in class instruction following an exercise class. Support was found that exercising increases cognitive functioning and specifically short bouts of vigorous exercise increase attention, memory, response time, and processing speed. Support was also found for increased motivation and engagement after exercising. A series of statistical analysis were conducted to test the research questions. Study contributions as well as limitations are discussed and included in this study.

Keywords: exercise, cognitive functioning, academic performance, engagement

CHAPTER ONE: LITERATURE REVIEW

Relation between Exercise and Psychological Health

Exercise and physical health are important elements of human health. Although in ancient Greek times the relation between exercise and intellectual functioning was emphasized, it was not until the 1980's that the health-and-wellness movement shed a renewed interest on the effect of exercise on psychological processes (Tomporowski, Davis, Miller, & Naglieri, 2008). Research areas of interest were mainly focused on the impact of physical activity on mental health, on cognition, and on aging. According to Van Praag (2009) regular exercise may delay or even prevent loss of cognitive functioning by aging or neurodegenerative diseases. Several cross-sectional studies indicated the benefits of aerobic exercise such as walking, running, bicycling, and swimming on reaction time (Churchill et al., 2002; Tomporowski et al., 2008). For example, individuals who walked, ran, biked or swam regularly during their life, responded much faster on visual and auditory processing tasks than people who did not exercise regularly. They also outperformed non-exercisers in tasks on working memory and performance (Churchill et al., 2002; Tomporowski et al., 2008). Experiments performed on adults and animals, found support for the hypothesis that regular physical activity has a positive effect on cognition and behavior (Tomporowski et al., 2008) whether it was examined under young(er) or old(er) participants. Findings in Colcombe et al.'s (2004) study, for instance, demonstrated that regular or increased physical activity is beneficial for cognitive functioning in an aging brain. Their study results revealed that exercising leads to increased task-related reaction time, decreased activity in brain regions associated with aging, and improved cardiovascular condition. The researchers conducted two different experiments where two groups of older high functioning adults were examined on their cognitive functioning after participating in exercise. The first group participated in a one-mile walk called "the Rockport walk" to measure cardiovascular fitness. After the walk participants performed in six successive five-minute blocks with 17 trials to test cognitive functioning. The second group was designed as a longitudinal study where participants were randomly assigned to either an aerobic group or a stretching and toning group. Both groups also performed in the cognitive functioning tests used in the first study. Participants in the second group started the two different interventions at 10-15 minutes, increasing each session with one minute until they reached 45-minute sessions. This exercise was held three times weekly over a period of six months. The study used neuroimaging testing with the functional Magnetic Resonance Imaging (fMRI) testing results revealing increased activity in the brain for intense physical activity. Besides the positive results on increased activity in the brain, another important finding was that regularity of exercise contributed significantly to the results (Colcombe et al., 2004). A study by Hillman et al. (2005) evidenced the benefits of regular exercise on cognitive functioning for the younger brains. In Hillman et al.'s research a group of high-fit and less-fit children (M_{age} = 9.6 years) was compared to a group of high-active and low-active young adults (M_{age} = 19.3 years) on mental functioning. Participants were first screened for their fitness levels to determine high- or less-fit or high- or low-active profiles. All four groups were presented a cognitive test in which participants had to respond to targeted and nontargeted stimuli by using a white and black line drawing a cat or a dog in three 3-minute runs consisting of 150 trials. After each 3-minute run a 2-minute rest period was included. Results revealed a significant interaction between age x fitness (SE = .53) in which young adults and high-fit participants had a faster response time than children and low-fit participants. Another age x fitness interaction was observed (SE = .11) where both young adult groups performed at a faster rate than the children's groups and where high-fit children outperformed the low-fit children. Response accuracy yielded significant effects of age and condition (*SE* = .27) with the young adults performing the cognitive tasks more accurate than the children. In addition, an interaction between fitness x condition indicated that high-fit or high-active participants were more accurate (*SE* = .12) than less-fit or low-active participants but this result was not significant. The finding that cognitive processing speed was faster for high-fit participants supports research on the overall benefits of physical activity on cognition (Hillman et al., 2005; Colcombe et al. 2004).

Effects of Exercise on Cognitive Functioning

Although much research on the effects of exercising on cognition has been on adults and especially older adults, a growing interest has emerged for research on the effects of exercise on cognitive functioning in child populations (Hillman et al., 2009). Several studies, for example Sibley and Etnier's (2003), Tomporowski et al.'s (2008), and Tomporowski, McCullick, Pendleton, and Pesce's (2015) study found a significant relation between cognitive benefits and physical activities. Sibley and Etnier's (2003) meta-analysis examined 44 studies that were designed to look for a relation between increased physical activity and improved academic performance and cognitive abilities in children and youth between age 4 and 18. An effect size of 0.32 revealed a positive relation between physical activity and cognition (Sibley & Etnier, 2003). Age was a moderator variable with an effect size of 0.36 for children age 6-13, and more specifically, an effect size of 0.40 for elementary age children and a slightly higher effect size of 0.48 for middle school children in Grades 6 to 8. The higher effect size for middle school age children was related to levels of social anxiety, which levels decreased after physical activity. Social anxiety is prevalent for this age group, thereby positively affecting the baseline levels (Sibley & Etnier, 2003). The results of the study did support the hypothesis that participation in physical activity is associated with improvement in cognitive performance in children and youth (Sibley & Etnier, 2003). Tomporowski et al.'s (2015) review of quantitative and qualitative exercise interventions supported the abovementioned findings by revealing significant results for a positive relation between children's physical activities and cognitive functioning. Their review not only focused on the classification of the interventions but also compared the types of condition, acute or chronic, in which exercise was delivered. Results indicated that chronic or systematic exercise alters children's executive functioning whereas acute exercise alters children's attention, processing speed and executive control. Results furthermore revealed that quantitative exercises with repetitive easy to follow movements (i.e., running on the treadmill) requiring less cognitive skills and effort, compared to the qualitative exercises requiring a high level of mental engagement (i.e., bouncing a ball with left versus right hand while balancing on a moving platform) both led to enhanced cognitive functioning (Tomporowski et al., 2015).

Effects of Exercise on Academic Achievement

Over the years many claims of academic benefits of physical education have been made, most of these claims based on scientific evidence (Sallis et al., 1999). In the famous Trois Rivieres study where students from Grade 1 up to Grade 6 received an increase in physical education thereby limiting time for academic courses, overall improvements were reported for class grades. Students in the experimental condition even received higher grades on math standardized tests but did not perform any different in other subject areas (Sallis et al., 1999). Results from an Australian study partly confirmed the abovementioned findings. In this study students in the experimental group received an hour of physical education each school day resulting in physiological and fitness improvements but no improvements academically. However, when this group was tested at two-year follow-up academic improvements in arithmetic and reading grades were reported as well as an improvement in classroom behavior (Sallis et al., 1999). In an effort to explain the resistance of school administrators on creating a better learning environment by increasing physical education and reducing core academic instruction time, Sallis et al. (1999) conducted a study in which they found strong evidence for an alternative hypothesis, namely that increased physical education does not negatively impact academic achievement. Their study design included three conditions with participants either in the specialist, teacher trained or control condition. Seven schools were selected for the study with either two or three schools in each condition. None of the seven schools had physical education teachers on staff or had a current physical education curriculum implemented. Participants in the specialist condition based on the Sports, Play and Active Recreation for Kids curriculum (SPARK) were taught high-level physical activity skills for a minimum of three days a week and 30 minutes per session for the duration of the schoolyear. Participants in the teacher trained condition were students whose classroom teachers received a total of 32 hours of professional instruction on developing a self-management and physical education curriculum. Participants in the control condition received their regular physical education by their classroom teacher without any specific or additional physical activities. Participants were tested by using achievement tests that assessed their skills in Mathematics, Language and Reading skills as well as a composite score known as the Basic Battery. An overall decline of academic achievement was observed for all conditions and was most likely a result of regression to the mean as baseline scores had been exceedingly higher than the national average scores. However, participants in the specialist condition showed increased reading skills. Declines on the basic battery and reading scores were less in the teacher trained condition compared to the other two groups. On three scales students in the trained teacher condition performed better compared to the control condition. This outcome might be related to increased confidence for classroom teachers to teach physical education and could implicate that teaching classroom teachers' physical education instructional skills could lead to better academic performance (Sallis et al., 1999). Sallis et al.'s (1999) study results further confirmed that elementary school-age participants did not experience any harmful effects of increased physical activities on results of standardized academic achievement tests.

Nevertheless, it was not for long that the results of an educational experiment conducted by several physical education teachers in Naperville, USA, sparked interest for more research under school age children on this topic (Ratey, 2008). In his famous book Spark, Ratey (2008) explained how Project Zero Hour started in 1990 in Naperville, Illinois, USA, when a physical education teacher felt the need to change the fate of US children's declining health. He introduced cardiovascular fitness as a radical alternative to the existing gym class. The main objective of Project Zero Hour was to give students before or during the school day a boost in reading abilities and other academic requirements by a variety of vigorous physical activities (Ratey, 2008). A dramatic increase in academic performance was noticed. Results of the, in 1999 taken, Trends in International Mathematics and Science Study (TIMSS) revealed that Naperville's eight graders outperformed students from around the world by finishing first in Science and sixth on Mathematics (Ratey, 2008). Naperville's unique approach to physical education was soon followed by neighbouring schools resulting in the district consistently ranking among the state's top ten in academic results (Ratey, 2008). Other research studies revealed similar findings. Ellemberg and St-Louis-Deschênes (2010) hypothesized that short periods of acute exercise increase children's cognition and reaction time. In their study 72 boys, with half of them being 7 years old, and the other half 10 years old, were examined. Of those two age groups, half of the group was in the experimental, the other half in the control condition. In the experimental condition participants cycled on an ergometer for 30 minutes after a five-minute warm up. The 30-minute exercise was finished off by a five-minute cool down period. During these 40 minutes the participants cycled while watching an age-appropriate TV show. Heartrates were checked every so many minutes to measure if heartbeats stayed in the 110-130 beats per minute condition. In the control condition participants sat on an ergometer without cycling while watching an age-appropriate TV show for the duration of 40 minutes. Directly before the exercise and watching the TV show, and shortly after, both groups were presented a five-minute simple reaction time task that measures low level sensorimotor functioning as well as visual and motor cortices, and a 10-minute choice response time task measuring decision making. Results indicated that participants in the exercise condition performed significantly faster on both the simple reaction and the choice response time task. After intervention students in the exercise condition responded 34 milliseconds faster on the simple reaction and 75 milliseconds faster on the choice response time task compared to students in the control condition. The enhancement in scores on the response time compared to the simple reaction time signifies the effect of exercise on cognitive functioning. Interestingly, increased heart rate was a significant contributor to the positive results in this study implying the importance of aerobic forms of exercise as a means to improved cognitive functioning (Ellemberg & St-Louis-Deschênes, 2010). Ellemberg and St-Louis-Deschênes' (2010) are not the only ones that found support for the prediction that acute exercise, with increased blood level rates as an important variable, improves cognition. In a study by Skriver et al. (2014) acute or intense bouts of exercise were positively correlated with improved cognitive functioning. In their study intense exercise resulted in elevated levels of all blood compounds with norepinephrine and lactate being the ones responsible for increased memory and learning skills that was exhibited through an improved acquisition of motor skills. An interesting finding on memory forming and consolidation was that larger concentrations of brain derived neurotropic factors would be present immediately following and 5-minutes after the exercise; this was also evident for concentrations of norepinephrine, and epinephrine whereas dopamine concentrations were largest at 5-minute and 15-minute after exercising. The same study found that positive effects of increased norepinephrine levels were also associated with better retention of the learned skills as confirmed by the results measured at 1 hour, 24 hours and 7 days follow-up (Skriver et al., 2014).

Effects of Acute Exercise on Executive Functioning

In a study by Piepmeier et al. (2015) the effects of acute intense exercise on executive functioning in children with or without ADHD were examined. The participants were 32 adolescents with 14 of them in either the inattentive or the hyperactive-impulsive or the combined ADHD condition and 18 adolescents without ADHD. The experiment consisted of two days in which half of the participants received on the first day a 30-minute exercise with the other half watching a nature documentary, while on the second day the group who received the exercise watched the documentary, and the documentary group performed the exercise. After either the exercise or the documentary condition participants were asked to complete three different cognitive tests. Mixed support was found for the hypothesis that acute exercise would positively influence executive functioning. Performance on the Stroop test which assesses selective attention and flexibility, was significantly better after the exercise condition compared to performance after the documentary condition. However, performance on the Tower of London task which measures planning in executive functioning, did not differ significantly for the exercise or documentary condition. The overall finding that the presence of ADHD was not the moderator for increased cognitive functioning after exercising was an important outcome. Especially since the results indicate that children with or without ADHD both benefit from exercise on cognitive performance (Piepmeier et al., 2015). Nevertheless, various other studies found that exercise has a positive effect on executive control, planning, scheduling, coordination, inhibition and working memory (Churchill et al., 2002). Parallel patterns in animal studies on behavior and functioning of an aging brain revealed that exercise has a positive effect in performance on tasks regulated by the hippocampus. Especially aerobic or intense fitness accounts for more positive results in cognitive functioning. However, various factors such as eating habits, smoking, personalities, intention, social circumstances and living situations makes the extent to which cognitive functioning level increases complicated (Churchill et al., 2002). Ratey (2008) referred in his book *Spark* to a situation where support was found for a direct effect of short bouts of acute exercise in children with ADHD. An experiment conducted to find alternative treatments for dyslexia in children with ADHD had thirty-five children participating in the study. The children were assigned to a collection of simple motor-skill drills twice a day for ten minutes. Within six months significant improvements in children's reading and writing fluency skills were observed as well as increased cognitive functioning (Ratey, 2008).

Effects of Exercise on Learning

Besides increased cognitive functioning, exercise also contributes to an increase of learning as was researched by Winter et al. (2007). The researchers conducted a study on bouts of intense anaerobic exercise and moderate aerobic exercise to test for effects on learning and memory. They not only found positive results for increased learning and memory but also positive changes in mood as correlations to the exercise. The main finding of the study was the direct correlation between intense exercise and learning. Participants learned 20% faster compared to moderate or no exercise (Winter et al., 2007). These findings suggest that intense bouts of exercise could be used in situations where immediate bouts of learning are needed, for example in situations where students are preparing for a test, or more specifically for children with learning difficulties such as attention and concentration. Furthermore, Braniff (2011) in her case-study on an active classroom, noticed that after implementing body breaks with physical movements during a regular school day, the teacher noticed elevations of mood through smiles on the student's faces compared with laughter and positive comments.

Using short bouts of exercise to improve readiness to learn is not a totally new concept. An informal interview with a retired Nova Scotia teacher revealed that in the 1960's and 1970's teachers would have their students starting the day with a short period of physical exercise called calisthenic exercise (Margeson, 2019). Calisthenic exercises are exercises where body weight is used as a resistance to improve strength through various movements such as jumps, push-ups, pull-ups, sit-ups, or runs (Santos et al., 2015). The overall goal of starting the day with calisthenic exercises was to warm students up for learning by stimulating blood circulation through the brain. In those days most students already received a considerable amount of exercise at the beginning of each school day by walking to school. On top of the walking, the calisthenic exercises would increase heart rates which is the most important element for a positive effect on cognitive functioning (Ellemberg & St-Louis-Deschênes, 2010; Ratey, 2010). The teacher recalled "it was a normal routine, without question every teacher started the school day with physical exercises for the students. Usually students were motivated, focused and ready to learn after exercising" (Margeson, 2019). In another interview a teacher explained to have experienced firsthand how an acute bout of exercise directly effects attention. During a presentation people in the room were invited to participate in a short, 4-minute intense aerobic exercise consisting of jumping jacks and runs in place or on the spot. Just before the exercise this teacher realized that he was not particularly focused but rather distracted with other people's movements. As soon as the 4-minute exercise was finished he noticed how his attention had changed. For the remainder of the presentation he was enthusiastic and fully engaged in the information presented (Thomson, 2019).

Motivation and Engagement

According to Ryan and Deci (2000a) motivation is an important phenomenon for educators as motivation is directly related to engagement and success in school. There are two forms of motivation: intrinsic and extrinsic motivation. In short, intrinsic motivation is the drive a person experiences to do something because of the accompanying pleasurable and enjoyable factors; extrinsic motivation on the other hand is the motivation to receive or work towards a goal (Ryan & Deci, 2000a). According to the researchers some of the subjects taught in schools are not necessarily interesting enough to increase students' intrinsic motivation. In such cases students have to be extrinsically motivated to participate or be successful in the classroom. Where extrinsic motivation is associated with disinterest and less effort, intrinsic motivation is associated with interest and enjoyment and feelings of competence (Ryan & Deci, 2000a). In a study on Self Determination Theory (SDT), Ryan and Deci (2000b) explained that intrinsic motivation enhances or diminishes depending on conditions of autonomy and confidence, two of the three factors of SDT. SDT is a needs process consisting of three essential elements, autonomy, confidence and relatedness for fostering growth, integration, social development and personal wellbeing (Ryan & Deci, 2000b). Ryan and Deci (2000b) found that supportive conditions of autonomy and confidence contributed positively to human growth whereas controlled conditions were negatively impacting human growth. They found similar results for extrinsic motivation where supportive conditions of autonomy, confidence and wellbeing fostered greater internalization and integration than non-supportive conditions (Ryan & Deci, 2000b). Froiland and Worrell (2016) supported the earlier mentioned findings indicating that intrinsic motivation is associated with increased engagement in the classroom and academic performance. Their study results suggested that engagement is positively associated with grade point average (GPA) via engagement thereby confirming the SDT claim that intrinsic motivation leads to engagement (Froiland & Worrell, 2016). Froiland and Worrell's study results emphasized that intrinsic motivation to learn leads to a higher level of engagement in the classroom. The question remains if students with elevated moods will be more intrinsically motivated to participate and engage in the classroom. According to Martin (2019) motivation is students' energy and drive to work hard and to learn with engagement as the behavior that is the result of this energy and drive. Both motivation and engagement can be perceived as positive or negative. Positive motivation and engagement can be enhanced with thoughts, feelings and behaviors such as self-confidence, realizing the importance of school, being focused on learning, planning, and working hard. Negative motivation and engagement can result in a reduced motivation and engagement also known as negative motivation and engagement (Martin, 2019). Examples are anxiety, avoidance of failures, self-sabotage and disengagement. In general, positive motivation is related to improved marks, more effective work attitude towards challenging tasks, better understanding of school related work and overall enjoyment of school life (Martin, 2019). These positive and negative motivation factors form together the Motivation and Engagement Wheel (Martin, 2019; see Figure 1).

Figure 1

The Motivation and Engagement Wheel (Martin, 2007)

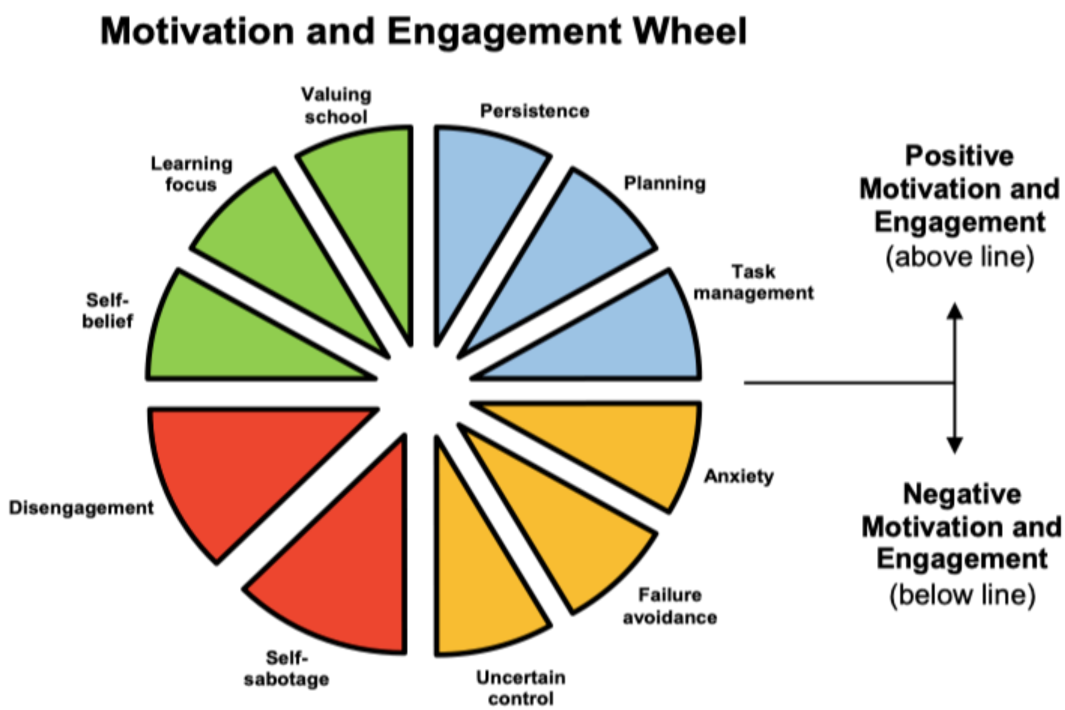


Figure 1. The Motivation and Engagement Wheel. Adapted from “The Motivation and Engagement Scale” and “The Motivation and Engagement Workbook” by A. J. Martin, 2019. Copyright 2019 by the Lifelong Achievement Group.

CHAPTER TWO: PHYSICAL ACTIVITY AMONGST STUDENTS

Physical Activity in the Public Schools

Given all the research findings and the history of physical activities, it is important to think about how often children are exposed to and what the goal of physical activity is in the public schools. As the Nova Scotia Department of Education and Culture indicated in the Physical and Health Education curriculum published in its Foundation for Active and Healthy Living, physical education has shifted from general sports activities to a more comprehensive approach focused on motor development and knowledge about how the body works with an emphasis on personal fitness (Nova Scotia Department of Education and Culture, 1998). Although the abovementioned curriculum document was developed in 1998, the main concepts are still actual today. According to the Physical Education outcomes of 2014/2015: "students will be expected to 1) demonstrate knowledge, skills, and attitudes necessary to be active for life; 2) demonstrate competencies of skill and movement concepts and strategies through participation in diverse physical education pursuits; and 3) participate in diverse physical activities that will foster personal, social and emotional growth and responsibility" (Nova Scotia Department of Education and Early Childhood Development, 2014). Nonetheless, the question arises 'are the amounts of physical education students are receiving during schooltime sufficient enough to promote cognitive development and growth?' Contradictory to children decades ago, children in this day and age are spending much more time on computers and in front of a TV screen thereby increasing sedentary lifestyles (Bidzan-Bluma & Lipowska, 2018). Bidzan and Lipowska's (2018) study results implicated that sedentary lifestyles are not associated with improved cognition, compared to intensive physical activity of at least an hour each day which positively affects cognitive functioning.

Are students active enough?

Colley et al. (2017) conducted a study over a period of nine years from 2007-2015 to compare percentages of children and youth in Canada to recommended amounts of physical activities. The study used the so called 'moderate-to-vigorous' physical activity (MVPA) as a measure to investigate if participants met the 60 minutes a day MVPA levels. Surveys were administered by interviewers visiting participants at home, followed by a series of physical measurements taken at a mobile medical examination centre. Afterwards participants were asked to wear an Actical accelerometer over their hip for seven consecutive days during waking hours to measure physical activity. They found that fewer than 10% of Canadian children and youth met the recommendation criteria of physical activity (Colley et al., 2017). Similar findings were observed in another longitudinal study by Cameron, Craig, Bauman, and Tudor-Locke (2016) where a pedometer was used to calculate mean steps per day. Data were collected from eight different studies with Canadian children and youth between age 5-19 years old over a period of nine years. The researchers were interested if the national goal of increasing steps for children in this age group was met. Participants received a pedometer together with a log and were asked to wear the pedometer for seven consecutive days and use the log to record the steps taken each day. Results revealed a median of 10,935 steps a day which meant a decline in mean steps of 6.1%. This result was contradictory to the earlier set goals by the federal, territorial and provincial ministers of sports and recreation to increase the mean number of steps from 11,500 to 14,500 for the year 2015 (Cameron et al., 2016). Interestingly, the shift in focus of the curricula from a sports-oriented to a more comprehensive physical and health education has not led to the anticipated increase in children's physical activities. Sibley and Etnier's (2003) earlier cited study referred to the problems associated with physical education programs being cut from schools in favor of core academic subjects. They mentioned that according to the School Health Policies and Programs Study 2000 there is a trend that physical education declines from around 50% in grades 1 through 5, to 25% in grade 8, to only 5% in grade 12. Only 8% of elementary schools and 6% of middle and high schools have physical education implemented for an entire school year (Sibley & Etnier, 2003). Despite these findings, initiatives like Project Spark and after school activities are positive indices of an increase of awareness for children's physical health and wellbeing.

Project Spark

Anecdotal evidence to illustrate that there is indeed growing awareness, is found in the implementation of Project Spark at a private school in Nova Scotia. In a personal meeting, the director of High School studies explained how Project Spark has influenced his experience of students' behavioral functioning and learning during a school day. About eight years ago the director of High School studies accidentally came across a news bulletin on Project Spark. He became interested and invited the Project Spark team to the school to introduce and explain the program. As mentioned earlier he himself experienced firsthand how acute exercise effects the brain (Thomson, 2019). It was this firsthand experience that led to the director of High School studies to become the main organiser for Project Spark, or as the school calls it: program Spark. Each school day at 9:20 am after a first period with a regular course, students and staff transition into program Spark. Students can choose during the school year from six different activities such as three-on-three basketball, soccer, ball hockey, ultimate frisbee, dance, Zumba, running, ellipticals, snowshoeing, and walking. The goal is to keep the groups small and the exercise time intense in order to increase heart rates. The emphasis is not on competition but rather on active involvement and fun (Ratey, 2008; Thomson, 2019). The educational team at this particular school has seen significant changes in behavior and attention in the classroom. Even more so, students are excited about the program and are fully committed to participate in the physical activities (Thomson, 2019). Despite the research and abovementioned anecdotal findings of the benefits of acute exercise for students, more research is needed to create a body of qualitative data that can and should be used as a tool to change the current implementation of physical education in the school. Most public schools offer physical education two or three times on an 8-day schedule. (Nova Scotia Department of Education and Early Childhood Development, 2014). Any extra physical activities happening during or outside schooltime totally depends on an administrator's vision of the importance of exercising as well as parents' perspectives on their child's level of physical activity. Compared to the public schools, private schools like Landmark East have the advantage of proposing ideas and if well received by the school's board of directors, implementing the new ideas (Thomson, 2019).

The Present Study

The purpose of the present study was to examine school-aged children's (age 11-14) and youth's (age 15) cognitive functioning directly following short periods of intense exercising. The researcher investigated if cognitive functioning increases academic performance after intense physical activity. The review of the literature confirmed a positive relation between cognitive functioning and exercising but raises some questions on the direct effectiveness on executive functioning (Piepmeier et al., 2015). Although Ellemberg and St-Louis-Deschênes' (2010) assumption that acute exercise improves cognition is supported, there is not enough support in the literature on children's increased academic performance directly following short bouts of intense exercising. Most research has been focused on the aging brain supporting the positive effect of physical activities on executive control, planning, scheduling, coordination, inhibition and working memory compared to evidence for the positive effect of physical activities for school age children and youth (Churchill et al., 2002). Bidzan-Bluma and Lipowska's systematic review suggest that physical activity affect children at different stages in life. For example, 3-5-year-old children's cognitive functioning improved after increased physical activity. Other examples found that exercise would positively correlate with improved working memory for students age 8-12; 12-year-olds would improve decision making after physical activity; regular and intense physical activity would positively affect children age 13-14 on attention and their ability to focus as well as executive functioning (Bidzan-Bluma & Lipowska, 2018). Some researchers emphasized the negative effect of sedentary lifestyles with no or minimal physical activity and too much screen time on shifting or flexible attention. They indicated that any form of physical activity is better than none (Bidzan-Bluma & Lipowska, 2018).

The present study builds upon previous research with three main objectives. First, it was predicted that exercising increases cognitive functioning. Cognitive functions such as memory, concentration, attention, focusing, response time and processing speed are all important conditions necessary to perform well in the core academic courses such as reading, writing and mathematics (Gal et al., 2018). The second objective was to investigate if intense exercise contributes positively to memory, attention, response time and processing speed (Janssen et al., 2014). The third and final objective was to identify student's motivation and level of engagement while participating in class instruction following exercise (Froiland & Worrell, 2016).

It was hypothesized that:

(1) Students perform better on a cognitive test after exercising.

(2) Short bouts of vigorous exercise increase attention, memory, response time and processing speed.

(3) Students are more motivated and engaged after short bouts of vigorous exercise.

Method

Participants

Participants in the study included 31 students of a Grade 7, Grade 8 and Grade 9 class from a private school in Nova Scotia. The Physical Activity Measurement questionnaire was used to examine how often participants exercise, the average time spend each time exercising, and the type of exercise. Participants in the study indicated to be fairly active. More than half of the participants exercise on a daily basis (69.7%); 27% would be active 4-6 times a week. One participant indicated to exercise an average of 1-3 times a week. The average time spend exercising for most participants (72%) lay between 1-2 hours for each time exercising. Eighteen percent of participants would exercise for half an hour to an hour each time exercising. Two participants indicated to exercise for half an hour each time they exercise. One participant indicated various times as the time spend exercising depended on the type of physical activity. Only one of the participants mentioned an easy type of exercise. The majority of participants (64%) use an aerobic type of exercise; and 33% of participants are involved in a moderate type of exercising. An average of exercise time and type was calculated and documented in the demographics section but not used in the statistical analysis (see Table 3). Gender and age were also documented but not used in the statistical analysis (see Table 3). Five employees of the school assisted in conducting the study; one employee was the Junior Health and Physical education teacher who was responsible for instruction of the physical exercise class to Grade 7 and 8 students; another employee was a Grade 8/9 classroom teacher who was responsible for the instruction of the 4-5 minute vigorous exercise to participants from Grade 8 or 9. Together with the classroom teachers of another group of Grade 9 students all teachers involved were also responsible for guiding through and monitoring of participants in the in-class portion of questionnaires and online games. The school's computer technician assisted with online distribution and collection of informed consent forms from parents/guardians, and with accessibility of an online game program so that each participant could start the program through their individual school email address. The experiment consisted of two intervention groups and one control group. Students were randomly assigned to the experimental or the control condition as follows: Eleven students from Grade 7 and Grade 9 were experimental group 1 and received a 30-minute moderate (according to Canadian Health recommendations) exercise, thirteen other students of two Grade 8 classes were assigned to experimental group 2 receiving a 5-minute vigorous exercise once a day during core academic classes on 4-6 days of the week, and the remaining seven students who were from the Grade 9 class were assigned to the control group; they did not receive any extra physical exercise during the academic part of the school day other than their scheduled physical activities at the end of the school day.

Independent variables in the analyses were the three different conditions, moderate, vigorous and no exercise, participants were assigned to. Dependent variables were the outcomes pre- and post of the tasks on the CogniFit™ games and the scores on questions from the Motivation and Engagement Scale. The Motivation and Engagement Scale assessed levels of positive and negative motivation and engagement but only scores on positive motivation and positive engagement were used in the statistical analysis.

Measures

The CogniFit™ assessment battery

The CogniFit™ assessment battery is an online cognitive assessment and training tool to measure different cognitive abilities through the use of a computer, tablet or smartphone. The overall evaluation of the CogniFit^{TM} assessment battery has been validated against several major neuropsychological tests, including Raven's Progressive Matrices, the Cambridge Neuropsychological Test Automated Battery, and the Wisconsin Card Sorting Test (Haimov, Hanuka, & Horowitz, 2008). The reliability and validity of the CogniFit^{TM} was also demonstrated in a sample data of 500 participants derived from various studies with an internal consistency of .70 (Cronbach's alpha), and test-retest reliability of .80 correlation coefficient (Shatil, 2013; Shatil, Metzer, Horvitz, & Miller, 2010). Other studies have confidently used the CogniFit^{TM} assessment battery to assess levels of cognitive functioning (Gigler, Blomeke, Shatil, Weintraub, & Reber, 2013). The CogniFit^{TM} assessment battery includes testing for skills on processing speed, attention and concentration, working memory, visual motor and executive functioning which are all necessary elements for academic achievement on mathematics, reading and spelling (Hillman et al., 2009). The CogniFit^{TM} assessment battery is game-like in nature and assesses participants on a variety of cognitive components to derive cognitive-specific scores across tests and to measure improvement on the CogniFit^{TM} training tasks. In the present study participants completed an online game intended to assess the following cognitive areas: reasoning, memory, attention, coordination and perception. Each of these five cognitive areas were comprised of various cognitive functions. These various functions are embedded in the different tasks of the online game. Each area score is a composite of raw assessment scores of the various functions, calculated by weights determined by factor analysis (information courtesy of CogniFit^{TM}). A mean score for reasoning was derived from the individual results of processing speed, planning and shifting. Memory scores were comprised by the scores on naming, working memory, contextual memory, auditory short-term memory, non-verbal memory, short-term memory and visual short-term memory. The mean for attention was derived from raw scores on focused attention, updating, divided attention and inhibition. The mean for coordination was comprised of raw scores from hand-eye coordination, and response time. The mean score for perception was derived from raw scores on recognition, visual perception, spatial perception, auditory perception, visual scanning and estimation. The mean scores of the five cognitive functions were used as pre- and post-data in the statistical analyses to compare and contrast the effect of exercise on cognitive functioning in general, and on each of the different cognitive tasks as outlined in the hypothesis. Participants completed the CogniFit™ assessment battery once at the beginning of the study and once at the end of the study. Participants used their personal laptops or computers. Ipads or smartphones were not recommended as certain functions would not be available to use. For example, one of the games required a joystick which would not show up on the Ipad or smartphone device. After finishing the CogniFit game results would automatically appear on the researcher's confidential CogniFit account. This contributed to the confidential nature of the responses of each individual participant as there was no involvement needed in person either of the teachers or the Junior School Director to gather results from participants before handing them over to the researcher.

The Motivation and Engagement Scale (MES)

The Motivation and Engagement Scale (MES) is an effective and practical tool for assessing motivation and engagement factors on performance in various achievement settings (Martin, 2007). The MES factors are based on four domains of thoughts and behaviors: the positive or negative thinking, and the positive or negative behaviors. Martin (2007) used these four domains as the basis of the earlier cited Motivation and Engagement Wheel which consists of positive engagement, negative engagement, positive motivation and negative motivation (see Figure 1). Its corresponding 11 measuring subscales have strong validity and reliability. Earlier studies found support for the validity of the MES as an applicable measure for assessing students' motivation and engagement (Liem & Martin, 2011). The MES is a paper and pencil test consisting of 44 questions or statements to be answered using a 5-point Likert-rating. Participants completed the MES questionnaire once at the beginning of the experiment and once at completion of the experiment. Participants filled out the questionnaire in a classroom setting and after completion paper questionnaires were collected by the teachers and stored in a locked cabinet in the Junior School Director's office until the researcher would collect the paper questionnaires. Once the paper questionnaires were received by the researcher, for each participant all 44 questions had to be converted into four different categories: (1) positive motivation; (2) negative motivation; (3) positive engagement; and (4) negative engagement. Each positive and negative motivation and engagement factor was tested with four questions. The answers to each four set of questions were combined and then converted into a score out of 100. This score was then converted to a Motivation Quotient (MQ), resulting in a total of 11 MQ's per participant. Finally, the M&E Wheel was used to transfer the 11 MQ's into an MQ of global positive motivation, global negative motivation, global positive engagement and global negative engagement. Only the global positive motivation and global positive engagement scores were used as pre- and post-data in the statistical analyses to compare and contrast the effect of exercise on motivation and engagement. Global positive motivation involves the areas of self-belief, valuing and a focus on learning; global positive engagement involves the areas of planning, task management and persistence. The age-group of participants in the current study is known to be of high concern for anxiety and fear of failure which could have influenced the distribution of the scores on the negative motivation and negative engagement factors, such as anxiety, failure avoidance, self-sabotage and disinterest and were therefore not included in the final analyses.

Procedure

Initial data collection began in early March and was put on hold due to the lockdown and school closures as a result of the COVID19 pandemic. Data collection continued the second week of September 2020 and finished towards the end of September 2020 with the experimental period spanning a time of about one full school week. Permission to conduct the study was obtained from the private school. To obtain approval, an email was sent with a copy of the thesis proposal attached (see Appendix A). Once ethics approval by the university was obtained and the school's approval received, the teachers from the private school were contacted. After teachers' commitment to assist in the study, a letter of consent and respective consent forms were sent to the parent(s)/guardian(s) of the Grade 6 and 7 combined and Grade 8 students (see Appendix B and C). After parent(s)/guardian(s)' consent was obtained, the school was contacted to confirm the start date, and to discuss the procedure and the materials with the teachers. On the first day of the experiment all participants were presented by their physical education teacher a letter of assent to inform the students about the study procedure and about their rights to withdraw (see Appendix D). After being informed, students were instructed on and presented with the game like CogniFit™ assessment battery. The online CogniFit™ assessment battery measures students' cognitive profile by assessing the various abilities such as attention, memory, response time, and processing speed as well as improvement in general cognitive functioning. On this day the online test was administered to establish a baseline for all participants and to familiarize them with the tests. Testing took place in the classroom under supervision of the classroom teacher/physical education teacher. Each participant used a desktop computer or laptop to access the online test. An invitation email with a link provided by the researcher was send to each participant to access the online test. The Motivation and Engagement Scale (MES) was also presented at the start of the experiment to all participants to establish a baseline for motivation and engagement. Furthermore, students were asked to fill out a short questionnaire on their current level of physical activities, known as the Physical Activity Measure and created for the purpose of this study (see Appendix E). The experimental condition would have started directly following the collection of the baseline data, however, due to the COVID19 lockdown and school closures, the progress of the study was postponed till the start of the new schoolyear in September 2020. The COVID19 lockdown and school closures also resulted in an attrition rate of 29.8% with 14 of the 47 participants not being able to return to school. Although participants remained the same participants who had been present at the start of the study in March, each participant had moved up a grade level which explains why throughout the remainder of the procedure participants are referred to as students from Grade 7-9 compared to students from Grade 6/7-8. During the experimental period, two data sets from two more participants were eliminated from the study due to a health issue and a technical failure of computer device while finishing the CogniFit online portion of the study. Participants received a reminder of continuation of the study by their respective physical education and/or classroom teachers. In the second week of September, the experimental group, further known as group 1, received a 30-minute moderate aerobic physical activity each school day for a period of one week. Prior to the moderate aerobic physical activity students received a 5-minute warm-up session. The aerobic physical activity ended with a 5-minute cool-down period. The moderate aerobic physical activities are exercises geared towards increased heart rates and blood flow. The exercises varied from running, sprinting, and swimming to circuit training. The second experimental group, further known as group 2, received each school day for a period of one week a 5-minute exercise consisting of jumping jacks, burpees, jump-squats, skipping, push-ups and jogging on the spot once a day. These 5-minutes intense exercises were meant to increase heart rate and blood flow. The control group, further known as group 3, did not receive any physical activity but followed their usual academic schedule. After about two weeks each group was presented with the same online test and the paper and pencil questionnaire in a similar manner as described above. Students did not have to fill out the Physical Activity Measure again. Group 1 received the tests directly following their moderate exercise time, with group 2 receiving the tests directly followed after the 5-minute intense exercise. Group 3 received the tests on the same day as the other groups during one of their academic classes. To maximize the effect of physical activity and to prevent the physical benefits of wearing of on the results of the M&E questionnaire or the CogniFit game, students finished these two measures on two different days directly following their physical exercise. To maintain confidentiality and to avoid experimenter bias, students were assigned a number as a unique identifier to code participant data for the statistical analysis.

Results

Data Analysis

A 2 × 3 mixed factor analysis of variance (ANOVA) was conducted to compare the effects of exercise on cognitive functioning in a moderate exercise, vigorous exercise and no exercise condition ($N = 31$) (see Table 1). Results revealed that moderate (pre $M = 499.27$, $SD = 91.74$; post $M = 551.6$, $SD = 73.7$) and vigorous exercise (pre $M = 475.85$, $SD = 124.87$; post $M = 539.7$, $SD=103.2$) increased cognitive functioning compared to the no exercise condition which did not increase cognitive functioning (pre $M = 410.29$, $SD = 118.19$; post $M = 399.57$, $SD = 131.36$). A significant main effect of time (pre- and post) on cognitive functioning, $F_{(1, 28)} = 5.83$,

$p < .05$, $\eta^2 = .172$, was observed accounting for 17.2% of the increase in cognitive functioning. Descriptive statistics showed the results of the three groups on the different conditions (see Table 2). A significant main effect of group was also found, $F_{(2,28)} = 3.46$, $p < .05$. Cohen's D was calculated to find the mean difference in standard deviation units between the three groups and a moderate effect was found for the moderate exercising, $d = .63$, as well as for the vigorous exercising, $d = .56$, accounting for the increase in cognitive functioning, and a negative effect for the no exercise, $d = -.085$. Furthermore, Bonferroni post-hoc tests indicated that the mean score for the moderate exercise ($M = 551.64$, $SD = 73.72$) was significantly different than the mean score for the no exercise ($M = 399.57$, $SD = 131.36$), $p < .05$ (see Figure 2). Box's Test of Equality of Covariance Matrices was conducted to test for homogeneity across the three groups. Results revealed that the assumption of equality of covariances, $F_{(6,4994)} = 6.78$, $p > .05$ was met, thereby indicating that ANOVA assumptions were not violated. Taken together, these results suggest that exercising whether moderate or vigorous does have a positive result on cognitive functioning with a greater effect on cognitive functioning for the moderate exercise group.

Descriptive statistics further revealed that memory, processing speed, attention and response time were all positively affected by physical activity (see Table 2). Results showed an increase of memory for moderate (pre $M = 527.36$, $SD = 109.78$; post $M = 585.36$, $SD = 95.46$) and vigorous exercise (pre $M = 479.85$, $SD = 146.42$; post $M = 552.31$, SD=131.93) compared to no increase for the no exercise condition (pre $M = 365.57$, $SD = 204.5$; post $M = 364$, SD = 173.19). A non-significant main effect of time (pre- and post) on memory, $F_{(1, 28)} = 3.21$, $p > .05$, $\eta^2 = .103$, was observed. A significant main effect of group yielded an effect size of $\eta^2 = .275$ for memory indicating that 27.5% of the increase in memory was explained by exercising, $F_{(2,28)} = 5.31$, $p < .05$. Cohen's D was calculated to find the mean difference in standard deviation units between the three groups and a moderate effect was found for the moderate exercising, $d = .56$, and a strong effect for the vigorous exercising, $d = .76$, accounting for the increase in memory, with a negative effect for the no exercise, $d = -.008$. Furthermore, Tukey post-hoc tests indicated that the mean scores for the moderate exercise ($M = 585.36$, $SD = 95.46$) and the vigorous exercise ($M = 552.31$, $SD = 131.93$) were significantly different than the mean score for the no exercise ($M = 364$, $SD = 173.19$), $p < 0.05$ (see Figure 3). Taken together, these results suggest that exercising, especially vigorous exercising, does have a positive effect on memory.

Results showed an increase of attention for moderate (pre $M = 470.82$, $SD = 191.99$; post $M = 531$, $SD = 125.87$) and vigorous exercise (pre $M = 428.1$, $SD = 171.05$; post $M = 523.15$, SD=141.23) compared to a decline for the no exercise condition (pre $M = 519.57$, $SD = 168.7$; post $M = 419.71$, $SD = 142.17$). A non-significant main effect on attention for both time, $F_{(1, 28)} = .313$, $p > .05$, $\eta^2 = .011$, and group, $F_{(2, 28)} = .159$, $p > .05$, $\eta^2 = .011$, were observed indicating that only 1% of the increase in memory was explained by time or exercising. Cohen's D was calculated to find the mean difference in standard deviation units between the three groups and a small effect was found for the moderate exercising, $d = .38$, and a moderate effect for the vigorous exercising, $d = .60$, accounting for the increase in attention, with a substantial negative effect for the no exercise, $d = -.64$. Although Bonferroni post-hoc tests showed the differences between participants in the moderate ($M = 531$, $SD = 125.87$) and the vigorous ($M = 523.15$, $SD = 141.23$) exercise condition who increased their levels of attention more than participants in the non-exercise condition ($M = 419.71$, $SD = 142.17$), these differences were not significant, $p > .05$ (see Figure 4).Taken together, these results suggest that exercising does have a positive effect on attention but a negative effect when not exercising.

Results showed an increase of response time for moderate (pre *M* = 550.91, *SD* = 110.57; post *M* = 602.45, *SD* = 159.36) and vigorous exercise (pre *M* = 495.31, *SD* = 223.73; post *M* = 582.15, *SD*=171.09) compared to a decline for the no exercise condition (pre *M* = 354.14, *SD* = 306.35; post *M* = 248.71, *SD* = 298.7). A non-significant main effect of time yielded an effect size of $\eta^2 = .002$, $F_{(1,28)} = .059$, $p > .05$ indicating only a very small percentage contributing to increase of response time. A significant main effect of group on response time yielded an effect size of $\eta^2 = .311$ indicating that 31.1% of response time was explained by exercising, $F_{(2,28)} = 6.32$, $p < .05$. Cohen's D was calculated to find the mean difference in standard deviation units between the three groups and small effects were found for both the moderate exercising, *d* = .38, and the vigorous exercising, *d* = .44, accounting for the increase in response time, with a negative effect for the no exercise, *d* = -.35. Furthermore, Tukey post-hoc tests indicated that the mean scores for the both moderate (*M* = 602.45, *SD* = 159.36) and vigorous exercise (*M* = 582.15, *SD* = 171.09) were significantly different than the mean score for the no exercise (*M* = 248.71, *SD* = 298.70), $p < .05$ (see Figure 5). These results suggest that exercising does have a positive effect on response time but a negative effect when not exercising.

Results furthermore revealed that exercising did not have a significant effect on processing speed. In fact, moderate exercise (pre *M* = 617.18, *SD* = 165.88; post *M* = 539, *SD* = 128.14) had a negative effect on processing speed compared to a small positive effect of vigorous (pre *M* = 611.77, *SD* = 193.44; post *M* = 625.92, *SD*=184.14) and no exercise (pre *M* = 573.29, *SD* = 295.14; post *M* = 579.29, *SD* = 267.87). Cohen's D was calculated to find mean differences in standard deviation units between the three groups and very small effects were found for both the vigorous exercise, *d* = .07, and the no exercise, *d* = .02 accounting for a small increase in processing speed, with a substantial negative effect for moderate exercise, *d* = -.53.

Taken together, these results suggest that only vigorous exercising leads to an increase in processing speed (see Figure 6).

Overall, the vigorous exercise condition contributed substantially more to the increase of the four cognitive variables than the moderate exercise condition. Calculations of Cohen's D revealed large and moderate mean difference in standard deviation units for the vigorous exercise group on increases of memory, $d = .76$, attention, $d = .61$, and response time, $d = .44$, compared to moderate exercise with moderate and small mean differences in standard deviation units on increase of memory, $d = .56$, attention, $d = .38$, and response time, $d = .38$. Although small, the vigorous condition also showed an increase in processing speed, $d = .07$; a decline in processing speed was observed for the moderate exercise condition, d = -.53 (see Figure 5). Test of Equality of Covariance Matrices was conducted to test for homogeneity on the four variables across the two conditions. Results revealed that the assumption of equality of covariances for memory, $F_{(6,4994)} = 1.45$, $p > .05$, processing speed, $F_{(6,4994)} = 1.32$, $p > .05$, attention, $F_{(6,4994)} = 2.53$, $p > .05$, and response time, $F_{(6,4994)} = 13.67$, $p>.05$, was met. However, Levene's test of Equality showed a variance of the three groups for the response time, $F_{(2,28)} = 4.13$, $p < .05$, thereby violating the assumptions of ANOVA for this particular variable and rejecting the Null hypothesis. A Pearson correlation coefficient was conducted to evaluate the relationship between the continuous variables on cognition and the four cognitive functions. Strong correlations were found between cognitive functioning and memory, $r = .93$, $p < .05$, cognitive functioning and attention, $r = .75$, $p < .05$, and response time, $r = .60$, $p < .05$, and a moderate correlation for processing speed, $r = .42$, $p < .05$. Furthermore, memory was strongly correlated with attention, $r = 0.54$, $p < .05$, and moderately correlated with response time, $r = 0.49$, $p < .05$. Processing speed was moderately correlated with response time, $r = 0.46$, $p < .05$. Attention was also moderately correlated with response time, $r = 0.4$, $p < .05$ (see Table 5).

The 2 x 3 mixed factor ANOVA was furthermore conducted to find out if exercising would increase motivation and engagement in the classroom ($N = 31$). Results from the first and second paper and pencil test on motivation and engagement revealed that exercising increases motivation, $F_{(1,28)} = 0.002$, $p > .05$. Descriptive statistics showed that moderate exercise increases motivation (pre $M = 93.18$, $SD = 9.71$; post $M = 96.45$, $SD = 9.66$), but vigorous (pre $M = 93.77$, $SD = 10.85$; post $M = 92$, $SD = 12.65$) and no exercise (pre $M = 99.71$, $SD = 8.75$; post $M = 97.86$, $SD = 10.53$) do not; in fact, a decrease in the vigorous and the no exercise condition was observed. A non-significant main effect on motivation for both time, $F_{(1, 28)} = .002$, $p > .05$, $\eta^2 = .000$, and group, $F_{(2, 28)} = 1.149$, $p > .05$, $\eta^2 = .076$, were observed indicating that only less than 1% of the increase in motivation was explained by time or exercising. Cohen's D was calculated to find a mean difference in standard deviation units between groups, and a small effect, $d = .337$, $p < .05$ was found accounting for the increase of motivation for the moderate exercise condition (see Figure 6). However, a decrease in motivation was observed for the vigorous, $d = -.151$, and the no exercise condition, $d = -.192$. Tukey post-hoc tests indicated that the mean scores for the moderate exercise ($M = 96.45$, $SD = 9.66$) and the no exercise ($M = 97.86$, $SD = 10.53$) were not significantly different from each other, $p > .05$; however, the mean score for the vigorous exercise ($M = 92$, $SD = 12.65$) was substantially lower (see Figure 7). These results suggest that students in moderate exercise conditions are more motivated whereas vigorous or no exercise have a negative effect on motivation.

Furthermore, results indicated that all three conditions, (moderate pre $M = 96.45$, $SD = 11.7$; post $M = 96.55$, $SD = 12.49$, vigorous pre $M = 97.85$, $SD = 8.99$; post $M = 100.69$, $SD =$

11.78, no exercise pre $M = 100.29$, $SD = 11.67$; post $M = 104$, $SD = 10.66$) led to an increased engagement, $F_{(1, 28)} = 1.165$, $p > .05$, $\eta^2 = .04$. A non-significant main effect on engagement for both time, $F_{(1, 28)} = 1.165$, $p > .05$, $\eta^2 = .04$, and group, $F_{(2, 28)} = .726$, $p > .05$, $\eta^2 = .049$, were observed indicating that 4-5% of increase in engagement was explained by time or exercising. Cohen's D was calculated to find the mean difference in standard deviation units of increased engagement, and a fairly small effect, $d = .0083$, for the moderate exercise condition, and small to medium effects for the vigorous, $d = .273$, and the no exercise condition, $d = .332$, were found accounting for increase of engagement (see Figure 8). Tukey post-hoc tests did not reveal significant differences between the three groups, ($M = 96.55$, $SD = 12.5$; $M = 100.69$, $SD = 11.78$; $M = 104$; $SD = 10.66$), $p > .05$ Taken together, results suggest that group condition does not have an effect on engagement. More specifically, whether students would exercise or not, levels of engagement increased. Descriptive statistics showed the results of the three groups on the two conditions (see Table 2). Box's Test of Equality of Covariance Matrices was conducted to test for homogeneity across the three groups. Results revealed that the assumption of equality of covariances for motivation, $F_{(6,4994)} = 7.61$, $p > .05$, and for engagement, $F_{(6,4994)} = 2.94$, $p > .05$ was met. Levene's test of Equality showed no variance in the three groups for both motivation, $F_{(2,28)} = 0.37$, $p > .05$, and engagement, $F_{(2,28)} = 0.05$, $p > .05$.

A Pearson correlation coefficient was further conducted to evaluate the relationship between motivation and engagement. A strong correlation was found on the post-test scores between levels of motivation and engagement, $r = .61$, $p < .05$ (see Table 5).

Discussion

Based on the findings of this study exercising is considered a contributing factor to increased cognitive performance, and especially moderate exercising ($ES = .63$) increased cognitive performance more than vigorous exercising. The main effect of exercise on cognitive functioning as observed in this study showed that students in either of the two exercise groups increased their cognitive functioning. Scores of students who did not exercise resulted in a small but negative effect size indicating a decline in cognitive functioning. This is an important finding that confirms the significance of exercising especially under school-aged children and youth. This finding was supported by Winter et al. (2007) who found that short bouts of exercise directly improve learning. Although the ages of participants (age 19-22) in Winter et al.'s (2007) study differed from the ages of participants in the present study, Winter et al.'s results offered strong evidence for an increase in cognition after exercising. In their study they found that participants who engaged in two short intense three-minute sprints improved their learning with 20% compared to participants in a sedentary or moderate exercise condition. The abovementioned finding was furthermore supported by Hillman et al. (2009). Their study results indicated that exercise increases cognitive functioning as well as attention. More specifically, Hillman et al.'s results found a larger effect (*SE* = .80) on attention following short bouts of exercise which was in line with findings in the current study where a large effect size (*SE* = .61) was observed after vigorous exercising compared to a medium effect size (*SE* = .38) after moderate exercising. Hillman et al. (2009) further indicated that these effects are especially true for the preadolescent population similar in age to the participants in the present study. In contrast to findings in the present study where levels of attention were higher after the vigorous condition compared to the moderate exercise, a study by Janssen et al. (2014) found that levels of attention increase more after moderate than vigorous exercising. In their study a moderate break and a vigorous exercising break were both 15 minutes in length. They explained their findings by using the inverted U-hypothesis which states that cognitive performance is at an optimal level of functioning when moderate levels of arousal are reached which would normally happen after moderate physical activity (Janssen et al., 2014). Similarly, findings that supported the positive effect of moderate physical activity on response time were also contradictory to findings in the present study where vigorous exercise led to more increased response time than moderate exercise. The difference between the outcomes of the two studies could simply be the duration of the exercise conditions. In the study by Janssen et al. (2014) the moderate exercise was significantly shorter than in the present study (15 minutes compared to 30 minutes) One could argue that the optimal state of arousal that would be present after moderate activity could have accounted for the increased attention but further research is needed to differentiate between the levels of arousal after different lengths and intensities of exercising. A study by Geertsen et al. (2016) revealed some interesting findings on attention and working memory. Although the researchers were primarily interested in finding associations between motor skills, exercise and cognitive functions and correlations with performance in mathematics and reading, they found a positive association between a leisure form of exercising and increased semantic memory as well as an association between more intense exercise and increased working memory and attention (Geertsen et al, 2016). Moreover, their findings indicated that performance in mathematics (ES = .10) and reading comprehension (ES = .18) increased significantly for participants in the intense exercise condition as well as for participants in the organised leisure sports (ES = .87; ES = 1.59). These results together with the findings in the present study are important and promising findings as they can be used to inform parents and educators about the positive effects of exercise on cognitive functioning in school-age children and adolescents. As the researcher of the present study predicted, support was found for vigorous exercise to have a larger effect on cognitive functions compared to a moderate form of exercise. Vigorous exercise had a larger effect on memory, *ES* = .76, attention, *ES* = .61, and response time, *ES* = .44, compared to moderate exercise (memory, *ES* = .56, attention, *ES* = .38, and response time, *ES* = .38). Although small, the vigorous condition also showed an increase in processing speed, *ES* = .07. Performance in the cognitive domains such as sustained attention, working memory, processing speed and reaction time are fundamental for core academic courses such as mathematics and language. For instance, reading comprehension requires long-term and working memory to use vocabulary knowledge and to recall spelling rules and word lists from memory, and similarly for mathematics, concepts of numbers and math strategies rely heavily on memory. The larger effect sizes for vigorous exercise on the abovementioned cognitive functions are important findings to use as a strategy to increase students' functioning on class assignments or tests. Educators would have this powerful strategy always at hand as 5-minute exercises in the classroom are easier to organize and implement than, for instance, a 30-minute gym class.

The findings of this study on motivation were consistent with the literature. The increased motivation after moderate exercising observed in this study was supported by Vazou et al. (2012) who found significant higher means of enjoyment and competence indicating increased levels of motivation related to physical activities. It is important to note that, according to Ryan and Deci's (2000a) SDT, participants experiencing tasks as useful or valuable is in line with the internalised form of regulation close to intrinsic motivation (a student wants to do well). Intrinsic motivation is associated with interest and enjoyment and feelings of competence (Ryan & Deci, 2000a). Based on the current findings, students in the vigorous and no exercise condition might not have found the CogniFit game and M&E questionnaire interesting enough to be intrinsically motivated. However, exercising does increase motivation as was found in this study for the moderate exercise group, suggesting that students would benefit more from longer physical exercise breaks compared to short vigorous exercise breaks in order to increase motivation for learning. The findings of the current study on engagement were also interesting. All three conditions showed an increase of engagement regardless of exercise. This is not surprising given that participants are students of a small school with small classes and positive teacher-student interactions. The school is known for teachers' sincere interest in students' wellbeing and a positive atmosphere in the classroom geared to success which would most likely result in positive levels of engagement amongst students. During the experimental phase of the study students were highly encouraged by their respective teachers to engage enthusiastically in the exercises, and to do well on the CogniFit online game as well as on the questionnaire. In line with results from a study by Martin (2006) students' performance is related to teachers' enjoyment of teaching, pedagogy, and affective orientations. Although Martin's (2006) study was conducted from a teacher's perspective, results revealed moderate effect sizes on student engagement, ES = .23-.42, indicating the importance of teacher's confidence and competency in teaching on the levels of engagement of students.

Given these results and the outcome of the present study, it is important to emphasise the significant difference between short amounts of aerobic exercise and longer moderate periods of exercising as recommended by World Health Standards for children and youth (Colley et al., 2017) as a strategy to increase cognitive functioning or performance. Not only did the present study found significant increases of cognitive functions related to short bouts of vigorous exercise, there is a substantial benefit of implementing short 3-5-minute exercises; first, the short time would most likely fit in busy schedules; second, the 3-5-minute exercises would most likely work amidst scheduled academic classes, and last, teachers would be able to attend to short exercises in their own classrooms without having to book time and space in a school gymnasium.

Limitations

There were several limitations in the present study. First, the sample size was smaller than intended. Due to the COVID19 lockdown and school closures a higher than usual attrition rate of 29.8% was observed with 14 of the 47 participants not being able to return to school, and therefore unable to continue the study. Results of two more participants were exempt from the final data-analysis due to one participant experiencing an injury during the experimental period and therefore not being able to exercise, and another participant experiencing technical failure of the electronic device while finishing the online CogniFit game. The smaller sample size also resulted in more variance, larger confidence intervals and small effect sizes. A larger sample size might have resulted in larger effect sizes. The smaller sample size also led to high(er) correlations between the different continuous variables in the study.

Second, the experimental period was shorter than initially planned. Due to the restrictions and limitations of the COVID19 health protocols, the participating school decided to only have the participants involved in the study over a short amount of time thereby compromising a more sustained effect of exercise on functioning in the classroom.

Another limitation was seen in the form of some technical glitches during the use of the CogniFit online game. Participants experienced that certain functions on their keyboard would not correspond with the tasks on the screen, i.e. when a joystick was required, and time would be lost to find the correct function key to compensate for the joystick. Another challenge was observed with written instructions on the screen for each individual task. Some instructions were lengthier than others; students would not take the time to thoroughly read through those long instructions which led to confusion and mistakes which inadvertently could have affected scores on those particular tasks. Students were encouraged by the respective teacher to take their time and to read instructions before starting the task. Confusion or misinterpretation of instructions could have been prevented would students have taken the time to read instructions well. This can very well be related to participant's age or to aspects of competition as the online gaming task found place with participants in the same room at the same time. Another limitation was the absence of demographics on learning disabilities. A small number of students was compromised especially on reading which might have affected their answers on the M&E questionnaire and could have interfered with their understanding of instructions on the tasks of the CogniFit game. Another limitation was seen in the physical activity levels of the participants. The school where the study was conducted has an extensive after school sports program mandatory for all students, and although some students indicated on the Physical Activity Measure not to be active more then 2-4 a week, all participants would have had a similar activity level based on the school's sports program. A confounding variable was present in the form of face masks. When baseline scores were collected students were not wearing a face mask but when final scores were collected students were required to wear a face mask according to the COVID19 public health regulations. Face masks were not mandatory while students were exercising, but during the in class portion of the experiment and could therefore have influenced the scores on the CogniFit game and the M&E questionnaire.

For future research the current study could be of interest would it be replicated with a larger sample size. The study could also be replicated including a longer experimental phase with one or two more data collection points spread out at i.e. one month, and three months' time. Furthermore, it would be interesting to study how exercising would benefit students with learning disabilities. To further examine the effect of aerobic exercise compared to moderate exercise, it would be advantageous to included measures of individual's heart rate and oxygen consumption as to assure the intensity of the physical activities and how that relates to an increase of cognitive functioning. Another interesting aspect of study could be the effect on the neurobiological processes in the brain after exercising. It would be interesting to include variables of age and gender and to examine if there are differences between those groups in relation to exercising and cognitive functioning.

Conclusion

It is crucial to the field of education and psychology to understand the benefits and effects of physical exercise. More specifically, it is critical to understand how exercising relates positively to students' cognitive functioning and students' motivation for engaging in classroom instructions. One of the responsibilities of the practice of school psychologists is to provide recommendations to schools how to better support students in and outside the classroom and more specifically to provide recommendations for students with learning challenges or diagnosed learning disabilities. Another responsibility of the practice of school psychologists is to facilitate information sessions or workshops for teachers to enhance classroom behavior and functioning especially for those situations where students are inattentive and not focused. The repetitive pattern of results of the present study showed the trend that exercising has positive outcomes on cognitive functioning as well as motivation and engagement. These results are believed to be beneficial to inform the practice of school psychologists and could help foster a collaborative approach to increase academic performance, as well as classroom behavior and functioning by implementing short bouts of physical activity during school days and by increasing physical activity in school programs. More specifically, knowing that cognitive domains such as attention, memory, processing speed and response time all increase after vigorous bouts of exercise, teachers could use this strategy shortly before a mathematics or literacy assignment is given.

However, if an overall increase of cognitive functioning is desired, teachers should be aware of the effectiveness of longer physical breaks in a moderate condition. Also, both motivation and engagement increase after moderate exercising and could be a very useful tool in situations where behavior is a concern or in general when educators notice a lack of motivation amongst their students.

Table 1

Characteristics of Participants

	%	*M*	*SD*
N=31			
Age in years		13.29	0.82
Gender			
male	61		
female	39		
Fitness level			
Moderately active	84		
Not as active	16		
Group condition			
Moderate exercise	36		
Vigorous exercise	42		
No exercise	22		

Table 2

Means, Standard Deviations and Confidence Intervals of Cognitive Functioning

Measure	Pre		Post	
	M (SD)	*95% CI*	*M (SD)*	*95% CI*
Cognitive Functioning	469.35 (114)		512.32 (115.66)	
Moderate exercise	499.27 (91.74)	[429.72-568.82]	551.64 (73.72)	
Vigorous exercise	475.85 (124.87)	[411.87-539.83]	539.77 (103.16)	
No exercise	410.29 (118.19)	[323.10-497.48]	399.57 (131.36)	
Memory	470.58 (157.30)		521.52 (153.93)	
Moderate exercise	527.36 (109.78)	[434.82-619.91]	585.36 (95.46)	[504.50-666.23]
Vigorous exercise	479.08 (146.42)	[393.95-564.21]	552.31 (132.93)	[477.93-626.69]
No exercise	365.57 (204.50)	[249.56-481.59]	364 (173.19)	[262.63-465.37]
Processing Speed	605 (204.62)		584.55 186.80	
Moderate exercise	617.18 (165.88)	[486.85-747.51]	539 (128.14)	[422.19-655.81]
Vigorous exercise	611.77 (193.44)	[491.88-731.66]	625.92 (184.14)	[518.47-733.37]
No exercise	573.29 (295.14)	[409.91-736.67]	579.29 (267.87)	[432.85-725.72]
Attention	464 (176)		502.58 (139.23)	
Moderate exercise	470.82 (191.99)	[360.68-580.96]	531 (12.87)	[446.91-615.09]
Vigorous exercise	428.08 (171.05)	[326.77-529.39]	523.15 (141.23)	[445.80-600.51]
No exercise	519.57 (168.70)	[381.51-657.64]	419.71 (142.17)	[314.30-525.13]
Response Time	483.16 (220.22)		514.06 (243.56)	
Moderate exercise	550.91 (110.57)	[418.55-683.27]	602.45 (159.36)	[477.80-727.11]
Vigorous exercise	495.31 (223.73)	[373.55-617.06]	582.15 (171.09)	[467.49-696.82]
No exercise	354.14 (306.35)	[188.22-520.07]	248.71 (298.70)	[92.46-404.97]

Table 3

Means, Standard Deviations and Confidence Intervals of Motivation and Engagement

Measure	Pre		Post	
	M (SD)	*95% CI*	*M (SD)*	*95% CI*
Motivation	94.9 (10.05)		94.9 (11.13)	
Moderate exercise	93.18 (9.71)	[86.99-99.38]	96.45 (9.66)	[89.53-103.38]
Vigorous exercise	93.77 (10.85)	[88.07-99.47]	92 (12.65)	[85.63-98.37]
No exercise	99.71 (8.75)	[91.95-107.48]	97.86 (10.53)	[89.18-106.54]
Engagement	97.9 (10.36)		99.97 (11.77)	
Moderate exercise	96.45 (11.7)	[89.9-103.01]	96.55 (12.5)	[89.25-103.84]
Vigorous exercise	97.85 (8.99)	[91.82-103.88]	100.69 (11.78)	[93.98-107.4]
No exercise	100.29 (11.67)	[92.07-108.51]	104 (11.77)	[94.85-113.15]

Table 4

Degrees of Freedom, F-values, P-values, Effect sizes and Partial Eta Squared

	(Df) F-value	*P-value*	*ES (d)*	η^2
Cognitive Functioning	*(1,28) 5.826*	*.023*		*0.172*
Moderate exercise	(2,28) 3.464	.045	0.63	0.198
Vigorous exercise	(2,28) 3.464	.045	0.56	0.198
No exercise	(2,28) 3.464	.045	-0.085	0.198
Memory	*(1,28) 3.213*	*.084*		*0.103*
Moderate exercise	(2,28) 5.314	.011	0.56	0.275
Vigorous exercise	(2,28) 5.314	.011	0.76	0.275
No exercise	(2,28) 5.314	.011	-0.0083	0.275
Processing Speed	*(1,28) 0.173*	*.68*		*0.006*
Moderate exercise	(2,28) 0.265	.769	-0.53	0.019
Vigorous exercise	(2,28) 0.265	.769	0.07	0.019
No exercise	(2,28) 0.265	.769	0.02	0.019
Attention	*(1,28) 0.313*	*.58*		*0.11*
Moderate exercise	*(2,28) 0.159*	.854	0.38	0.011
Vigorous exercise	*(2,28) 0.159*	.854	0.61	0.011
No exercise	*(2,28) 0.159*	.854	-0.64	0.011
Response Time	*(1,28) 0.059*	*.81*		*0.002*
Moderate exercise	(2,28) 6.324	.005	0.38	0.311
Vigorous exercise	(2,28) 6.324	.005	0.44	0.311
No exercise	(2,28) 6.324	.005	0.35	0.311
Motivation	(1,28) *0.002*	*.962*		*0.000*
Moderate exercise	(2,28) 1.149	.332	0.34	0.076
Vigorous exercise	(2,28) 1.149	.332	-0.15	0.076
No exercise	(2,28) 1.149	.332	-0.19	0.076
Engagement	*(1,28) 1.165*	*.29*		*0.04*
Moderate exercise	(2,28) 0.726	.493	0.008	0.049
Vigorous exercise	(2,28) 0.726	.493	0.27	0.049
No exercise	(2,28) 0.726	.493	0.33	0.049

Table 5

Correlations between Continues Variables

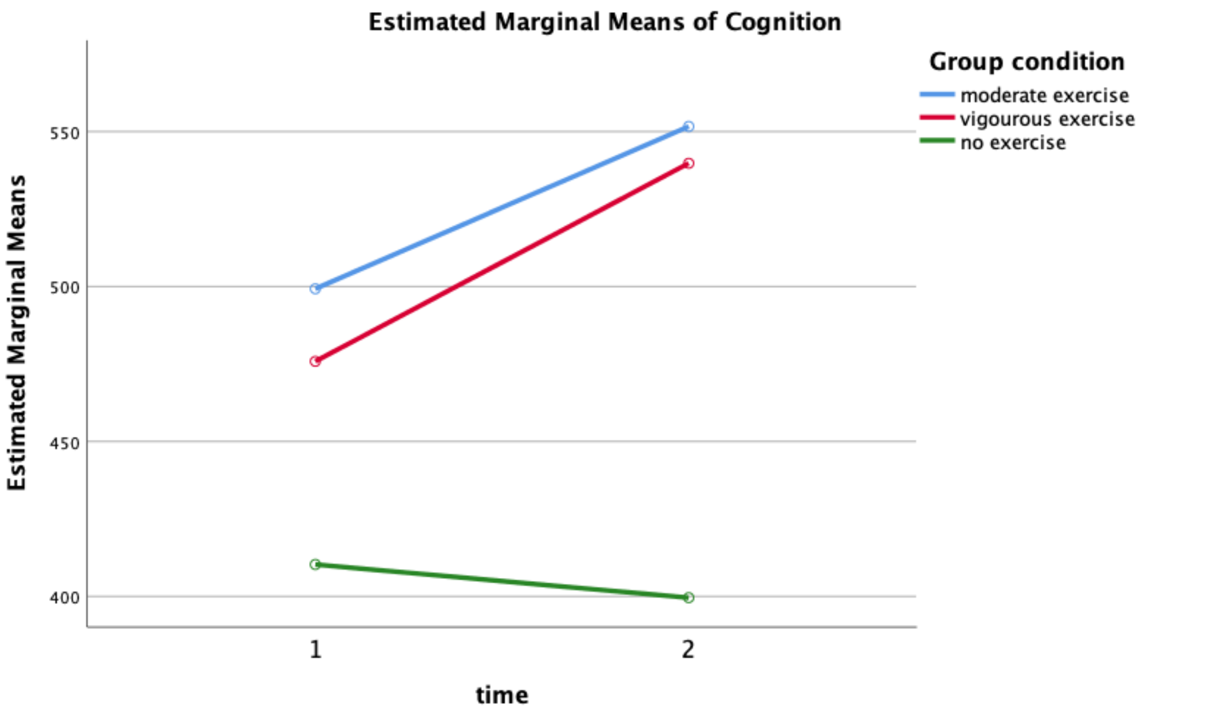
Correlations between Pre and Post Conditions and Continuous Variables

PRE-Scores	r p	Motivation	Engagement	Cognitive Functioning	Memory	Processing Speed	Attention	Response Time
Motivation		1	.505**	-.083	-.135	-.215	.182	-.324
		--	.004	.657	.470	.245	.327	.075
Engagement		.505**	1	.254	.209	.200	.172	.017
		.004	--	.167	.258	.281	.356	.929
Cognitive F		-.083	.254	1	.913**	.371*	.623**	.678**
		.657	.167	--	.000	.040	.000	.000
Memory		-.135	.209	.913**	1	.291	.370	.657**
		.47	.258	.000	--	.112	.040	.000
Processing		-.215	.2	.371*	.291	1	.134	.230
		.245	.281	.040	.112	--	.474	.212
Attention		.182	.172	.623**	.370*	.134	1	.165
		.327	.356	.000	.040	.474	--	.374
Response T		-.324	.017	.678**	.657**	.230	.165	1
		.075	.929	.000	.000	.212	.374	--
POST-Scores								
Motivation		1	.608	-.093	-.082	-.165	.131	-.186
		--	.000	0.619	.663	.375	.482	.316
Engagement		.608	-.093	.032	.047	.012	.047	-.096
		.000	.619	.866	.803	.950	.804	.607
Cognitive F		-.093	-.082	1	.926**	.416*	.746**	.597**
		.619	.663	--	.000	.020	.000	.000
Memory		-.082	-.165	.926**	1	.351	.543**	.491**
		.663	.375	.000	--	.053	.002	.005
Processing		-.165	.131	.416*	.351	1	.240	.455**
		.375	.482	.020	.053	--	.194	.010
Attention		.131	-.186	.746**	.543**	.240	1	.401*
		.482	.316	.000	.002	.194	--	.025
Response T		-.186		.597**	.491**	.455*	.401*	1
		.316		.000	.005	.010	.025	--

**. *Correlation is significant at the .01 level (2-tailed)*
*. *Correlation is significant at the .05 level (2-tailed)*

Figure 2

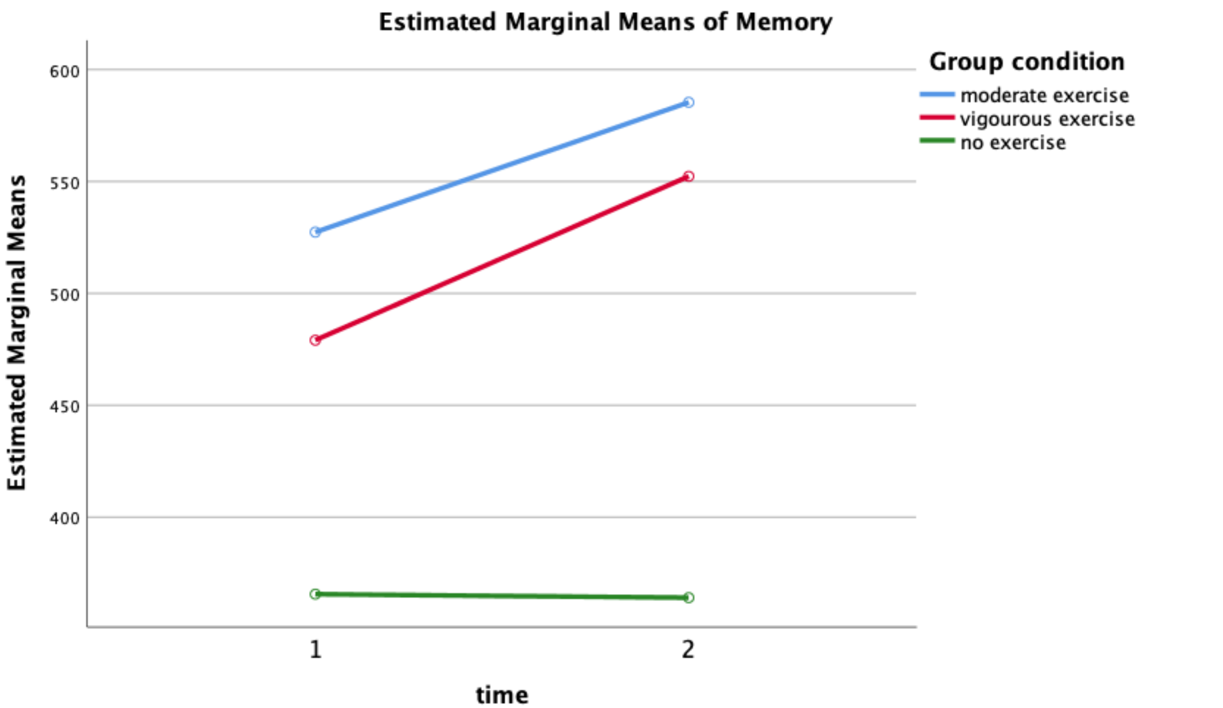
Time by Exercise on Cognition



Note: Moderate exercise (d = .63), vigorous exercise (d = .56), no exercise (d = -.085). The figure is showing a substantial increase of cognitive functioning for both exercise conditions, and a small decline for the no exercise condition.

Figure 3

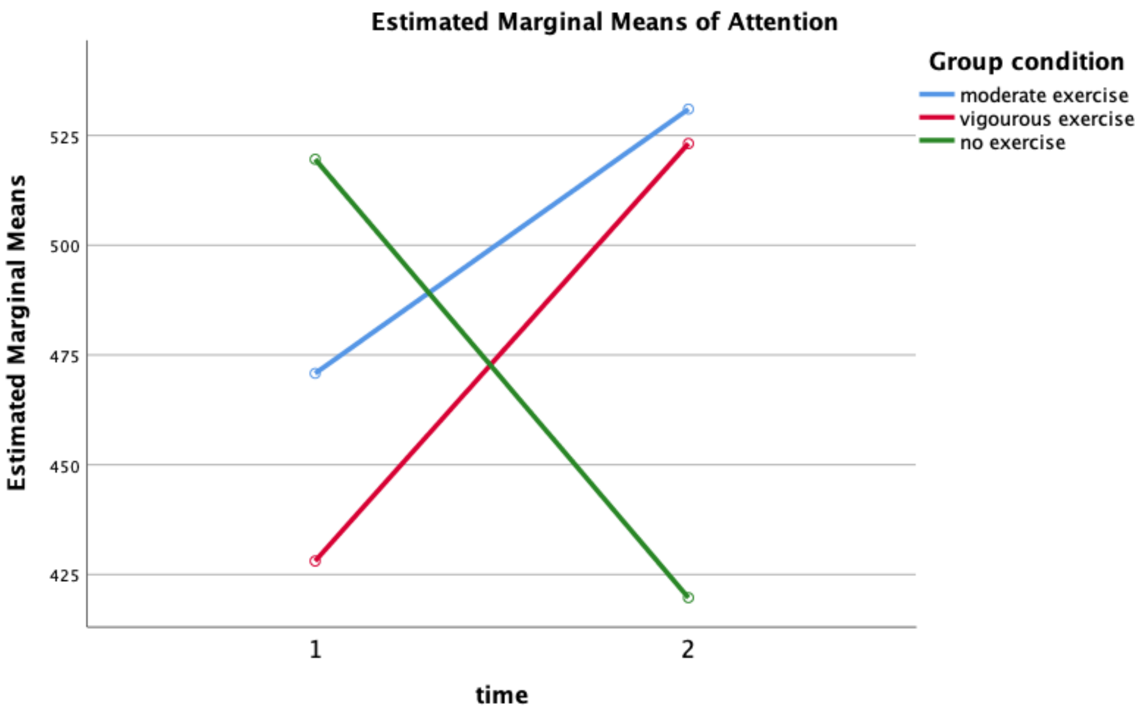
Time by Exercise on Memory



Note: Moderate exercise (d = .56), vigorous exercise (d = .76), no exercise (d = -.008) The figure is showing a substantial increase of memory for both exercise conditions, and a small decline for the no exercise condition.

Figure 4

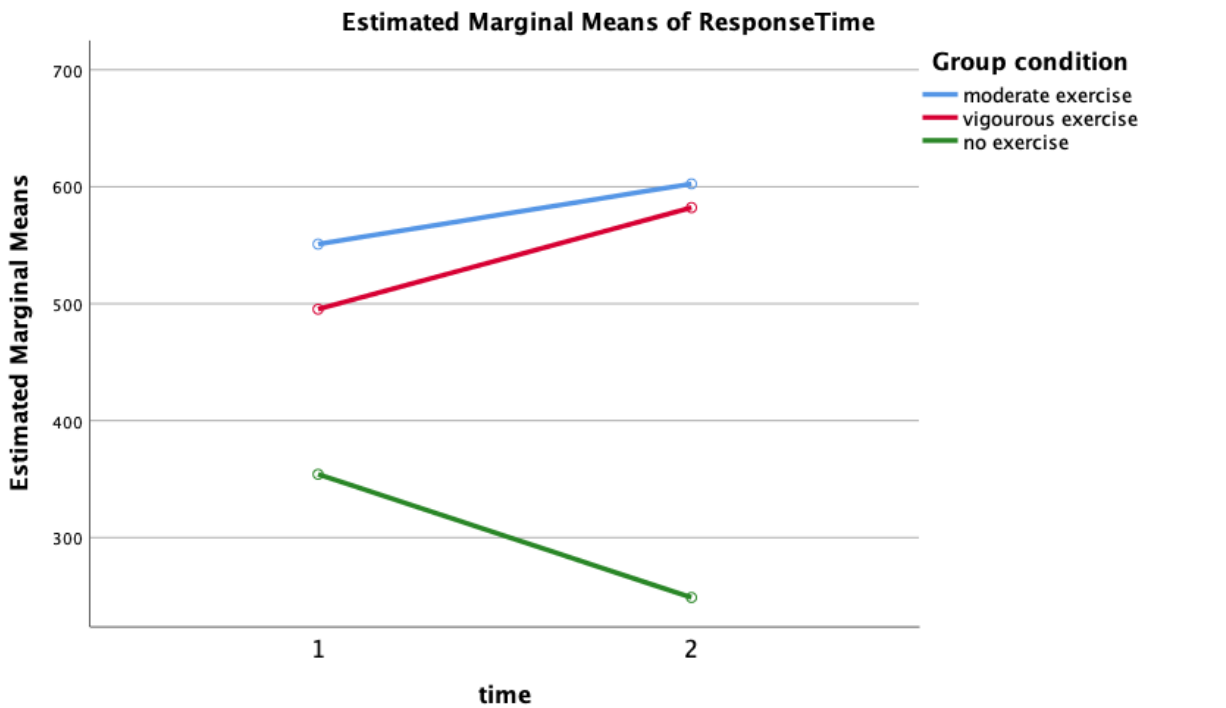
Time by Exercise on Attention



Note: Moderate exercise (d = .378), vigorous exercise (d = .608), no exercise (d = -.642). The figure is showing a substantial increase of cognitive functioning for both exercise conditions, and a substandial decline for the no exercise condition.

Figure 5

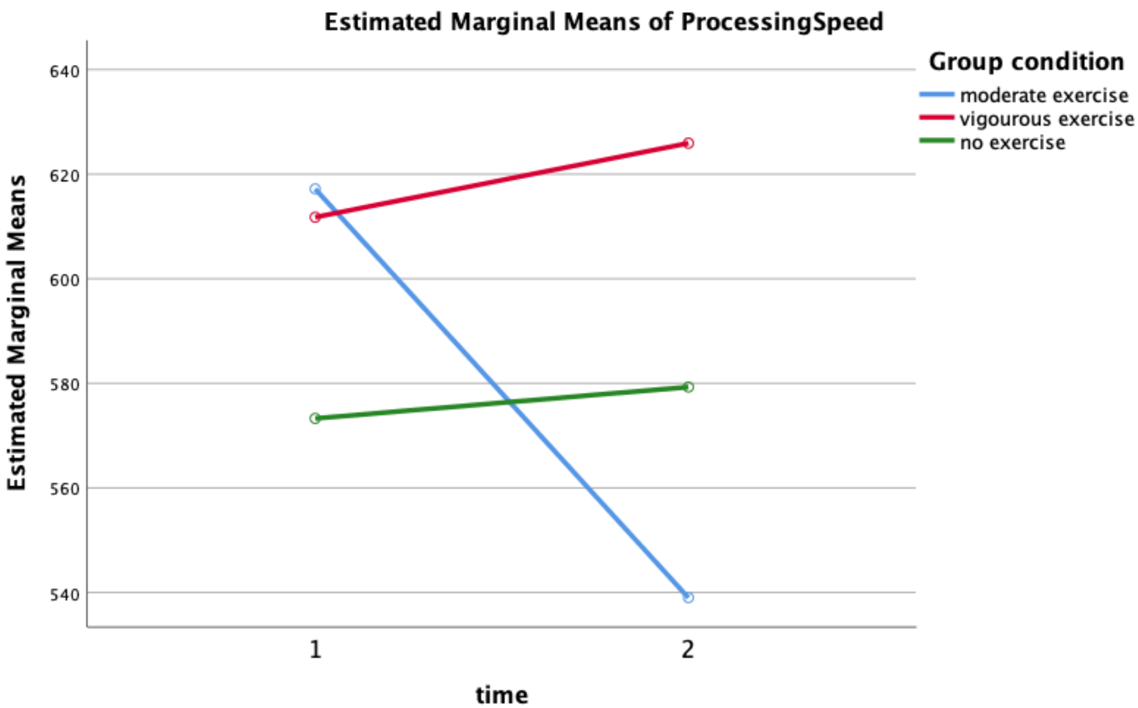
Time by Exercise on Response Time



Note: Moderate exercise (d = .382), vigorous exercise (d = .439), no exercise (d = -.349). The figure is showing a substantial increase of response time for both exercise conditions, and a substantial decline for the no exercise condition.

Figure 6

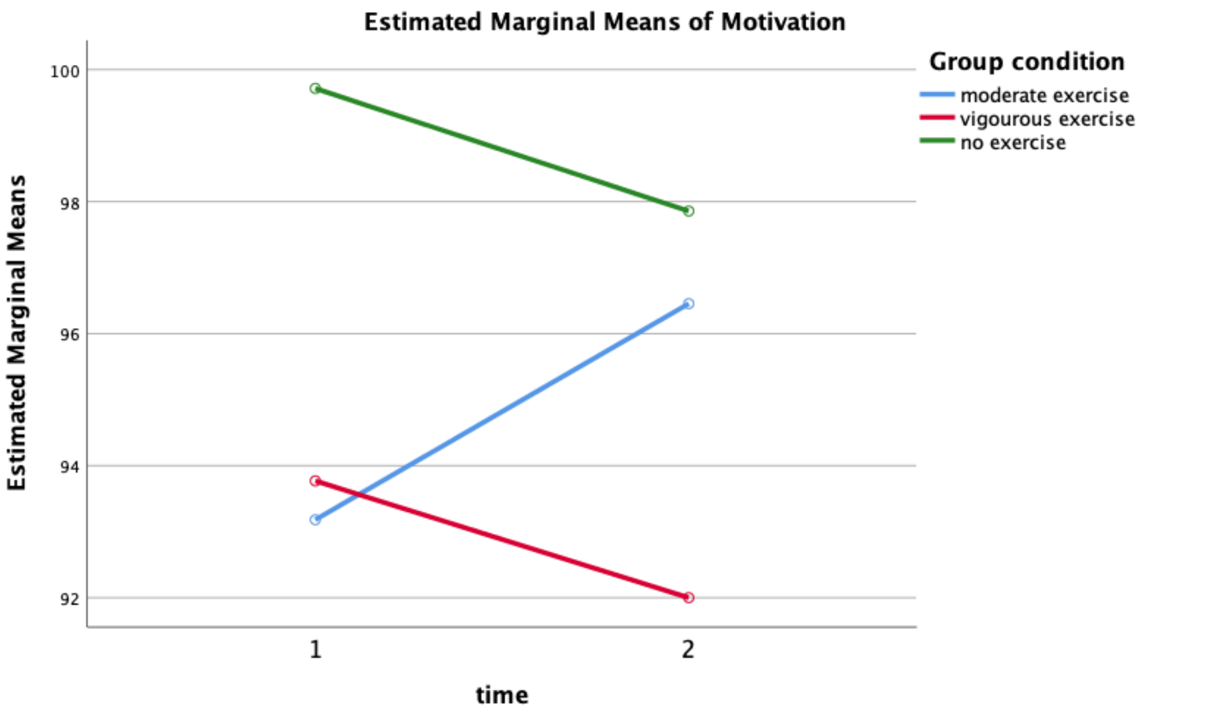
Time by Exercise on Processing Speed



Note: Moderate exercise (d = -.532), vigorous exercise (d = .075), no exercise (d = .021). The figure is showing an increase of processing speed for the vigorous exercise condition and the no exercise condition, and a steep decline for the moderate exercise condition.

Figure 7

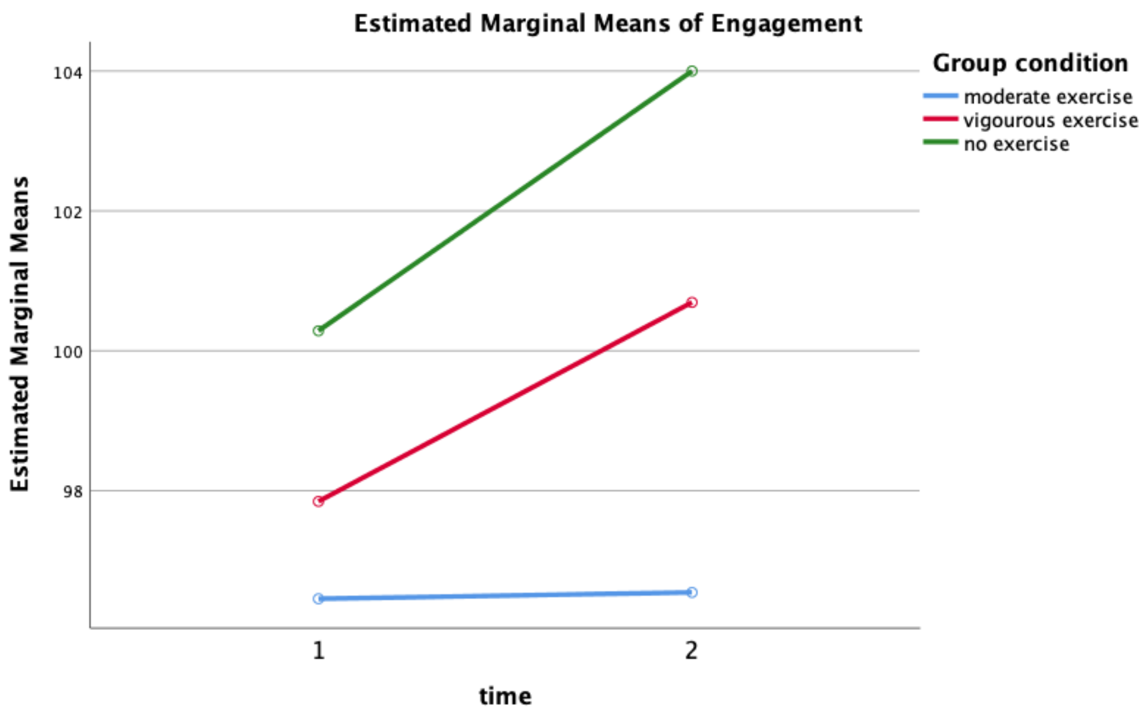
Time by Exercise on Motivation



Note: Moderate exercise (d = .337), vigorous exercise (d = -.151), no exercise (d = -.192). The figure is showing an increase of motivation for the moderate exercise condition and declines for the vigorous and no exercise conditions.

Figure 8

Time by Exercise on Engagement



Note: Moderate exercise (d = .0083), vigorous exercise (d = .273), no exercise (d = .332). The figure is showing an increase of engagement for the vigorous and the no exercise condition and a very small increase for the moderate exercise condition

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Appendix A

Information Letter to the school

Dear director of the Junior School,

My name is Annemarie Stigter and I am currently a graduate student in the school psychology program at Mount Saint Vincent University. One of the requirements of this program is the completion of a thesis. I am conducting a research study entitled, "*What are the benefits of exercise?" Examining the effects of acute exercise on cognitive functioning in school-aged children and youth.* The purpose of this study is to gain a better understanding of the importance of physical activities and what the effects of exercising is on students.

I am interested in studying if exercise has a positive effect on concentration and performance as well as engagement in the classroom. Furthermore, I am interested to find out if exercise results in an increase of academic performance. My goal is to use the results to inform the practice of school psychologists and help foster a collaborative approach on physical activity in school programs. It is important to understand the benefits of physical exercise especially for children who are more challenged in their concentration, learning and academic performance.

Your school has an excellent Wellness program that would fit very well with the design of my research study. Participants for the experiment would be preferably Grade 6 and Grade 7 students that participate in the Wellness program that started September 2019. This group would be experimental group 1. Group 2 will be formed by students from part of Grade 8 who are participating in a short 4-5-minute intense exercise facilitated by the physical education teacher during her instruction time for Grade 8. Group 3 will be formed by the remaining Grade 8 students who are not participating in the Wellness program or receiving the short intense exercise activity.

I would be collecting data through the online game program CogniFit^{TM} that assesses cognitive performance such as problem solving, reaction time, processing speed and executive processing. These games have no harmful effects but are a rather fun way to assess student's performance. I would also collect data through the paper and pencil test Motivation and Engagement Scale that assesses students' motivation and engagement in the classroom. The first data collection would be taken during a regular class session before the start of the Wellness program or the short intense exercise activity. The second and last data collection would be taken four weeks later during a regular class session. Data would be collected for both the Grade 6 and Grade 7 combined students who are participating in the Wellness program, and the Grade 8 students who are participating in the short intense physical activity as well as the Grade 8 students who are not participating in any of the physical exercises mentioned above.

The data collected will be kept confidential; students will be asked to use their student number to get access to the online game implemented through the school for the purpose of the study. For the paper and pencil test students write down their student number. All data accumulated will be stored in a password protected database on a password protected computer. After data analysis is completed the accumulated data, and any identifiable information, will be destroyed. The results of the study will be published in my thesis report, and possibly in a scientific journal or presented at research conferences. The results will also be made available to the school as well as to the parent(s)/guardian(s) of the participants.

I am kindly asking your permission to collect data within your school for the abovementioned experiment.

If you would like more information on my research study, I would be happy to send you a copy of my thesis proposal. Please do not hesitate to contact me by email or by phone if you have any questions.

Thank you for your time,

Annemarie Stigter, BScA
Graduate student School Psychology (MASP)

Appendix B

Letter of Informed Consent

Dear Parent(s)/Guardian(s),

My name is Annemarie Stigter and I am currently a graduate student in the school psychology program at Mount Saint Vincent University. One of the requirements of this program is the completion of a thesis. I am conducting a research study entitled, "*What are the benefits of exercise?" Examining the effects of acute exercise on cognitive functioning in school-aged children and youth.* The purpose of this study is to gain a better understanding of the importance of physical activities and what the effects of exercising are on students. I am interested to study if exercise has an effect on concentration and performance as well as engagement in the classroom. Furthermore, I am interested to find out if exercise results in an increase of response time and processing speed. My goal is to use the results to inform the practice of school psychologists and help foster a collaborative approach on physical activity in school programs. It is important to understand the possible benefits of physical exercise especially for children who are more challenged in their concentration, learning and academic performance.

Your child's school has excellent physical activity programs that would fit very well with the design of my research study. The participants for this study would be either receiving 45 minutes of moderate physical exercise during their scheduled Wellness class, or 4-5 minutes of intense exercise during their class time with the physical education teacher, or no physical exercise other than the regular end of the school day activities. The Wellness class and the short exercises will be facilitated by the school's physical education teacher. If your child is in Grade 6/7, your child will be in the 45-minutes moderate exercise group; if your child is in Grade 8, your child will be randomly assigned to the 4-5-minutes intense exercise or no exercise group.

I would be collecting data through the online game program CogniFit™ that assesses cognitive performance such as problem solving, reaction time, processing speed and executive processing. These games have no known harmful effects but are a rather fun way to assess student's performance. I would also be collecting data through the paper and pencil test Motivation and Engagement Scale that assesses students' motivation and engagement in the classroom. The students will be introduced to the online games on two separate dates. The time allocated for finishing the four games is approximately 30-45 minutes and will be scheduled during regular class time in collaboration with the school's junior head master and teacher(s). The time allocated for finishing the paper and pencil test is approximately 10-15 minutes and will be scheduled during regular class time. The data collected will be kept confidential; first, your child will use his/her student number to get access to the online game implemented through the school for the purpose of the study. For the paper and pencil test students write down their student number. Second, all data accumulated will be stored in a password protected database on a password protected computer.

After data analysis is completed the accumulated data, and any identifiable information, will be destroyed. The results of the study will be published in my thesis report, and possibly in a scientific journal or presented at research conferences. The results will also be made available to the school and to you as the parent(s)/guardian(s) of the participants.

I am kindly asking your permission to have your child participate in the abovementioned experiment. Please confirm by signing the attached consent form.

Thank you very much,

Annemarie Stigter, BScA
Graduate student School Psychology (MASP)

Appendix C

Consent Form

PARENT/GUARDIAN CONSENT FORM

Name of Child: ____

Child's Date of Birth: ____

Name of Parent(s)/
Guardian(s): ____

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I, __________________________________ consent to my child's participation in the experimental study "*What are the benefits of exercise?" Examining the effects of acute exercise on cognitive functioning in school-aged children and youth".* This study is led by Annemarie Stigter, a student in the Master of Arts in School Psychology program at Mount Saint Vincent University. Participation includes doing a 30-45-minute session of online cognitive gaming assessing cognitive processes such as problem solving, reaction time, processing speed and executive processing. Participation also includes spending 10-15-minute completing a paper-based survey about students' motivation and engagement in the classroom, and their personal fitness. The participant will use his/her student number to get access to the online game, and to fill out the questionnaires. These games have no known harmful effects. All data will be kept confidential and stored in a password protected database on a password protected computer. After data analysis is completed the accumulated data will be destroyed. The results of the study will be made available to the school and to parent(s) and/or caregiver(s) through a written debriefing. The results of the study will be published in my thesis report upon graduation from the school psychology program. No identifying information will be reported. Results might further be published in a scientific journal and/or presented at research conferences.

Parent(s)/Guardian(s) signature: ____

Date: ____

Appendix D

Letter of Assent

Dear participants,

My name is Annemarie Stigter and I am currently a graduate student in the school psychology program at Mount Saint Vincent University. For this program I have to conduct a research study. I am curious about the benefits of exercise. The purpose of this study is to better understand if physical activities and students' academic performance are related.

With your school's permission, I am asking you to volunteer to take part. I have also asked your parents and/or caregiver(s) for permission. I want you to know that participation is voluntary, and you always have the right to not participate or stop participating at any time.

Participation includes doing two online games that will take about 30 to 45 minutes. These games help me understand how you solve problems, the speed at which you do things and your self-control. These games are not harmful and might be fun! You will also be asked to complete a paper-based survey that will take about 10 to 15 minutes. This survey will ask you about what motivates you, how engaged you are in your classes and the kinds of physical activities you do. All answers will be kept confidential. This means I will not share any information with anyone. You will use your student number to get access to the online game; you will also use your student number on the paper questionnaires. All this information will be stored in a password protected database on a password protected computer. The results of the study will be discussed with the school in an information session, and to your parent(s) and/or caregiver(s) in a letter. These results will be about the group of students. Your personal results will never be shared or identifiable. The results of the study will be published when I graduate from the school psychology program. Results might also be published in a scientific journal or presented at research conferences.

If you have any questions or concerns, you can address them with your classroom teacher or by contacting me via email.

Thank you very much,

Annemarie Stigter, BScA
Graduate student School Psychology (MASP)

Appendix E

Physical Activity Measurement

Student ID: ____

Gender: M / V (circle your choice)

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How often do you exercise?

- DAILY
- 4 TO 6 TIMES A WEEK
- 1 TO 3 TIMES A WEEK
- NOT AT ALL

How long do you exercise each time you exercise?

- HALF AN HOUR
- BETWEEN HALF HOUR AND 1 HOUR
- BETWEEN 1 TO 2 HOURS
- OTHER: ……….

What type of exercise do you do?

- EASY (i.e. walking the dog)
- MODERATE (i.e. HIKING, BIKING)
- AEROBIC EXERCISE WITH INCREASED HEART RATE

Appendix F

Debriefing for Parents/Teaching team

'What are the benefits of exercise?" Examining the effects of acute exercise on cognitive functioning in school-age children and youth.'

Dear parents and teaching team

Exercise and physical health are important elements of human health. Research has shown that there are positive effects of exercise on cognitive functioning, academic achievement as well as readiness to learn in relation to classroom behavior and engagement (Hillman et al., 2005; Ratey, 2008; Tomporowski, 2008). Therefore, it is important to understand the benefits of physical exercise especially for students who are easily distracted or students who experience challenges with learning and academic performance or students who are not motivated to learn.

The purpose of the study your child/student participated in, was to explore if exercise has a positive effect on cognitive functioning as well as on motivation and engagement in the classroom. My goal was to use the study results to inform the practice of school psychologists and help foster a collaborative approach on physical activity in school programs.

The study aimed to answer three questions: (1) Do students perform better on a cognitive test after a period of exercising? (2) Does acute exercise increase attention, memory, response time and processing speed? (3) Are students more motivated and engaged in the classroom after having exercised? Support was found that exercising increases cognitive functioning as well as attention, memory, processing speed and response time. Specifically, short bouts of intense vigorous exercise had a direct impact on the cognitive domains that were studied resulting in an increase of attention, memory, processing speed and response time. These cognitive domains are essential for core academics and contribute positively to, for instance, reading comprehension, recall of spelling rules as well as math strategies and number concepts. Support was also found for increased motivation and engagement after moderate exercising. According to Ryan and Deci's (2000) theories on motivation, motivation is directly related to engagement and success in school.

These results are believed to be beneficial to help foster a collaborative approach to increase academic performance, as well as classroom behavior and functioning by implementing short bouts of physical activity during school days and by increasing physical activity in school programs. More specifically, knowing that cognitive domains such as attention, memory, processing speed and response time all increase after vigorous bouts of exercise, educators should be informed about these effects as they could use this strategy shortly before a mathematics or literacy assignment is given. In relation to an overall increase of cognitive functioning, teachers should be aware of the effectiveness of longer physical breaks in a moderate exercise condition.

Also, both motivation and engagement increase after moderate exercising and could be a very useful tool in situations where behavior is a concern or in general when educators notice a lack of motivation amongst their students.

If you would like more information, or have any questions or concerns regarding your child's participating in this study, feel free to contact Annemarie Stigter by email or Dr. Daniel Séguin by email or by phone.

Thank you for your contribution to this study. Your child's/student's participation is greatly appreciated, and we hope you found it to be an interesting experience. Results will be made available through the Research system at Mount Saint Vincent University in December 2020.

Appendix G

Debriefing for participants

'What are the benefits of exercise?" Examining the effects of acute exercise on cognitive functioning in school-age children and youth.'

Dear participants

Exercise and physical health are important for our health. Studies have shown that there are positive effects of exercise on learning. Therefore, it is important to understand how physical exercise would help you learn better, especially for students who are easily distracted or students who find school difficult or students who are not motivated to learn.

The purpose of the study you participated in, was to explore if exercise has a positive effect on cognitive functioning as well as on motivation and engagement in the classroom. My goal was to use the study results to inform the practice of school psychologists and help raising awareness for more physical activity in school programs.

With the study I wanted to answer questions such as: (1) Would you do better on a test after a period of exercising? (2) Would you pay more attention, rely better on your memory, have faster response time and processing speed after you have exercised? (3) Would you be more motivated and engaged in the classroom after having exercised? The answers to those questions were all a Yes! I did find support that exercising increases cognitive functioning meaning that you would do better on a test after having exercised. Exercising, specifically the short bouts of intense vigorous exercise, also increases attention, memory, processing speed and response time. These functions are very important for your academic courses and would help with, for instance, easier understand what you are reading, quicker recall of spelling rules as well as math strategies and number concepts. I also found support for increased motivation and engagement after half an hour of moderate exercising. This means that when you are not so motivated to learn, half an hour of exercise would boost your motivation and you would be more engaged in the classroom which would lead to more success at school.

Not only does exercise help you at school, but it can also help you at home when you are working on your schoolwork, and have a hard time to focus. Just go outside or on the treadmill for a 5-minute sprint, or do push-ups and jump-squads, and you will notice a difference in your ability to focus. This exercise would not only help you but would benefit anyone who needs to focus or stay attentive. Therefore, you can share with anyone who is interested, especially your parents, family members and friends, how they can use this strategy whenever they need too.

Thank you for your contribution to this study. I am glad you participated, and I hope you found it to be an interesting experience. If you want more information you can contact me, Annemarie Stigter, by email and I would be happy to answer your questions.