Running against the schedule: are children exercising at the right time? A comment on the Portuguese education system

A correr em contra-horário: estarão as crianças a exercitar-se à hora certa? Um comentário ao sistema educativo português

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Keywords
Physical education; school exercise; cognition; portuguese education system.

Abstract

Introduction: We have all pondered on the physical and emotional benefits of exercise and often we find ourselves associating exercise to health and wellbeing. However, recent scientific developments have brought into light several benefits of exercise that had not yet been addressed by the scientific community before. The benefits of exercise that reach beyond physical and mental wellbeing such as benefits for the brain and, more specifically, for cognition, attention, and executive functions are now under close investigation.
Aim: These new insights render the education community powerful, as we have the tools to better our education system by simply applying these insights to benefit the learning process of our children.
Materials and Methods: Here we explore the International success tales on the optimization of the benefits derived from physical exercise. In a pilot study, we investigated 219 schedules from 8 Secondary Schools in Greater Lisbon, and questioned teachers about their insights on learning and behavior in pre-theoretical disciplines physical education versus post-theoretical disciplines physical education.
Results: Portuguese schools seem to favor afternoon scheduling of physical education and the perceptions of teachers seem to point to physical education as an obstacle to the learning process of more theoretical disciplines.
Conclusion: The international success tales show the importance of physical activity in the morning and clear learning benefits for more theoretical disciplines. Hence, we seek to explore these success tales, while discussing how the Portuguese education system, but also each educational community, should emulate other countries that have put this newly obtained knowledge into practice.

Palavras-chave
Educação física; exercício escolar; cognição; sistema educativo português.

Resumo

Introdução: *Já todos ponderámos acerca dos benefícios físicos e emocionais do exercício físico, associando-o à saúde e bem-estar. No entanto, recentes desenvolvimentos científicos têm evidenciado diversos benefícios do exercício que não tinham, até agora, sido abordados. Pesquisas recentes colocaram sob escrutínio científico os benefícios do exercício também para a função cerebral – nomeadamente para a cognição, atenção e funções executivas.*
Objetivo: *Estes novos conhecimentos podem dar à comunidade educativa ferramentas para, fundamentadamente, alterar práticas que favoreçam o processo de aprendizagem das crianças e jovens.*
Materiais e Métodos: *Aqui propomo-nos a explorar as práticas de sucesso que levam à otimização dos benefícios do exercício físico. Num estudo piloto investigámos 219 horários de oito escolas secundárias da Grande Lisboa e questionámos os professores acerca do comportamento e aprendizagem nas disciplinas teóricas pré- ou pós-educação física.*
Resultados: *As escolas parecem favorecer horários vespertinos, e as percepções dos professores vão ao encontro da educação física como um obstáculo ao processo ensino-aprendizagem das disciplinas mais teóricas.*
Conclusão: *Os relatos de sucesso internacionais mostram a importância da atividade física matutina e benefícios de aprendizagem claros para as disciplinas mais teóricas. Assim, procuramos que o sistema educativo português, mas também cada comunidade educativa, possa encontrar nestes relatos justificação para iniciar uma reflexão, conduzir os seus próprios projetos-piloto e colocar em prática estes novos conhecimentos.*

Introduction

A change in paradigm for exercise prescription: From fighting obesity to enhancing cognition

Traditionally, physical exercise has been prescribed as a means to fight obesity that should be specifically implemented as part of weight loss programs in schools.[1] Expanding research on the impact of physical exercise has led us to understand that other than weight loss, neurocognitive and academic performance benefits also occur[2] and, more so, in overweight youth.[3] Thus, much discussion has been fueling the debate on the importance of a widespread implementation of physical education in schools.[4] Nowadays we know that the neurobiological processes that occur with exercise training have extensive positive implications in the maintenance of physical, mental and cognitive health throughout the lifespan.[5,6] Exercise practice has been linked to the deferral of degenerative brain processes during old age[7] and even to the size of brain structures, as higher-fit older adults present larger hippocampal volume, associated with improvements in spatial memory.[8]

The establishment of a link between physical exercise and cognitive function[9] has particular relevance when it comes to the performance of children and youth, namely in the school environment. Ratey and Hagerman[10] discuss a relation between the execution of certain vigorous exercises and the enhancement of executive functions. Moreover, they present data that relates physical education (PE) with the improvement of behavioral inhibitory processes and working memory. The book authored by Ratey and Hagerman[10] had worldwide diffusion and in some countries, namely in the USA, it fueled changes in the education system, leading some schools to adapt their indications for interventions with children and youngsters with behavioral problems and learning difficulties. These authors have contended that in challenging populations, PE and school sports contribute to diminish absenteeism and improve good behavior.[10]

Exercise your body: Change your brain

Some studies have shown a great benefit of learning experiences involving movement and the body. Namely Fernandes and colleagues[11] have shown an improvement in mathematics learning in children with learning disorders. The authors propose that psychomotor-aided learning boosts academic performance by heightening the possibilities of somatosensory performance and the sense of self-efficacy. However, when it comes to the specific relation between PE and the enhancement of academic performance in children and adolescents, a hazy scenario is drawn. We are still in an embryonic phase of data collection and the dissemination of results from these studies is still quite confusing and mostly limited to the neuroscientific community, as very few conclusions are fueling a debate in the educational circles.

In fact, the results that positively relate physical activity and cognitive function, namely in what relates to academic performance, are far from consensual. For instance, Joyce and collaborators[12] found that 30 minutes of moderate exercise led to faster responses in cognitive tests (both in response execution and response inhibition) while maintaining accuracy. These effects lasted at least 52 minutes post-exercise. Coe and colleagues,[13] on the other hand, showed that vigorous rather than moderate physical activity had a positive impact on students' grades. Nevertheless, the authors caution that other variables might influence these results, such as the non-controlled socioeconomic status and state that there might not exist a true causal relation between PE and academic performance.[13] Although Donnelly and Lambourne[14] have established a link between physical activity, cognitive function and academic achievement, a later systematic review by Donnelly and collaborators[15] identify several inconsistencies in the various studies attempting to link physical activity and academic achievement. Indeed, there seems to be a general trend but no clear positive relation. In the former study, it is suggested that the relation between physical activity and academic achievement might be modulated by the behavior and posture of the teacher, i.e., teachers who are more physically active had more physically active students participating in the 'Physical Activity across the Curriculum' project, whereby physical activity would be implemented as an alternative means to sedentary theoretical learning.[14]

Hoza and collaborators[16] show that physical activity interventions before school are more efficient on reducing inattention and moodiness at home in children at risk of ADHD and typically developing children, compared to sedentary classroom-based interventions. Schmidt-Kassow and colleagues,[17] on the other hand, have found that simultaneous physical activity during encoding of novel words, but

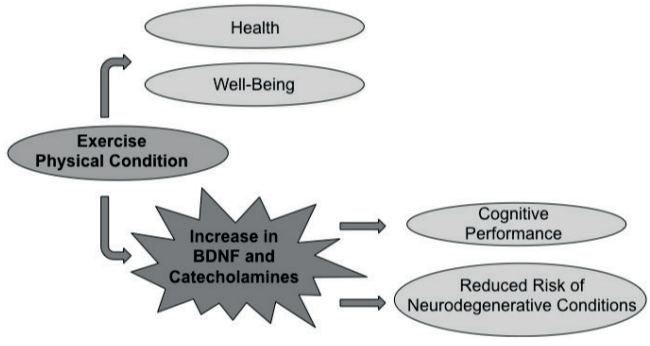
not prior to the creation of these new memories, led to better performance in recall. It seems that, in this case, exercising during learning is more beneficial for memory formation than the absence of exercise or even exercising beforehand. Others, however, show that single bouts of low to moderate intensity classroom-based exercise sessions do not bring about any alterations in information processing speed or selective attention, independently of the type of exercise in question (i.e., aerobic, coordination, or strength exercises).[18] The authors suggest caution when it comes to exercise prescription to enhance cognitive performance in class. Surprisingly, recent research has shown that exercising (at high-intensity) four hours after encoding new information not only improves memory performance, but also alters the way memories are stored in the brain, when compared with participants working out immediately after the encoding task or not working out at all.[19] Crucially, the authors found that, two days later, those who had exercised immediately after the encoding task obtained the worst performance in recall. Although it is not clear why this might happen, again, this is a telltale sign that we must be cautious with timing when prescribing exercise programs, especially in school settings.

On the other hand, Kubesch and collaborators[20] have shown that the duration of exercise breaks differently impacts the improvement of executive attention and that a 30-minute PE aerobic program boosts on-task attention in face of distraction in young adolescents (13-14 years of age), but not a 5-minute PE aerobic program. Recurrent and enduring physical activity should lead to an increase in school performance since the latter is greatly dependent on executive functions, as the amelioration of inhibitory capacity leads to a decrease in unruliness and an improvement in attention. Conversely, other studies seem to point to a general benefit of physical activity on cognition when analyzing post-exercise sessions of adolescents with a 45-minute lag, instead of immediate cognitive testing.[21] In this research, Cooper and collaborators introduce a mid-morning peak of vigorous exercise for adolescents in a school setting. The authors investigate the putative delayed cognitive benefits in working memory and executive functions tasks. Despite the positive results – enhanced answer speeds across domains – some doubts remain, as the authors suggest a generic effect of exercise in cognitive speed without the establishment of isolated effects on specific functions.

It seems that, due to the lack of consensus from research,[22] PE must increasingly justify its presence in the school curricula, and many studies have come forth in an attempt to establish a link between PE and academic achievement. However, these studies vary in exercise time, type, intensity, and even cognitive testing lag. It is, thus, important to understand the possible mechanisms that pertain the exercise-cognition relationship in order to provide specific support for PE as a pathway for academic improvement. In their meta-analysis, Sibley and Etnier[23] suggest the existence of two major mechanisms that help explain the relationship between cognitive benefits and exercise: the 'physiological mechanisms' (such as increase in cerebral blood flow and arousal levels, changes in the central nervous system and modulation of neurotransmitters) and the 'learning/developmental mechanisms' (such as the synesthetic experiences of motor learning that might aid memory and cognitive processes).

As reported above, physical exercise can positively impact cognitive performance[5] and even postpone or reduce the risk of developing a neurodegenerative disease.[24] These benefits have been systematically associated to an increase in brain-derived neurotrophic factor (BDNF) levels and to the production and secretion of specific catecholamines (such as the hormones dopamine, epinephrine (adrenaline) and norepinephrine (noradrenaline).[25,26]

Figure 1 – Physical exercise and ultimately, physical condition, impact not only physical and mental health, but also cognitive performance and risk of developing a neurodegenerative disease. The latter are mediated by an increase of specific hormone secretion and BDNF (Retrieved and adapted from Abreu and Rato, 2018 [27]).



BDNF is a protein produced by neurons that has various effects in the central nervous system such as growth, differentiation and restoration of neurons, thus impacting cognitive performance. Exercise has been found to elevate BDNF levels in humans and such BDNF modulation is dependent on exercise

intensity.[28] Catecholamines, on the other hand, are chemical compounds connected to the plasma protein, circulating in the blood. They can function as hormones, transmitting chemical signals from one cell to another. Prefrontal catecholamines have been implicated in attention and working memory as the imbalance of these neuromodulators has been associated with attention and working memory deficits in disorders such as ADHD, Parkinson's and Schizophrenia[29] (Figure 1). Early research had already established that in the recovery period after exercise, catecholamine levels (specifically epinephrine and norepinephrine) continue to increase.[30] This might explain why exercise timing and a gap between exercise and cognitive performance might benefit students. Other than timing and duration, exercise intensity has also been associated with performance in working memory tasks[31] and the type of exercise has been linked to the cognitive benefits that it entails (e.g. coordinative physical exercise enhances mental coordination cognitive tasks).[32]

Indeed, the putative cognitive benefits of physical exercise might derive from enhanced neuroplasticity brought upon by neurogenesis. Surprisingly, the formation of new neurons (initially thought to take place only during early *in utero* brain development) is an unremitting process that can be potentiated by regular physical exercise.[33] It seems that due to the shared pathways of the action-observation network (AON) and to embodiment mechanisms, even observing others exercise can lead to specific cognitive benefits.[34]

Mueller[35] has systematized research pertaining to the influence of emotions on cognitive control, pinpointing the relevance and need for further research in development and adolescent psychopathology. Despite the diffuse findings concerning the impact of positive emotions on cognitive control (benefits in executive function depend on the specific cognitive process assessed), Mueller uncovered consistent results showing that negative emotions compromised executive control. If we consider that the alterations of the central opioid system after physical exercise are associated to a boost in euphoria and wellbeing,[36] we might start to understand how exercise, cognition and positive emotions might be linked. Since the endogenous opioid system is implicated in the stress response and pain regulation, we might envisage that physical exercise should contribute to the reduction of stress and pain perception, as well as to the stabilization of humor. Hence, physical exercise should doubly impact cognition: directly, via neuromodulation, and indirectly, through the stabilization of emotions that will, in turn, positively affect cognitive performance.

Materials and Methods

The rational of our study was to analyze International studies and interventions in order to assess the key factors in order to optimize the cognitive and behavioral benefits of exercise in schools. Subsequently, we performed a pilot study in Portuguese schools in which we assessed PE scheduling and its possible reasoning and contrasted these results with the international literature.

Work it out: What we can learn from foreign success tales

Many countries have taken into account the collected data on the interaction between exercise and cognition and have used it to develop new recommendations related to the integration of physical activity in schools, considering intensity, timing, duration and even intended goals of exercise prescription. Others have developed thought-out longitudinal studies aimed at advancing knowledge on the field of exercise prescription in schools.

In the 1950's in France, the academic curriculum was reduced by 26% and PE was increased in the same proportion.[37] These changes were based on early indications that pointed to the reduction of unruliness, increase in attention and decrease of absenteeism associated to the practice of exercise.

The Trois Rivieres study[38] developed in Quebec, Canada, shows that an extra hour of PE, in addition to the standard PE class, led to better academic performance in several theoretical disciplines and even in the conduct of students, pointing to the extension of PE programs as a means to enhance academic performance.

In line with the argument above, in a study funded by the German Federal Ministry of Education and Research, Stroth and collaborators[39] compared the putative benefits of a 20-minute aerobic endurance exercise and cardiovascular fitness. The authors show that physical fitness, but not acute bouts of physical exercise, leads to the enhancement of cognitive processing, due to a more efficient executive control.

Partly based on findings relating increased time in physical activity and sport and increased academic performance,[40] the Department of Education and Early Childhood Development of the state of Victoria, in

Australia, promoted a program destined to reinforce physical exercise and sports for students up to 10 years of age. The program called 'Improving School Sport and Physical Education in Your School'[41] is a well-structured program that provides support for teachers (training and resources) as well as awareness.

In the USA, Ratey and Hagerman's book[10] discussing the science of exercise and the brain led to a widespread of Ratey's indications in many schools across the country. Namely, children and youngsters with behavioral problems were working out more and the debate concerning exercise and cognition suddenly received new impetus that influenced the neighboring country, Canada. Based on the principles disseminated by Ratey and Hagerman,[10] some schools in Canada took part in the program 'Sparking Life' requiring students to vigorously exercise for 20 minutes before classes, with the aim of verifying if the boasted learning, attention, motivation and behavioural benefits did indeed exist, in order to extend the program across the region.[42] In the news piece by Abdalhadi[42], many benefits were reported, such as an increase in problem solving abilities, decrease in disciplinary problems, improved attention and behaviour, to name some. It is important to note that the 'Sparking Life' program does not approach exercise in a traditional competitive manner but involves a wide range of strenuous play intended to elevate heart rate before the start of the academic day.[43]

The University of Oxford[44] in the United Kingdom is also currently testing the academic benefits of a training intervention designed to optimize PE content for larger brain gains. The 'Fit to Study' project aims to test the efficiency of such training interventions, considering the strong evidence that neuroscience can aid in improving education but also considering the sparse results that probably arise from the use of different methodologies and measures. This very innovative efficacy trial project includes traditional cognitive measures as well as pre- and post-brain scans on a subgroup of children, in order to investigate the possible brain changes of exercise interventions.

As it seems, the current state of the art concerning the links between exercise and cognition has been considered to be robust enough to incite effectiveness trials and the operationalization of certain conceptual learnings across the world. In view of this, it seems that in Portugal we might be lagging behind.

Do we need to revamp school exercise schedules? Considerations from a pilot study in Lisbon

In Portugal, the weight attributed to PE has varied from an important investment in human and material resources to the devaluation of the discipline. From 2012 onwards, in secondary schools, PE classification was no longer considered on the establishment of the academic evaluation unless the student aimed to proceed with higher education on this subject.[45] This situation has since been revoked and alterations were established in 2018. However, the status and importance given to PE is still questionable, with teachers and parents divided concerning the status of this discipline.

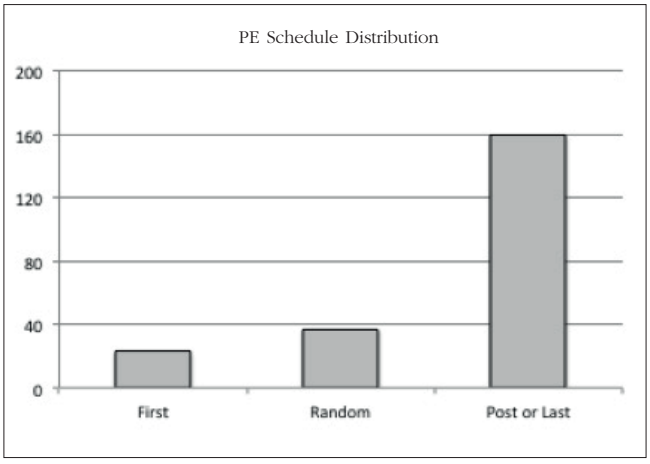
Certain educational trends have had an important role in the way PE is viewed by policy makers, school officials and families in Portugal. Since the state exams for University access are the most valued exams in the country, it might be natural that more hours are allocated to the study and practice of these exams. We are, however, forgetting the indirect power of exercise for boosting learning, when we contemplate only the direct earnings of sedentary theoretical training. This trend is not specific to Portugal and we find it in other countries: either associated to budget reductions or to the favoring of more traditional theoretical disciplines in detriment to time allocated to PE.[23]

Despite the fact that several exercise benefits for cognition have been unquestionably assessed and despite the fact that this undisputable information is accessible via several communicational channels in our society, there still seems to exist a culture that ranks the importance of school disciplines, often relegating PE to the bottom of the hierarchal pyramid. This appears to be even more so as we advance in degrees of schooling. In Portugal, the teachers of more academic disciplines often regard PE as a disturbing element of learning. As such, schools seem to favor the scheduling of PE following the more demanding academic disciplines. We developed a pilot study with the aim to further investigate this anecdotal perception wherein we analyzed 219 schedules from 8 Secondary Schools in Greater Lisbon, and questioned teachers about their insights on learning and behavior in pre-theoretical disciplines PE versus post-theoretical disciplines PE.[46]

Results

We found that the observed frequencies are not similar to the expected frequencies (which would happen, had there not been a choice criterion in PE placement in scheduling) (c2 = 153.32, df = 2, p = 0.000). Moreover, post-hoc adjusted residual testing showed that all scheduling choices were independent, i.e., both 'first' (n = 23) and 'random' (n = 37) choices are lower than expected and 'post or last' (n = 159) are significantly higher than expected. Albeit taken from a small sample, these data seemingly confirm that most students in secondary schools are exercising only after the theoretical acquisitions take place in typically sedentary classes (Figure 2).

Figure 2 – Frequency distribution of 219 PE schedule choices in 8 schools across Greater Lisbon: i. First – PE as first class of the day; ii. Random – PE randomly assigned at different weekdays and before and after theoretical disciplines; and iii. Post or Last – PE assigned after theoretical disciplines or at the end of the school day.



A subsample of these schedules presented a particular characteristic: PE occurred twice a week, once immediately before Mathematics class and once immediately after Mathematics class. We were able to obtain responses to a questionnaire from seven teachers concerning their insights associated to six aspects in class performance: concentration, attention, self-control, discipline, time for task completion and noise. Our questionnaire used a Visual Analog Scale to assess the teachers' subjective perception of class performance for each item. The analysis from such a small sample did not yield any distinct trend and seemed to be more associated to the teachers' preferences than to the performance items or PE schedule placing. Moreover, in a question where teachers were asked when they preferred to teach Mathematics, the teachers referred the first period of the day due to students being less agitated, at the beginning of the week due to students being less tired and in two consecutive periods due to the possibility of more extensive work on the same subject. It is interesting to note that none of the inquired teachers mentioned (either positively or negatively) the impact of PE scheduling.

Despite the absence of opinion (of the inquired teachers) concerning PE placement in the class schedule, we found a clear tendency to place PE after the more academic disciplines. This does not seem to be a coincidence and we urge the development of larger follow-up studies. The absence of an opinion related to PE placement in class schedules led us to believe that teachers do not consider this to be relevant for the behavioral and academic performance of students. The absence of a trend concerning insights related to performance in Mathematics class before and after PE also supports the need for further studies in order to develop specific criteria for scheduling PE based on tangible performance data. Currently, in Portugal, the criteria used for creating schedules is not generalized to the education system and is defined by the pedagogical board, approved by the general council and applied, with a certain degree of freedom, by the director of the school. It is thus a situation in which the whole school community (teachers, parents and students) can get involved and decide. However, the different constituents of the school community are not equally informed or even motivated by the same performance reasons.

PE scheduling also has other limitations: it needs to respect food digestion, available space, human and material resources, available shower rooms to avoid delays to the next class and uncomfortable perspiring students. The two schools that placed PE as the last discipline of the day or posterior to more academic classes justified this choice by stating that this would avoid perspiring and tired students in subsequent theoretical classes.

Discussion and Conclusion

It seems clear that, although a lot is still to be done in order to unambiguously define the best schedule for PE, the type of PE program that should be followed and the effective duration of such program, in Portugal, we are neither observant of what is already known nor are we seriously aiming at learning more about these important issues, like so many other countries in the world.

Here we intend to contribute to the important reflection concerning the link between physical activity and academic achievement by questioning the sparse reasons for why certain decisions are made in schools in the Portuguese education system. Are these reasons supported by valid arguments? Despite the several remaining doubts, we seem to hold some certainties: physical activity in childhood and adolescence highly influences later quality of life,[47] there seems to exist a direct relationship between physical activity in school and academic performance,[23] the specificities of PE classes foster social development and self-esteem[4] and better results seem to be achieved when PE and academic instruction are integrated and, as such, traditional academic subjects should incorporate physical activity.[48] It seems that we are in dire need to change the curriculum and the education system. We hope that these insights might help leverage these changes.

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