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Sit Less, Move More!? A Pilot Study on the Effectiveness of a National School-Based Physical Activity Program

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Abstract: In recent years, children and adolescents have spent more time sitting and engaging in less physical activity than recommended by health authorities. Despite widespread efforts to promote physical activity through school-based programs, the impact of specific intervention programs often remains untested. Therefore, in this pilot study, the effects of a national school-based physical activity program were assessed. A sample of 80 first- and second-grade primary school students aged between 7 and 9 years (M = 7.95, SD = 0.44) of eight classes was cluster randomly assigned to either the experimental group (EG; classroom-based physical activity breaks) or the control group (CG; conventional school lessons). Primary outcomes included objective measurements of sedentary behaviour, step counts, and moderate-to-vigorous physical activity (MVPA) during the intervention. Secondary outcomes encompassed assessments of aerobic fitness performance, executive functions, academic achievement, and scholastic well-being before and after the 20-week intervention. The results indicate that students of the EG spent less time sedentary and took more steps during school mornings than their counterparts of the CG. The physical activity program resulted in a 630-step increase and a 10-minute reduction in sitting time daily. However, there were no effects on MVPA level, aerobic fitness performance, or cognitive functions (including executive functions and academic achievement). The implications of these findings are discussed in light of comprehensive school physical activity approaches.

Keywords: *Classroom-based physical activity breaks, program effectiveness, cognitive and mental health, moderate-to-vigorous physical activity (MVPA).*

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Introduction

Global trend data shows that children and adolescents' daily routines are increasingly characterised by a lack of physical activity and prolonged sitting (Chaput et al., 2020; Farooq et al., 2020). It has been estimated that 80% of children and adolescents worldwide do not meet the World Health Organization's (2020) recommendation of 60 minutes of moderate-to-vigorous physical activity (MVPA) daily (Guthold et al., 2020). Prolonged sitting has been shown to affect young people's physical and mental health negatively (Biddle, 2019; Zhang et al., 2022). Furthermore, inactivity and irregular physical activity during childhood and adolescence are often linked to inactivity in adulthood (Corder et al., 2019; Telama et al., 2014), which increases the risk of chronic diseases later in life (Kallio et al., 2021). On the other hand, regular physical activity, especially at MVPA levels, can benefit children's and adolescents' health (Rodriguez-Ayllon et al., 2019).

Not merely leisure time but also explicitly school time is characterised by a high amount of sedentary time. Meta-analytical findings indicate that primary school students spend 63% of their school day being sedentary (Egan et al., 2019). This issue is not limited to Anglo-American contexts; a European study also confirms that 63% of school time is

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spent in sedentary activities for children and adolescents (van Stralen et al., 2014). Research indicates that traditional seated lessons fail to fulfil children's requirements for physical activity, as evidenced by higher levels of physical activity during leisure time compared to school hours (Saint-Maurice et al., 2018; Steele et al., 2010). The American Heart Association (Pate et al., 2006) recommends that children and adolescents engage in 30 minutes of MVPA during school hours. The few studies that have objectively measured compliance with this recommendation have shown that only a minority of students adhere to the guidelines for physical activity during school hours (e.g., Grao-Cruces et al., 2018; van Stralen et al., 2014). Schools' potential to increase physical activity opportunities is bolstered by their widespread accessibility to children and adolescents, who dedicate a significant portion of their time to these educational institutions. This assertion is corroborated by research indicating that schools possess unique efficacy in promoting physical activity compared to alternative settings (Naylor & McKay, 2009; van Sluijs et al., 2021).

Systematic reviews show that school-based physical activity interventions can increase students' physical activity levels (Masini et al., 2020) and reduce sedentary time (Hynynen et al., 2016). In addition, school-based physical activity interventions also have the potential to enhance children's aerobic fitness performance (Neil-Sztramko et al., 2021). In physical education, interventions targeting physical activity intensity effectively augment MVPA levels among children and adolescents (Wong et al., 2021). Nonetheless, the evidence regarding enhancing physical activity intensity levels is somewhat less definitive for alternative school-based exercise environments, such as classroom activities or playground activities (Love et al., 2019; Neil-Sztramko et al., 2021).

Classroom-based physical activity interventions that foster physical activity yield favourable outcomes demonstrating promising effects on psychological dimensions, mainly cognitive functions and mental health (Robles-Campos et al., 2023; Watson et al., 2017). In cognitive functions, executive functions (EFs) seem to profit more than other cognitive abilities from additional (cognitively engaging) physical exercises, both in short (Anzeneder, Zehnder, et al., 2023; Jäger et al., 2015; Schmidt et al., 2016) and in long-term (Egger et al., 2019; Mao et al., 2024; Schmidt et al., 2015). EFs encompass the skills children employ to regulate their behaviour, such as establishing goals, managing impulses, and directing attention. Children with well-honed EFs can effectively follow teacher instructions and focus on tasks for extended periods, which is crucial for academic learning (Diamond, 2013). In turn, academic achievement in maths (Sneck et al., 2019) and languages (Martin-Martinez et al., 2023) could also be improved through additional opportunities for physical activity at school, especially knowing that empirically supported models conceive EFs as mediators explaining the relationship between children's physical activity-related outcomes and academic achievement (Schmidt et al., 2017). Positive correlations between EFs and academic achievement have repeatedly been demonstrated (e.g., Spiegel et al., 2022; Willoughby et al., 2019). Concerning mental health outcomes, a meta-analysis examining the influence of interventions within educational settings has unveiled favourable outcomes on students' well-being, resilience, quality of life, and mitigation of anxiety and depression symptoms (Andermo et al., 2020).

Upon closer examination, the attributes of successful school-based physical activity interventions present a varied landscape: Daly-Smith et al. (2021) suggest that the emphasis on promoting physical activity typically centres around integrating physical activity into the classroom environment, with a particular focus on incorporating physical activity breaks or movement-based learning activities. Physical activity breaks hold promise for influencing students' mental and physical health. According to Kuzik et al. (2022), active lessons were most beneficial for health and well-being. A review summarising the outcomes of healthy and physically active school initiatives across Europe highlights the positive effects of physical activity breaks, typically facilitated by teachers during lessons and lasting 5-10 minutes each. The evidence supporting their efficacy is strong in this context (Bailey et al., 2022).

In summary, the referenced findings indicate that school-based physical activity interventions have a broad potential impact. By integrating physical activity into everyday school life and, above all, into the classroom, positive changes can be achieved in terms of physical health and various aspects of cognitive functions and mental well-being among students. Promoting physical activity in schools thus provides a compelling case for promoting physical health and represents a pertinent argument for schools regarding its positive influence on cognitive functions. Strengthening EFs through additional physical activity breaks can significantly improve learning behaviour, increase cognitive functions, and improve overall academic performance (Sember et al., 2020) – despite the supposedly "lost time" in a subject. Therefore, integrating physical activity into the school day aligns with holistic education and may offer short- and long-term benefits for children and adolescents.

Regardless of these potential benefits, the effects of ecologically valid school-based physical activity interventions are rarely assessed in longitudinal studies, highlighting a need for more rigorous evaluations of their effectiveness (Masini et al., 2022). In this regard, Vazou et al. (2020) formulated the question of whether practical, experience-based programs can impact students' physical and cognitive performances in the same way as theory-based approaches. Therefore, the aim of the present study was to pilot a trial investigating the effectiveness of Switzerland's largest school-based physical activity promotion initiative.

Schule bewegt [School in Motion] is an example of a program grounded in practical experience rather than theoretical frameworks. The national program is widely accepted by elementary school teachers and involves around 150'000 students. Providing a large collection of ideas for classroom-based physical activity breaks and free materials encourages teachers to integrate at least 20 minutes of physical activity breaks each day in addition to the three mandatory physical education lessons per week. Despite substantial investments from the federal government and numerous other supporters, the program has only been evaluated once, using an online survey administered to teachers and their students. On the one hand, the students' survey results indicated that the program may positively influence students' subjective well-being and attention (Feller et al., 2021). However, since it was a survey, students' physical activity behaviour and cognitive performance could not be objectively measured with the gold standard methods, such as accelerometry or reaction-based cognitive tests. On the other hand, the teacher survey revealed that teachers with a high affinity for sports were the primary users of the program. Only 45% of the teachers enrolled in the program implemented the daily physical activity breaks, while a third did so only once a week or less. To complement this initial program evaluation of students' and teachers' self-report with objective data, the present study aimed to pilot an effective trial of the "*Schule bewegt*" program by measuring primary outcomes, such as sedentary and physical activity behaviour and secondary outcomes, such as cognitive functions, academic achievement and scholastic well-being.

Methodology

Research Design

This pilot study adopts a quasi-experimental intervention design featuring two distinct groups: an experimental group (EG) and a waiting control group (CG). The students of the EG engaged in two sessions of 10-minute physical activity breaks daily over 20 weeks. Before the intervention, teachers of the EG (n = 4) attended a 2.5-hour training session to ensure standardised instruction of the classroom-based physical activity breaks. Meanwhile, the CG (n = 4) maintained participation in conventional school lessons without incorporating physical activity breaks. The primary outcome variable, objectively measured physical activity behaviour (including sedentary behaviour, step counts, and MVPA), was assessed over five consecutive days during weeks seven and ten of the intervention. Data collection for secondary outcome variables (including EFs, academic achievement, and scholastic well-being) occurred before and after the 20-week intervention. Background variables (see Table 1) were collected during the pre-testing.

Participants

Teachers and principals were directly approached to recruit participants for the study, enrolling 92 students from eight mixed first- and second-grade classes. Only second graders were included in the sample to ensure greater age homogeneity. The data of six students were removed from the sample due to one or more absences at the pre- or post-measurement. A further six students were excluded due to invalid data in the physical activity measurement. The final sample comprised 80 students aged between 7 and 9 years (M = 7.95 years, SD = 0.44; 42.5% girls). Taking previous studies into account, an a priori power analysis (with 1 - beta error probability = .80; alpha error probability = .05; effect size f = .38; numerator of df = 3; number of groups = 2; number of covariates = 1) was conducted. This resulted in a total sample size of N = 80 subjects. An overview of the descriptive characteristics of the study participants can be found in Table 1. The eight classes were randomly assigned to either the EG or the CG. The EG and CG did not exhibit statistically significant differences in all measured background variables (ps > .05). A significant difference between the two groups emerged in terms of gender distribution ($\chi^2(1) = 6.02$, p = .020, Cramer's V = .274). The CG demonstrated a notably higher proportion of boys (8%) than the EG (40%). All secondary outcome variables did not differ between the groups at pre-measurement (ps > .05). However, a significant difference was observed in aerobic fitness performance between the two groups. Specifically, students in the CG exhibited significantly superior aerobic fitness performance compared to the EG at pre-measurement (F(1, 79) = 27.47, p < .001, η_p^2 = .26).

Instruments

Sedentary behaviour, step counts and MVPA were objectively measured utilising accelerometers (Actigraph GT3X; Pensacola, FL) positioned on the right hip (Rowlands et al., 2014). An epoch length of 15 seconds was designated for the analyses (Edwardson & Gorely, 2010). MVPA was determined using the algorithm developed by Freedson et al. (2005), as employed in the SOPHYA study (Bringolf-Isler et al., 2016). Students wore the accelerometer continuously for eight consecutive days. Due to known reactivity to accelerometer measurement in young children (Dösegger et al., 2014), the first measurement day was excluded from data analysis. Consequently, the time between 08:00-12:00 a.m. on five consecutive school mornings was included in all analyses of the present study.

Aerobic fitness performance was measured using the multistage 20-metre shuttle run test (Léger et al., 1988). The reliability and validity of the 20-metre shuttle run test have been demonstrated (Liu et al., 1992). The value reflects the duration of the run in minutes.

The three domains of EFs – working memory, inhibition, and cognitive flexibility (Miyake et al., 2000) – were measured through tablet-based assessments utilising the E-Prime software (Psychology Software Tools, Pittsburgh, PA). Working memory was assessed with the colour span backward task (Roebers & Kauer, 2009; Schmid et al., 2008). The total number of correctly recalled trials was used as the dependent measure. Acceptable test-retest reliabilities are available for a younger age group (Schmid et al., 2008). Inhibition and cognitive flexibility were assessed using a flanker task (Eriksen & Eriksen, 1974), adapted from Röthlisberger et al. (2012). Reaction times in milliseconds were calculated as the dependent measure for inhibition and cognitive flexibility (Egger et al., 2019). The split-half correlations for congruent and incongruent reaction times are r = .80-.83 (Stins et al., 2005).

Standardised academic achievement tests were used to assess academic performance in mathematics, reading, and spelling: The *Heidelberg Arithmetic Test 1-4* [Heidelberger Rechentest 1-4] (Haffner et al., 2005) records the level of performance in the subject area of maths. The retest reliability is r_{tt} = .69-.89. The *Salzburg Reading Screening 1-4* [Salzburger Lesescreening 1-4] (Mayringer & Wimmer, 2003) measures basic reading skills as required in a natural reading context. The parallel test reliability for Year 2 is r = .92. The *Hamburg Writing Sample 1-10* [Hamburger Schreib-Probe 1-10] (May et al., 2018) measures learners' spelling and basic spelling strategies. The retest-reliability of the *Hamburg Writing Sample* for the grapheme hits is r_{tt} = .97. The values calculated according to the manual were used in each case, representing the T-values for the grapheme hits.

One of the six constructs of the scholastic well-being questionnaire by Hascher (2004) assessed students' positive attitudes towards school (three items, e.g., "I enjoyed going to school"). The scale's internal consistency was α = 0.83 (Hascher, 2004).

The PAQ-C Questionnaire (Kowalski et al., 2004) was employed to assess the self-rated MVPA level of students throughout the school year. This instrument has demonstrated validity and reliability in measurement. Accordingly, all item-scale correlations are above .30, and the scale reliability was acceptable for both genders (α = .80-.83) (Crocker et al., 1997).

Socioeconomic status (SES) was assessed using the Family Affluence Scale II (Boudreau & Poulin, 2009). Information on the goodness criteria can be found in Schnohr et al. (2013).

To calculate the body mass index (BMI), weight (in kilograms) was divided by the square of height (in metres), accounting for sex and age (Himes, 2009). The data used to assess the BMI are based on reference values from a large sample of German children (Kromeyer-Hauschild et al., 2001).

Procedure

In the EG (n = 30), children engaged in two 10-minute physical activity breaks daily. These breaks were derived from the physical activity promotion program known as "*Schule bewegt*". Teachers facilitated the implementation of these breaks using the module cards provided. The selection of specific physical activities during the breaks, as outlined by the program's guidelines, was determined by the students, the teacher, or randomly. The module cards encompassed exercise breaks categorised into six areas: bone strengthening, endurance training, muscle strengthening, mobility exercises, relaxation techniques, and dexterity activities. Throughout the 20-week intervention period, the teachers of the EG classes administered the daily physical activity breaks. During this intervention phase, the EG teachers diligently completed a daily self-report detailing the frequency and precision of implementation, serving as a form of treatment control. The students within the CG (n = 50) followed regular school lessons without specifically staged physical activity breaks.

During the pre- and post-measurements, at least two supervisors were present at all assessments and were responsible for conducting standardised verbal instructions at the outset of each test session. Assessments were conducted in different settings: tests related to EFs and background questionnaire variables were administered in a dedicated room for groups of four students; academic achievement and scholastic well-being were assessed within the classroom; and aerobic fitness performance was evaluated in the gym.

Data Analyses

Statistical analyses were performed with SPSS 28.0 (SPSS Inc., Chicago, IL, USA). The analyses were carried out in several steps: (1) Firstly, the data set was adjusted for missing data and checked for outliers using Mahalanobis distance (Fidell & Tabachnik, 2003). (2) The two study groups were then analysed for baseline differences using independent t-tests. (3) Descriptively, all measured variables mean values and standard deviations of the CG and EG were determined and are presented in Table 1. (4) As the prerequisites for a multilevel analysis were not fulfilled (only eight classes at the context level; Hox et al., 2018), the primary outcome variables (sedentary behaviour, step counts and MVPA level) were analysed using separate ANOVAs. (5) The changes between the pre- and post-measurement of the secondary outcome variables were analysed using separate analyses of covariance. The pre-measurement value of each variable was used as the covariate. (6) A significance level of $p < .05$ was set for all tests. The partial Eta-square and Cohen's d were used to estimate the effect size.

Results

Preliminary Analyses

During the 20-week intervention, out of the planned 200 physical activity breaks of two 10-minute sessions per day, the teachers carried out an average of M = 120 physical activity breaks, corresponding to an average implementation rate of 60%. The implementation rate was significantly higher in the first half of the intervention (M = 70.76; SD = 14.26) than in the second half (*M* = 49.24; *SD* = 13.61). The lowest implementation rate was 88, and the highest was 163 physical activity breaks. In terms of treatment fidelity, the teachers reported that, on average, they were able to implement the physical activity breaks almost precisely as described in the module cards (*M* = 3.70, *SD* = 0.21; on a 4-point Likert scale from 1 = not at all to 4 = precisely as described).

Main Analyses

Table 1 presents the means and standard deviations for all variables. Analysis of the primary outcome variables (see Figure 1) reveals that students in the EG spend significantly less time sitting ($F(1, 79) = 9.95$, $p = .002$, $\eta_p^2 = .113$) and have a significantly higher average number of step counts compared to the CG ($F(1, 79) = 13.03$, $p < .001$, $\eta_p^2 = .143$). Although EG students exhibit a higher level of MVPA descriptively, this difference is not statistically significant ($F(1, 79) = 3.58$, $p = .062$, $\eta_p^2 = .044$).

Table 1. Means and Standard Deviations of All Variables Separated by Both Study Groups.

All variables	**CG** *n* = 50	**EG** *n* = 30
	M (SD)	***M (SD)***
Background variables		
Age [in years]	8.04 (0.49)	7.83 (0.39)
Gender [girls/boys]	16/34	18/12
Socioeconomic status [0-9]	7.14 (1.59)	6.63 (1.21)
BMI [kg/m^2]	16.19 (2.07)	16.23 (2.98)
Self-reported PA level [1-5]	2.91 (0.59)	3.03 (0.64)
Sedentary behaviour and physical activity		
Average of sedentary behaviour [in minutes[a]]	181.25 (11.97)	171.86 (14.32)
Average of step counts[a]	3028.16 (680.19)	3659.53 (872.19)
Average time of MVPA level [in minutes[a]]	9.86 (2.86)	11.08 (2.68)
Executive functions (EFs)		
Pre-test		
Working memory [accuracy]	3.14 (0.35)	3.30 (0.53)
Inhibition [reaction time[b]]	123.34 (243.60)	139.89 (122.33)
Cognitive flexibility [reaction time[b]]	535.97 (349.06)	582.88 (327.92)
Post-test		
Working memory [accuracy]	3.39 (0.63)	3.53 (0.77)
Inhibition [reaction time[b]]	87.34 (94.31)	103.26 (93.32)
Cognitive flexibility [reaction time[b]]	345.52 (169.53)	380.59 (155.51)
Academic achievement		
Pre-test		
Mathematics	51.63 (6.29)	52.45 (6.36)
Spelling	52.48 (3.44)	53.09 (6.52)
Reading	104.24 (13.66)	102.66 (14.09)
Post-test		
Mathematics	57.31 (7.64)	55.96 (5.48)
Spelling	55.48 (4.43)	57.09 (4.33)
Reading	107.03 (18.04)	107.32 (14.87)
Fitness performance		
Pre-test		
Aerobic fitness performance [in minutes]	5.99 (1.63)	3.66 (2.34)
Post-test		
Aerobic fitness performance [in minutes]	6.24 (2.15)	5.01 (2.23)
Mental health		
Pre-test		
Scholastic well-being [1-4]	3.37 (0.58)	3.44 (0.50)
Post-test		
Scholastic well-being [1-4]	3.21 (0.47)	3.43 (0.40)

[a]Average of five consecutive school mornings from 08:00 to 12:00 a.m. [b]Reaction times measured in milliseconds.

For the secondary outcome variables, individual ANCOVAs revealed no significant differences between the two study groups regarding aerobic fitness performance, EFs, or academic achievement (see Table 2). However, a significant difference was found in scholastic well-being. Specifically, while participants in the CG showed a decline in scholastic well-being after 20 weeks, those in the EG maintained stable levels of well-being throughout the intervention.

Table. 2. Inferential Statistics of the Four Separate ANCOVAs Regarding the Secondary Outcome Variables Fitness Performance, EFs, Academic Achievement, and Scholastic Well-Being at Pre- and Post-Test for the Two Groups.

Secondary outcome variables	***F***	***p***	**η_p^2**
Fitness performance			
Aerobic fitness performance	1.06	.309	.014
Executive functions (EFs)			
Working memory	0.44	.510	.006
Inhibition	0.48	.492	.006
Cognitive flexibility	0.68	.413	.009
Academic achievement			
Mathematics	3.95	.050	.050
Spelling	3.34	.072	.043
Reading	0.85	.359	.011
Mental health			
Scholastic well-being	4.64	.034*	.057

*$p < .05$

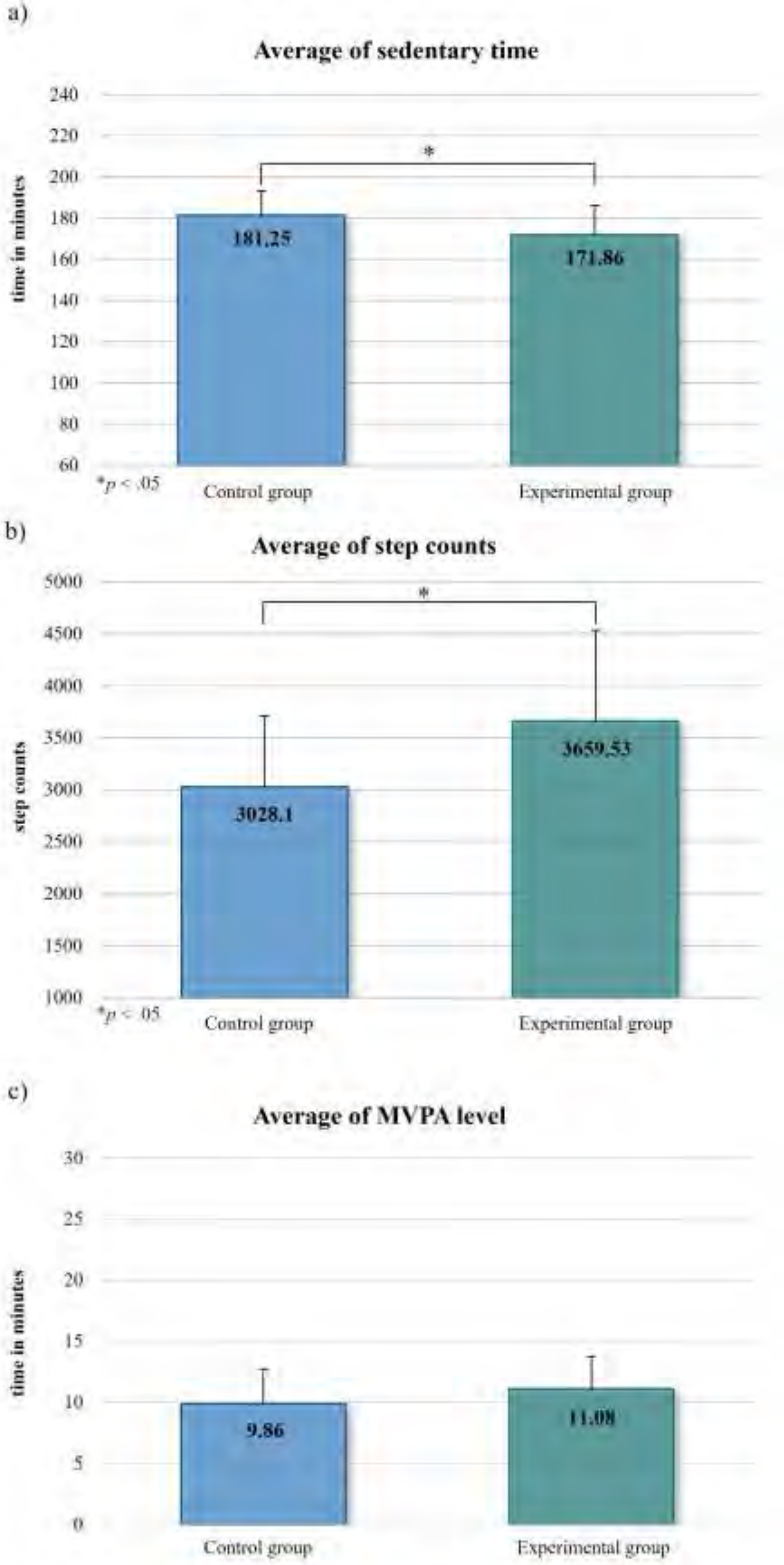

Figure 1. The Means and Standard Deviations for the Three Primary Outcome Measures a) Average of Sedentary Time, b) Average of Step Counts, and c) Average of MVPA Level During the Intervention Are Presented as Averages Over Five Consecutive School Mornings From 8:00 to 12:00 a.m.

Discussion

The pilot study aimed to examine the effectiveness of the Swiss physical activity program *Schule bewegt*. Over 20 weeks, students in the EG engaged in two daily 10-minute classroom-based physical activity breaks. The primary outcome measures included sedentary behaviour, step counts and MVPA level. Secondary outcomes focused on aerobic fitness performance, cognitive performance (including EFs and academic achievement), and scholastic well-being before and after the intervention. The results revealed significant differences between the CG and the EG regarding reduced sedentary behaviour and increased step counts. However, no significant differences were found in MVPA levels. The intervention did not significantly affect cognitive function, as measured by EFs and academic achievement. The program helped maintain existing levels of scholastic well-being, preventing a decline typically observed towards the end of the school year. A detailed discussion of these findings follows in the subsequent section.

Sedentary Behaviour, Step Counts, and MVPA

The results of the present study indicate that students of the EG spent 10 minutes less sedentary and took 630 more steps during school mornings than their counterparts of the CG. In general, the findings of reduced sedentary behaviour and enhanced step counts in the EG align with two recent reviews (Daly-Smith et al., 2018; Masini et al., 2020), which also found a decrease in sedentary behaviour and an increase in physical activity for students due to classroom-based physical activity breaks such as hole-body movements behind a desk. Similar exercises are included in the program and thus explain the two positive results found in favour of the experimental group. Although the program guidelines recommended that teachers conduct 20 minutes of physical activity breaks daily, sitting time was reduced by only 10 minutes compared to the control group. This outcome may be explained by the fact that the physical activity breaks were implemented only 60% of the time. In the second half of the intervention period, the average was even below 50%. Both the frequency of implementation observed in this study and the existing evaluation by Feller et al. (2021) indicate a decline in the use of the program over time, suggesting a lack of sustainable implementation. Therefore, it is uncertain whether the positive effects will persist after the intervention ends, as other studies suggest that the effects disappear or diminish following a guided implementation (Bailey et al., 2020; Hynynen et al., 2016).

The study found no significant differences in MVPA levels between the EG and CG, indicating that the current content of the *Schule bewegt* program does not effectively enhance aerobic fitness in students. On average, students in the EG engaged in MVPA for similar durations during school mornings as those in the CG. This explains the two groups' lack of improvement in aerobic fitness performance. This finding aligns with previous reviews and meta-analyses, such as those by Love et al. (2019) and Neil-Sztramko (2021), which suggest that school-based physical activity interventions have limited effects on increasing MVPA levels. However, other recent reviews highlight that classroom-based physical activities can significantly improve MVPA, including higher-intensity exercises (Amor-Barbosa et al., 2022; Masini et al., 2020; Peiris et al., 2022). For example, Peiris et al. (2022) found that effective interventions, often lasting 5 to 9 weeks with daily activities of 10 to 15 minutes, featured light jogging followed by high-intensity exercises like skipping, jumping, and running in place (e.g., Drummy et al., 2016). To enhance MVPA levels, it is crucial to modify the content of physical activity breaks in the classroom to include more vigorous exercises. Currently, the *Schule bewegt* program focuses mainly on low to medium-intensity activities. By incorporating a greater variety of activities that promote MVPA, the program could increase physical activity intensity and help meet the recommended 30 minutes of daily physical activity during school hours. Additionally, introducing physical activity breaks outside the classroom, such as in playgrounds, could provide more opportunities for higher-intensity exercises. For example, Lubans et al. (2022) recommend incorporating brief but vigorous activities to elevate MVPA levels among children and adolescents.

Another, more comprehensive approach to increasing MVPA levels through school-based physical activity programs is proposed by Beets et al. (2016): This approach aims to (a) broaden school-based physical activity opportunities, (b) prolong existing opportunities, and (c) optimise them to impact the physical activity levels of children and adolescents positively. In the KISS study (Kriemler et al., 2011), a physical activity program was developed according to this approach, which expanded the array of activities available by introducing additional physical activity breaks in the classroom, extended the duration of physical education lessons, and enhanced quality through the involvement of trained physical education teachers. The outcomes are promising, as the program has enhanced MVPA levels and aerobic fitness performance. Thus, within the school environment, the program *Schule bewegt* should expand physical activity opportunities – such as active learning approaches, actively commuting to and from school, and active breaks – to bolster MVPA (Jones et al., 2020) and potentially improve children's aerobic fitness performance.

Cognitive Performance

The findings regarding cognitive performance, including EFs and academic achievement, show a dichotomy. While the 20-week physical activity break intervention did not positively affect any of the six cognitive measures (working memory, inhibition, cognitive flexibility, mathematics, spelling, reading) assessed, this result contradicts subjective assessments reported by Feller et al. (2021), which anticipated improvements in attention performance due to the *Schule bewegt* program. However, these results are not entirely surprising, as studies showing positive effects on children's cognitive functions through physical activity breaks typically use specific interventions designed to enhance cognitive functions

(Masini et al., 2020). For example, Egger et al. (2019) demonstrated that targeted physical activity breaks incorporating physical and cognitive challenges led to improved students' EFs. Traditionally, physical and cognitive activities are approached separately in school settings, but emerging recommendations suggest integrating physical activity with learning content to maximise cognitive function outcomes (Mavilidi et al., 2018). For instance, combining movement with learning, such as in language acquisition, can enhance academic achievement by creating strong memory traces and improving recall (Madan & Singhal, 2012; Schmidt et al., 2019). Therefore, cognitive performance cannot be improved solely through generic physical breaks, as included in the current program. Instead, enhancements in cognitive function require either cognitively demanding physical breaks with appropriate difficulty levels (Anzeneder, Benzing et al., 2023; Egger et al., 2018; Jäger et al., 2015), optimal dosages of activity (Anzeneder, Zehnder et al., 2023; Pesce et al., 2013), or task-relevant movements (Mavilidi et al., 2018).

Scholastic Well-Being

The descriptive findings on scholastic well-being indicate that students in both study groups reported high comfort levels at school. However, a significant decline in scholastic well-being was observed among CG students between the pre-and post-measurements. This decline could be attributed to the timing of the second measurement, conducted in June, shortly before the end of the school year. It is likely that overall school fatigue towards the end of the academic year, compared to six months before the Christmas holidays, contributed to this decrease. Hascher et al. (2011) have shown that fluctuations in scholastic well-being can occur over a school year. Additionally, Schüpbach et al. (2016) found a slight decline in positive attitudes toward school, particularly in the first two years of schooling. This could further explain the decrease in scholastic well-being among CG students.

In contrast, EG students' sustained high levels of scholastic well-being over the 20 weeks could be attributed to the physical activity breaks. Systematic reviews by Papadopoulos et al. (2022) and Rafferty et al. (2016) suggest that school-based physical activity interventions can positively impact well-being. Holt et al. (2019) also found that the effective implementation of physical activity interventions can enhance well-being at school, particularly when students are allowed to have a say in the content of physical activities, as suggested by self-determination theory (Deci & Ryan, 2000), and when intergroup competition is not introduced. In this study, students in the EG were allowed to co-determine the physical activity breaks, enhancing their sense of autonomy. Although this did not increase well-being – possibly due to a ceiling effect – it contributed to maintaining their well-being.

Implementation of Intervention

Consistent and sustained implementation of interventions or programs is vital for achieving positive outcomes (Bailey et al., 2020). However, the current study found that despite teachers being instructed to conduct and document physical activity breaks daily, they did so only about 60% of the time on average. Moreover, the frequency of these breaks declined to below 50% in the latter half of the intervention period. Similar findings were reported by Feller et al. (2021), where only 45% of teachers who committed to conducting daily physical activity breaks in the *Schule bewegt* program did so regularly, and over 20% implemented them less than once a week. These findings suggest that the effects observed in this study regarding sedentary behaviour and physical activity might not be replicated in real-world settings, as sustained and consistent implementation by teachers is challenging.

Despite these challenges, teachers play a crucial role in ensuring the long-term success of such programs (Daly-Smith et al., 2021). In the current program, while there is material support like ideas and movement materials for children, additional support for teachers is lacking. A review focusing on implementing physical activity interventions from a teacher's perspective highlights time constraints and the quality and availability of physical activity ideas as the main barriers. Furthermore, teachers seek support from school administration based on a shared vision when trying to integrate more physical activity into their daily routines (Naylor et al., 2015). To achieve this, appropriate training and ongoing support for teachers and school staff are essential to ensure the sustainable implementation of school-based physical activity programs (McMullen et al., 2022).

Conclusion

In conclusion, this study highlights the importance of the content and consistent implementation of school physical activity programs. The *Schule bewegt* program, while effective in reducing sedentary behaviour and maintaining scholastic well-being, did not significantly impact MVPA levels or cognitive performance, indicating that adjustments in the intensity and integration of additional physical activities are necessary. The findings suggest that the program's physical activity breaks need to incorporate higher-intensity exercises and cognitively engaging tasks to achieve broader benefits, such as improved aerobic fitness and cognitive function. Furthermore, the study underscores the critical role of teachers in sustaining these interventions and the need for comprehensive support, including adequate resources and administrative backing, to ensure effective program implementation. For future interventions, enhancing teacher training and providing continuous support could be key strategies to optimise the success and sustainability of school-based physical activity programs.

Recommendations

Based on the study's findings, several recommendations can be made to enhance the effectiveness of the *Schule bewegt* program and promote physical activity in schools more broadly.

Firstly, the program should diversify the types of physical activities it includes to meet better the recommended 30 minutes of MVPA during school hours. This can be achieved by incorporating a broader range of activities, such as active learning, structured physical activity breaks, walking initiatives, and additional sports programs before and after school (Beets et al., 2016). High-intensity interval training programs, in particular, have been shown to enhance aerobic fitness significantly (da Silva Bento et al., 2021) and mental health outcomes (Leahy et al., 2020) and should be considered for integration into the program.

Secondly, to improve cognitive outcomes, physical activities should be tailored to include cognitive challenges. This can be accomplished by designing activities that incorporate cognitive tasks with appropriate difficulty levels (e.g., Egger et al., 2018), ensuring optimal dosage (e.g., Anzeneder, Zehnder et al., 2023), or involving task-relevant movements (e.g., Mavilidi et al., 2018). Such modifications could enhance cognitive functions, including executive functions, and improve overall academic achievement.

Thirdly, for the program to be effective, consistent and sustained implementation is crucial (Webster et al., 2015). This requires the involvement of school management and other staff to embed physical activity into teachers' daily routines, thereby increasing acceptance and sustainability within the school environment. Designating physical activity leaders, typically physical education teachers can provide essential support and guidance to all stakeholders, ensuring long-term program success (Stoepker et al., 2020). In Switzerland, mainly, physical activity programs are often implemented at the level of individual classes rather than at the school level; thus, adopting a comprehensive, multi-component approach similar to the *Comprehensive School Physical Activity Program* (CSPAP) implemented in the United States could enhance the effectiveness and sustainability of physical activity initiatives (Kuhn et al., 2021; Sutherland et al., 2016). This approach, which involves various school settings and stakeholders, has successfully promoted and intensified physical activity in schools in other countries and could serve as a model for future programs.

Lastly, schools require context-specific support to implement and maintain these programs effectively. This support might include financial resources, such as compensating physical activity leaders, providing specialised teacher training, equipping playgrounds, and engaging experts from the sports and health sectors (Carson et al., 2014; Webster et al., 2015). By adopting a holistic and systemic approach involving the entire school community, including students, schools can foster a culture of lifelong physical activity, ultimately contributing to the long-term health and well-being of children and adolescents.

Limitations

The present study has several limitations that should be noted. First, participant randomisation was conducted at the class level, a common practice in school-based research. Due to time constraints during testing and the substantial demands on participating children, the evaluation of potential confounding factors had to be limited. As a result, essential variables such as disability or language status were not thoroughly assessed. Although teachers were asked in advance about any disabilities or language deficits among participants, this method may not have fully captured these variables. Additionally, objective physical activity was measured over only five consecutive school mornings rather than across the entire intervention period. This limited timeframe may not fully represent students' sedentary behaviour, step counts, and MVPA levels throughout the program. Teachers' awareness about when students wore the Actigraphs could also have led to reactivity effects, potentially causing more consistent implementation of physical activity breaks and resulting in data that might overestimate actual levels of sedentary behaviour and physical activity. Furthermore, randomisation at the class level resulted in uneven group sizes, which could affect the robustness of the findings. However, ANCOVA is generally resilient to differences in group sizes, provided that the assumptions of homogeneity are met (e.g., Howell, 2020; Montgomery, 2013). Lastly, the study only measured outcomes at the pre- and post-intervention stages. Including follow-up assessments would have been more effective in evaluating the sustainability of the program's effects. Future research should incorporate additional follow-up assessments to better understand the long-term impacts and sustainability of school-based physical activity programs.

Ethics Statements

The Faculty of Human Sciences of the University of Bern Ethics Committee has reviewed the ethics application (Nr. 2015-7-1314769) and classified the study described therein as ethically unobjectionable. To obtain the consent of the students for the effectiveness evaluation, the research team personally informed each class about the project. Subsequently, an information letter, including a consent form, was provided to take home. The form allowed separate consent for participation in accelerometry, the EFs and academic achievement tests, the 20-metre shuttle run test, and the student questionnaire. As the students were not of legal age, the form had to be signed by the parents or legal guardians and returned to the teacher within two weeks. The teacher then forwarded the completed forms to the research team. To treat participants' data confidentially, each participant was assigned an individually chosen participant code, which was used for data collection purposes. All participants also had the right to withdraw from the study at any time at their discretion.

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Conflict of Interest

There is no conflict of interest.

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Authorship Contribution Statement

Egger: Conceptualization, design, data acquisition, data analysis, statistical analysis, writing, final approval. Gasser: Writing, editing. Kamer: Writing, editing, critical revision of manuscript. Schmidt: Supervision, reviewing, critical revision of manuscript.

References

Amor-Barbosa, M., Ortega-Martínez, A., Carrasco-Uribarren, A., & Bagur-Calafat, M. C. (2022). Active school-based interventions to interrupt prolonged sitting improve daily physical activity: A systematic review and meta-analysis. *International Journal of Environmental Research and Public Health, 19*(22), Article 15409. https://doi.org/10.3390/ijerph192215409

Andermo, S., Hallgren, M., Nguyen, T.-T.-D., Jonsson, S., Petersen, S., Friberg, M., Romqvist, A., Stubbs, B., & Elinder, L. S. (2020). School-related physical activity interventions and mental health among children: A systematic review and meta-analysis. *Sports Medicine - Open*, *6*, Article 25. https://doi.org/10.1186/s40798-020-00254-x

Anzeneder, S., Zehnder, C., Martin-Niedecken, A. L., Schmidt, M., & Benzing, V. (2023). Acute exercise and children's cognitive functioning: What is the optimal dose of cognitive challenge? *Psychology of Sport and Exercise*, *66*, Article 102404. https://doi.org/10.1016/j.psychsport.2023.102404

Anzeneder, S., Zehnder, C., Schmid, J., Martin-Niedecken, A. L., Schmidt, M., & Benzing, V. (2023). Dose-response relation between the duration of a cognitively challenging bout of physical exercise and children's cognition. *Scandinavian Journal of Medicine and Science in Sports, 33*(8), 1439–1451. https://doi.org/10.1111/sms.14370

Bailey, D. H., Duncan, G. J., Cunha, F., Foorman, B. R., & Yeager, D. S. (2020). Persistence and fade-out of educational-intervention effects: Mechanisms and potential solutions. *Psychological Science in the Public Interest*, *21*(2), 55–97. https://doi.org/10.1177/1529100620915848

Bailey, R., Vašíčková, J., Vlček, P., Raya Demidoff, A., Pühse, U., Heck, S., & Scheuer, C. (2022). *An international review of the contributions of school-based physical activity, physical education, and school sport to the promotion of health-enhancing physical activity*. Zenodo. https://doi.org/10.5281/ZENODO.5899571

Beets, M. W., Okely, A., Weaver, R. G., Webster, C., Lubans, D., Brusseau, T., Carson, R., & Cliff, D. P. (2016). The theory of expanded, extended, and enhanced opportunities for youth physical activity promotion. *The International Journal of Behavioral Nutrition and Physical Activity*, *13*, Article 120. https://doi.org/10.1186/s12966-016-0442-2

Biddle, S. J. H., Ciaccioni, S., Thomas, G., & Vergeer, I. (2019). Physical activity and mental health in children and adolescents: An updated review of reviews and an analysis of causality. *Psychology of Sport and Exercise, 42*, 146–155. https://doi.org/10.1016/j.psychsport.2018.08.011

Boudreau, B., & Poulin, C. (2009). An examination of the validity of the Family Affluence Scale II (FAS II) in a general adolescent population of Canada. *Social Indicators Research*, *94*, 29–42. https://doi.org/10.1007/s11205-008-9334-4

Bringolf-Isler, B., Probst-Hensch, N., Kayser, B., & Suggs, S. (2016). *Schlussbericht zur SOPHYA-Studie [Final report on the SOPHYA study]*. Swiss tropical and public health institute. https://bit.ly/3MFskWj

Carson, R. L., Castelli, D. M., Beighle, A., & Erwin, H. (2014). School-based physical activity promotion: A conceptual framework for research and practice. *Childhood Obesity*, *10*(2), 100–106. https://doi.org/10.1089/chi.2013.0134

Chaput, J.-P., Willumsen, J., Bull, F., Chou, R., Ekelund, U., Firth, J., Jago, R., Ortega, F. B., & Katzmarzyk, P. T. (2020). 2020 WHO guidelines on physical activity and sedentary behaviour for children and adolescents aged 5-17 years:

Summary of the evidence. *International Journal of Behavioral Nutrition and Physical Activity, 17*, Article 141. https://doi.org/10.1186/s12966-020-01037-z

Corder, K., Winpenny, E., Love, R., Brown, H. E., White, M., & van Sluijs, E. (2019). Change in physical activity from adolescence to early adulthood: A systematic review and meta-analysis of longitudinal cohort studies. *British Journal of Sports Medicine, 53*(8), 496–503. https://doi.org/10.1136/bjsports-2016-097330

Crocker, P. R. E., Bailey, D. A., Faulkner, R. A., Kowalski, K. C., & McGrath, R. (1997). Measuring general levels of physical activity: Preliminary evidence for the Physical Activity Questionnaire for Older Children. *Medicine and Science in Sports and Exercise*, *29*(10), 1344–1349. https://doi.org/10.1097/00005768-199710000-00011

Daly-Smith, A. J., Zwolinsky, S., McKenna, J., Tomporowski, P. D., Defeyter, M. A., & Manley, A. (2018). Systematic review of acute physically active learning and classroom movement breaks on children's physical activity, cognition, academic performance and classroom behaviour: Understanding critical design features. *BMJ Open Sport and Exercise Medicine, 4*(1), Article e000341. https://doi.org/10.1136/bmjsem-2018-000341

Daly-Smith, A., Morris, J. L., Norris, E., Williams, T. L., Archbold, V., Kallio, J., Tammelin, T. H., Singh, A., Mota, J., von Seelen, J., Pesce, C., Salmon, J., McKay, H., Bartholomew, J., & Resaland, G. K. (2021). Behaviours that prompt primary school teachers to adopt and implement physically active learning: A meta synthesis of qualitative evidence. *International Journal of Behavioral Nutrition and Physical Activity*, *18*, Article 151. https://doi.org/10.1186/s12966-021-01221-9

da Silva Bento, A. F. P., Páez, L. C., & de Mendonça Raimundo, A. M. (2021). School-based high-intensity interval training programs for promoting physical activity and fitness in adolescents: A systematic review. *Journal of Teaching in Physical Education*, *41*(2), 288–300. https://doi.org/10.1123/jtpe.2020-0187

Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry*, *11*(4), 227–268. https://doi.org/10.1207/S15327965PLI1104_01

Diamond, A. (2013). Executive Functions. *Annual Review of Psychology*, *64*, 135–168. https://doi.org/10.1146/annurev-psych-113011-143750

Dösegger, A., Ruch, N., Jimmy, G., Braun-Fahrländer, C., Mäder, U., Hänggi, J., Puder, J. J., Kriemler, S., & Bringolf-Isler, B. (2014). Reactivity to accelerometer measurement of children and adolescents. *Medicine and Science in Sports and Exercise*, *46*(6), 1140–1146. https://doi.org/10.1249/MSS.0000000000000215

Drummy, C., Murtagh, E. M., McKee, D. P., Breslin, G., Davison, G. W., & Murphy, M. H. (2016). The effect of a classroom activity break on physical activity levels and adiposity in primary school children. *Journal of Paediatrics and Child Health*, *52*(7), 745–749. https://doi.org/10.1111/jpc.13182

Edwardson, C. L., & Gorely, T. (2010). Activity-related parenting practices and children's objectively measured physical activity. *Pediatric Exercise Science*, *22*(1), 105–113. https://doi.org/10.1123/pes.22.1.105

Egan, C. A., Webster, C. A., Beets, M. W., Weaver, R. G., Russ, L., Michael, D., Nesbitt, D., & Orendorff, K. L. (2019). Sedentary time and behavior during school: A systematic review and meta-analysis. *American Journal of Health Education*, *50*(5), 283–290. https://doi.org/10.1080/19325037.2019.1642814

Egger, F., Conzelmann, A., & Schmidt, M. (2018). The effect of acute cognitively engaging physical activity breaks on children's executive functions: Too much of a good thing? *Psychology of Sport and Exercise, 36*, 178–186. https://doi.org/10.1016/j.psychsport.2018.02.014

Egger, F., Benzing, V., Conzelmann, A., & Schmidt, M. (2019). Boost your brain, while having a break! The effects of long-term cognitively engaging physical activity breaks on children's executive functions and academic achievement. *PLoS ONE*, *14*(3), Article e0212482. https://doi.org/10.1371/journal.pone.0212482

Eriksen, B. A., & Eriksen, C. W. (1974). Effects of noise letters upon the identification of a target in a nonsearch task. *Perception and Psychophysics*, *16*, 143–149. https://doi.org/10.3758/BF03203267

Farooq, A., Martin, A., Janssen, X., Wilson, M. G., Gibson, A.-M., Hughes, A., & Reilly, J. J. (2020). Longitudinal changes in moderate-to-vigorous-intensity physical activity in children and adolescents: A systematic review and meta-analysis. *Obesity Reviews, 21*(1), Article e12953. https://doi.org/10.1111/obr.12953

Feller, R., Lussi, I., Wicki, W., Näpflin, C., & Stoffel, S. K. (2021). *Evaluation «schule bewegt»: Für mehr Bewegung in Schweizer Schulen. Evaluation 2018–2020* [Evaluation of «school on the move»: For more exercise in Swiss schools. Evaluation 2018–2020]. Gesundheitsförderung Schweiz [Health Promotion Switzerland].

Fidell, L. S., & Tabachnik, B. G. (2003). Preparatory data analysis. In A. Schinka & W. F. Velicer (Eds.), *Handbook of psychology* (2nd ed., pp. 115–141). John Wiley & Sons. https://doi.org/10.1002/0471264385.wei0205

Freedson, P., Pober, D., & Janz, K. F. (2005). Calibration of accelerometer output for children. *Medicine and Science in Sports and Exercise*, *37*(11), 523–530. https://doi.org/10.1249/01.mss.0000185658.28284.ba

Grao-Cruces, A., Segura-Jiménez, V., Conde-Caveda, J., García-Cervantes, L., Martínez-Gómez, D., Keating, X. D., & Castro-Piñero, J. (2019). The role of school in helping children and adolescents reach the physical activity recommendations: The UP&DOWN study. *Journal of School Health, 89*(8), 612–618. https://doi.org/10.1111/josh.12785

Guthold, R., Stevens, G. A., Riley, L. M., & Bull, F. C. (2020). Global trends in insufficient physical activity among adolescents: A pooled analysis of 298 population-based surveys with 1.6 million participants. *The Lancet. Child and Adolescent Health, 4*(1), 23–35. https://doi.org/10.1016/S2352-4642(19)30323-2

Haffner, J., Baro, K., Parzer, P., & Resch, F. (2005). *Heidelberger Rechentest (HRT 1-4)* [Heidelberg Arithmetic Test 1-4]. Hogrefe.

Hascher, T. (2004). *Wohlbefinden in der Schule* [Scholastic well-being]. Waxmann.

Himes, J. H. (2009). Challenges of accurately measuring and using BMI and other indicators of obesity in children. *Pediatrics*, *124*(Sup_1), 3–22. https://doi.org/10.1542/peds.2008-3586D

Holt, A.-D., Smedegaard, S., Pawlowski, C. S., Skovgaard, T., & Christiansen, L. B. (2019). Experimental' experiences of autonomy, competence and relatedness in 'Move for Well-being in Schools': A physical activity intervention. *European Physical Education Review*, *25*(3), 640–658. https://doi.org/10.1177/1356336X18758353

Howell, D. C. (2020). *Statistical methods for psychology.* Cengage Learning.

Hox, J. J., Moerbeek, M., & van de Schoot, R. (2018). *Multilevel analysis: Techniques and applications* (3rd ed.). Routledge.

Hynynen, S.-T., van Stralen, M. M., Sniehotta, F. F., Araújo-Soares, V., Hardeman, W., Chinapaw, M. J. M., Vasankari, T., & Hankonen, N. (2016). A systematic review of school-based interventions targeting physical activity and sedentary behaviour among older adolescents. *International Review of Sport and Exercise Psychology*, *9*(1), 22–44. https://doi.org/10.1080/1750984X.2015.1081706

Jäger, K., Schmidt, M., Conzelmann, A., & Roebers, C. M. (2015). The effects of qualitatively different acute physical activity interventions in real-world settings on executive functions in preadolescent children. *Mental Health and Physical Activity*, *9*, 1–9. https://doi.org/10.1016/j.mhpa.2015.05.002

Jones, D., Innerd, A., Giles, E. L., & Azevedo, L. B. (2020). Association between fundamental motor skills and physical activity in the early years: A systematic review and meta-analysis. *Journal of Sport and Health Science*, *9*(6), 542–552. https://doi.org/10.1016/j.jshs.2020.03.001

Kallio, P., Pahkala, K., Heinonen, O. J., Tammelin, T. H., Pälve, K., Hirvensalo, M., Juonala, M., Loo, B.-M., Magnussen, C. G., Rovio, S., Helajärvi, H., Laitinen, T. P., Jokinen, E., Tossavainen, P., Hutri-Kähönen, N., Viikari, J., & Raitakari, O. T. (2021). Physical inactivity from youth to adulthood and adult cardiometabolic risk profile. *Preventive Medicine, 145*, Article 106433. https://doi.org/10.1016/j.ypmed.2021.106433

Kowalski, K. C., Crocker, P. R. E., & Donen, R. M. (2004). *The Physical Activity Questionnaire for Older Children (PAQ-C) and Adolescents (PAQ-A) manual*. University of Saskatchewan. https://bit.ly/4epTnRj

Kriemler, S., Meyer, U., Martin, E., van Sluijs, E. M. F., Andersen, L. B., & Martin, B. W. (2011). Effect of school-based interventions on physical activity and fitness in children and adolescents: A review of reviews and systematic update. *British Journal of Sports Medicine*, *45*(11), 923–930. https://doi.org/10.1136/bjsports-2011-090186

Kromeyer-Hauschild, K., Wabitsch, M., Kunze, D., Geller, F., Geiss, H. C., Hesse, V., von Hippel, A., Jaeger, U., Johnsen, D., Korte, W., Menner, K., Müller, G., Müller, J. M., Niemann-Pilatus, A., Remer, T., Schaefer, F., Wittchen, H.-U., Zabransky, S., Zellner, K., … Hebebrand, J. (2001). Perzentile für den Body-mass-Index für das Kindes- und Jugendalter unter Heranziehung verschiedener deutscher Stichproben [Percentiles for body mass index in childhood and adolescence based on various German samples]. *Monatsschrift Kinderheilkunde*, *149*, 807–818. https://doi.org/10.1007/s001120170107

Kuhn, A. P., Kim, E., Lane, H. G., Wang, Y., Deitch, R., Turner, L., Hager, E. R., & Parker, E. A. (2021). Associations between elementary and middle school teachers' physical activity promoting practices and teacher- and school-level factors. *The International Journal of Behavioral Nutrition and Physical Activity*, *18*, Article 66. https://doi.org/10.1186/s12966-021-01129-4

Kuzik, N., da Costa, B. G. G., Hwang, Y., Verswijveren, S. J. J. M., Rollo, S., Tremblay, M. S., Bélanger, S., Carson, V., Davis, M., Hornby, S., Huang, W. Y., Law, B., Salmon, J., Tomasone, J. R., Wachira, L.-J., Wijndaele, K., & Saunders, T. J. (2022). School-related sedentary behaviours and indicators of health and well-being among children and youth: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity*, *19*, Article 40. https://doi.org/10.1186/s12966-022-01258-4

Léger, L. A., Mercier, D., Gadoury, C., & Lambert, J. (1988). The multistage 20 metre shuttle run test for aerobic fitness. *Journal of Sports Sciences*, *6*(2), 93101. https://doi.org/10.1080/02640418808729800

Leahy, A. A., Mavilidi, M. F., Smith, J. J., Hillman, C. H., Eather, N., Barker, D., & Lubans, D. R. (2020). Review of high-intensity interval training for cognitive and mental health in youth. *Medicine and Science in Sports and Exercise*, *52*(10), 2224–2234. https://doi.org/10.1249/mss.0000000000002359

Liu, N. Y.-S., Plowman, S. A., & Looney, M. A. (1992). The reliability and validity of the 20-meter Shuttle Test in American students 12 to 15 years old. *Research Quarterly for Exercise and Sport*, *63*(4), 360–265. https://doi.org/10.1080/02701367.1992.10608757

Love, R., Adams, J., & van Sluijs, E. M. F. (2019). Are school-based physical activity interventions effective and equitable? A meta-analysis of cluster randomized controlled trials with accelerometer-assessed activity. *Obesity Reviews*, *20*(6), 859–870. https://doi.org/10.1111/obr.12823

Lubans, D. R., Eather, N., Smith, J. J., Beets, M. W., & Harris, N. K. (2022). Scaling-up adolescent high-intensity interval training programs for population health. *Exercise and Sport Sciences Reviews*, *50*(3), 128–136. https://doi.org/10.1249/JES.0000000000000287

Madan, C. R., & Singhal, A. (2012). Encoding the world around us: Motor-related processing influences verbal memory. *Consciousness and Cognition*, *21*(3), 1563–1570. https://doi.org/10.1016/j.concog.2012.07.006

Mao, F., Huang, F., Zhao, S., & Fang, Q. (2024). Effects of cognitively engaging physical activity interventions on executive function in children and adolescents: A systematic review and meta-analysis. *Frontiers in Psychology*, *15*, Article 1454447. https://doi.org/10.3389/fpsyg.2024.1454447

Martin-Martinez, C., Valenzuela, P. L., Martinez-Zamora, M., & Martinez-de-Quel, Ó. (2023). School-based physical activity interventions and language skills: A systematic review and meta-analysis of randomized controlled trials. *Journal of Science and Medicine in Sport*, *26*(2), 140–148. https://doi.org/10.1016/j.jsams.2022.12.007

Masini, A., Ceciliani, A., Dallolio, L., Gori, D., & Marini, S. (2022). Evaluation of feasibility, effectiveness, and sustainability of school-based physical activity “active break” interventions in pre-adolescent and adolescent students: A systematic review. *Canadian Journal of Public Health*, *113*, 713–725. https://doi.org/10.17269/s41997-022-00652-6

Masini, A., Marini, S., Gori, D., Leoni, E., Rochira, A., & Dallolio, L. (2020). Evaluation of school-based interventions of active breaks in primary schools: A systematic review and meta-analysis. *Journal of Science and Medicine in Sport*, *23*(4), 377–384. https://doi.org/10.1016/j.jsams.2019.10.008

Mavilidi, M. F., Ruiter, M., Schmidt, M., Okely A. D., Loyens, S., Chandler, P., & Paas, F. (2018). A narrative review of school-based physical activity for enhancing cognition and learning: The importance of relevancy and integration. *Frontiers in Psychology*, *9*, Article 2079. https://doi.org/10.3389/fpsyg.2018.02079

May, v. P., Malitzky, V., & Vieluf, U. (2018). *Hamburger Schreib-Probe 1-10* [The Hamburg Writing Sample 1-10]. Ernst Klett Verlag.

Mayringer, H. & Wimmer, H. (2003). *Salzburger Lesescreening für die Klassenstufen 1-4* [The Salzburg Reading Screening]. Huber.

McMullen, J. M., Kallio, J., & Tammelin, T. H. (2022). Physical activity opportunities for secondary school students: International best practices for whole-of-school physical activity programs. *European Physical Education Review*, *28*(4), 890–905. https://doi.org/10.1177/1356336X221092281

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "Frontal Lobe" tasks: A latent variable analysis. *Cognitive Psychology*, *41*(1), 49–100. https://doi.org/10.1006/cogp.1999.0734

Montgomery, D. C. (2013). *Design and analysis of experiments.* John Wiley & Sons.

Naylor, P.-J., & McKay, H. A. (2009). Prevention in the first place: Schools a setting for action on physical inactivity. *British Journal of Sports Medicine*, *43(1),* 10–13. https://doi.org/10.1136/bjsm.2008.053447

Naylor, P.-J., Nettlefold, L., Race, D., Hoy, C., Ashe, M. C., Higgins, J. W., & McKay, H. A. (2015). Implementation of school based physical activity interventions: A systematic review. *Preventive Medicine*, *72*, 95–115. https://doi.org/10.1016/j.ypmed.2014.12.034

Neil-Sztramko, S. E., Caldwell, H., & Dobbins, M. (2021). School-based physical activity programs for promoting physical activity and fitness in children and adolescents aged 6 to 18. *The Cochrane Database of Systematic Reviews*, 9, Article CD007651. https://doi.org/10.1002/14651858.CD007651.pub3

Papadopoulos, N., Mantilla, A., Bussey, K., Emonson, C., Olive, L., McGillivray, J., Pesce, C., Lewis, S., & Rinehart, N. (2022). Understanding the benefits of brief classroom-based physical activity interventions on primary school-aged children's enjoyment and subjective wellbeing: A systematic review. *Journal of School Health*, *92*(9), 916–932. https://doi.org/10.1111/josh.13196

Pate, R. R., Davis, M. G., Robinson, T. N., Stone, E. J., McKenzie, T. L., & Young, J. C. (2006). Promoting physical activity in children and youth: A leadership role for schools: A scientific statement from the American Heart Association Council on nutrition, physical activity, and metabolism (physical activity committee) in collaboration with the Councils on cardiovascular disease in the young and cardiovascular nursing. *Circulation*, *114*(11), 1214–1224. https://doi.org/10.1161/CIRCULATIONAHA.106.177052

Pesce, C., Crova, C., Marchetti, R., Struzzolino, I., Masci, I., Vannozzi, G., & Forte, R. (2013). Searching for cognitively optimal challenge point in physical activity for children with typical and atypical motor development. *Mental Health and Physical Activity*, *6*(3), 172–180. https://doi.org/10.1016/j.mhpa.2013.07.001

Rafferty, R., Breslin, G., Brennan, D., & Hassan, D. (2016). A systematic review of school-based physical activity interventions on children's wellbeing. *International Review of Sport and Exercise Psychology, 9*(1), 215–230. https://doi.org/10.1080/1750984X.2016.1164228

Robles-Campos, A., Zapata-Lamana, R., Gutiérrez, M. A., Cigarroa, I., Nazar, G., Salas-Bravo, C., Sanchez-Lopez, M., & Reyes-Molina, D. (2023). Psychological outcomes of classroom-based physical activity interventions in children 6-to 12-year-olds: A scoping review. *Retos: Nuevas Tendencias en Educación Física, Deporte y Recreación*, *48*, 388–400.

Rodriguez-Ayllon, M., Cadenas-Sánchez, C., Estévez-López, F., Muñoz, N. E., Mora-Gonzalez, J., Migueles, J. H., Molina-García, P., Henriksson, H., Mena-Molina, A., Martínez-Vizcaíno, V., Catena, A., Löf, M., Erickson, K. I., Lubans, D. R., Ortega, F. B., & Esteban-Cornejo, I. Role of physical activity and sedentary behavior in the mental health of preschoolers, children and adolescents: A systematic review and meta-analysis. *Sports Medicine, 49*, 1383–1410. https://doi.org/10.1007/s40279-019-01099-5

Roebers, C. M., & Kauer, M. (2009). Motor and cognitive control in a normative sample of 7-year-olds. *Developmental Science*, *12*(1), 175–181. https://doi.org/10.1111/j.1467-7687.2008.00755.x

Röthlisberger, M., Neuenschwander, R., Cimeli, P., Michel, E., & Roebers, C. M. (2012). Improving executive functions in 5- and 6-year-olds: Evaluation of a small group intervention in prekindergarten and kindergarten children. *Infant and Child Development*, *21*(4), 411–429. https://doi.org/10.1002/icd.752

Rowlands, A. V., Rennie, K., Kozarski, R., Stanley, R. M., Eston, R. G., Parfitt, G. C., & Olds, T. S. (2014). Children's physical activity assessed with wrist- and hip-worn accelerometers. *Medicine and Science in Sports and Exercise*, *46*(12), 2308–2316. https://doi.org/10.1249/MSS.0000000000000365

Saint-Maurice, P. F., Bai, Y., Vazou, S., & Welk, G. (2018). Youth physical activity patterns during school and out-of-school time. *Children*, *5*(9), Article 118. https://doi.org/10.3390/children5090118

Schmid, C., Zoelch, C., & Roebers, C. M. (2008). Das Arbeitsgedächtnis von 4- bis 5-jährigen Kindern [The working memory of 4- to 5-year-old children]. *Zeitschrift für Entwicklungspsychologie und Pädagogische Psychologie*, *40*(1), 2–12. https://doi.org/10.1026/0049-8637.40.1.2

Schmidt, M., Benzing, V., & Kamer, M. (2016). Classroom-based physical activity breaks and children's attention: Cognitive engagement works! *Frontiers in Psychology*, *7*, Article 1474. https://doi.org/10.3389/fpsyg.2016.01474

Schmidt, M., Benzing, V., Wallman-Jones, A., Mavilidi, M.-F., Lubans, D. R., & Paas, F. (2019). Embodied learning in the classroom: Effects on primary school children’s attention and foreign language vocabulary learning. *Psychology of Sport and Exercise*, *43*, 45–54. https://doi.org/10.1016/j.psychsport.2018.12.017

Schmidt, M., Egger, F., Benzing, V., Jäger, K., Conzelmann, A., Roebers, C. M., & Pesce, C. (2017). Disentangling the relationship between children’s motor ability, executive function and academic achievement. *PloS ONE*, *12*(8), Article e0182845. https://doi.org/10.1371/journal.pone.0182845

Schmidt, M., Jäger, K., Egger, F., Roebers, C. M., & Conzelmann, A. (2015). Cognitively engaging chronic physical activity, but not aerobic exercise, affects executive functions in primary school children: A group-randomized controlled trial. *Journal of Sport and Exercise Psychology*, *37*(6), 575–591. https://doi.org/10.1123/jsep.2015-0069

Schnohr, C. W., Makransky, G., Kreiner, S., Torsheim, T., Hofmann, F., de Clercq, B., Elgar, F. J., & Currie, C. (2013). Item response drift in the Family Affluence Scale: A study on three consecutive surveys of the health behaviour in school-aged children (HBSC) survey. *Measurement*, *46*(9), 3119–3126. https://doi.org/10.1016/j.measurement.2013.06.016

Schüpbach, M., Wustmann, C., & Herzog, W. (2016). Entwicklung des schulischen Wohlbefindens in den ersten zwei Schuljahren: Welche Rolle spielen individuelle Schülerinnen- und Schülermarkmale? [Development of scholastic well-being in the first two school years: What role do individual student characteristics play?]. *Unterrichtswissenschaft: Zeitschrift für Lernforschung*, *44*(3), 282–298.

Sember, V., Jurak, G., Kovač, M., Morrison, S. A., & Starc, G. (2020). Children's physical activity, academic performance, and cognitive functioning: A systematic review and meta-analysis. *Frontiers in Public Health, 8,* Article 307. https://doi.org/10.3389/fpubh.2020.00307

Sneck, S., Viholainen, H., Syväoja, H., Kankaapää, A., Hakonen, H., Poikkeus, A.-M., & Tammelin, T. (2019). Effects of school-based physical activity on mathematics performance in children: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity*, *16*, Article 109. https://doi.org/10.1186/s12966-019-0866-6

Spiegel, J. A., Goodrich, J. M., Morris, B. M., Osborne, C. M., & Lonigan, C. J. (2021). Relations between executive functions and academic outcomes in elementary school children: A meta-analysis. *Psychological Bulletin*, *147*(4), 329–351. https://doi.org/10.1037/bul0000322

Steele, R. M., van Sluijs, E. M. F., Sharp, S. J., Landsbaugh, J. R., Ekelund, U., & Griffin, S. J. (2010). An investigation of patterns of children's sedentary and vigorous physical activity throughout the week. *International Journal of Behavioral Nutrition and Physical Activity*, *7*, Article 88. https://doi.org/10.1186/1479-5868-7-88

Stins, J. F., Polderman, J. C., Boomsma, D. I., & de Geus, E. J. C. (2005). Response interference and working memory in 12-year-old children. *Child Neuropsychology*, *11*(2), 191–201. https://doi.org/10.1080/092970490911351

Stoepker, P., Dauenhauer, B., Carson, R. L., McMullen, J., & Moore, J. B. (2020). Becoming a physical activity leader (PAL): Skills, responsibilities, and training. *Strategies, 34*(1), 23–28. https://doi.org/10.1080/08924562.2020.1841695

Sutherland, R. L., Campbell, E. M., Lubans, D. R., Morgan, P. J., Nathan, N. K., Wolfenden, L., Okely, A. D., Gillham, K. E., Hollis, J. L., Oldmeadow, C. J., Williams, A. J., Davies, L. J., Wiese, J. S., Bisquera, A., & Wiggers, J. H. (2016). The physical activity 4 everyone cluster randomized trial: 2-year outcomes of a school physical activity intervention among adolescents. *American Journal of Preventive Medicine*, *51*(2), 195–205. https://doi.org/10.1016/j.amepre.2016.02.020

Telama, R., Yang, X., Leskinen, E., Kankaanpää, A., Hirvensalo, M., Tammelin, T., Viikari, J. S. A., & S, Raitakari, O. T. (2014). Tracking of physical activity from early childhood through youth into adulthood. *Medicine and Science in Sports and Exercise*, *46*(5), 955–962. https://doi.org/10.1249/mss.0000000000000181

van Sluijs, E. M. F., Ekelund, U., Crochemore-Silva, I., Guthold, R., Ha, A., Lubans, D., Oyeyemi, A. L., Ding, D., & Katzmarzyk, P. T. (2021). Physical activity behaviours in adolescence: Current evidence and opportunities for intervention. *The Lancet*, *398*(10298), 429–442. https://doi.org/10.1016/S0140-6736(21)01259-9

van Stralen, M. M., Yıldırım, M., Wulp, A., te Velde, S. J., Verloigne, M., Doessegger, A., Androutsos, O., Kovács, É., Brug, J., & Chinapaw, M. J. M. (2014). Measured sedentary time and physical activity during the school day of European 10- to 12-year-old children: The ENERGY project. *Journal of Science and Medicine in Sport*, *17*(2), 201–206. https://doi.org/10.1016/j.jsams.2013.04.019

Vazou, S., Webster, C. A., Stewart, G., Candal, P., Egan, C. A., Pennell, A., & Russ, L. B. (2020). A systematic review and qualitative synthesis resulting in a typology of elementary classroom movement integration Interventions. *Sports Medicine - Open, 6*, Article 1. https://doi.org/10.1186/s40798-019-0218-8

Webster, C. A., Beets, M., Weaver, R. G., Vazou, S., & Russ, L. (2015). Rethinking recommendations for implementing comprehensive school physical activity programs: A partnership model. *Quest, 67*(2), 185–202. https://doi.org/10.1080/00336297.2015.1017588

Willoughby, M. T., Wylie, A. C., & Little, M. H. (2019). Testing longitudinal associations between executive function and academic achievement. *Developmental Psychology*, *55*(4), 767–779. https://doi.org/10.1037/dev0000664

Wong, L. S., Gibson, A.-M., Farooq, A., & Reilly, J. J. (2021). Interventions to increase moderate-to-vigorous physical activity in elementary school physical education lessons: Systematic review. *Journal of School Health*, *91*(10), 836–845. https://doi.org/10.1111/josh.13070

Watson, A., Timperio, A., Brown, H., Best, K., & Hesketh, K. D. (2017). Effect of classroom-based physical activity interventions on academic and physical activity outcomes: A systematic review and meta-analysis. *International Journal of Behavioral Nutrition and Physical Activity, 14*, Article 114. https://doi.org/10.1186/s12966-017-0569-9

World Health Organization. (2020). *WHO Guidelines on physical activity and sedentary behaviour.* https://bit.ly/3TsszHR

Zhang, J., Yang, S. X., Wang, L., Han, L. H., & Wu, X. Y. (2022). The influence of sedentary behaviour on mental health among children and adolescents: A systematic review and meta-analysis of longitudinal studies. *Journal of Affective Disorders, 306*, 90–114. https://doi.org/10.1016/j.jad.2022.03.018