EFFECTS OF PHYSICAL ACTIVITY INTERVENTION AMONG UNIVERSITY STUDENTS: A NARRATIVE REVIEW

EFFETTI DI UN INTERVENTO DI ATTIVITÀ FISICA TRA GLI STUDENTI UNIVERSITARI: UNA REVISIONE NARRATIVA

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ABSTRACT

Physical activity is crucial for maintaining physical and mental health but remains overlooked, especially among university students. In reviewing the literature regarding the integration of physical activity intervention into education, classroom movement breaks have emerged. This narrative review describes the feasibility of incorporating movement breaks into university classes regarding acceptability, practicality, and efficacy. Also, we describe their physical and cognitive outcomes for acute and chronic intervention. However, it is impossible to draw definitive conclusions due to the heterogeneity in intervention components, it seems that classroom movement breaks are feasible and may be considered for incorporation into university classes to increase enjoyment. Future studies should employ objective measures to determine the effects on overall physical activity levels and cognitive outcomes.

L'attività fisica è fondamentale per il mantenimento della salute fisica e mentale, ma è sottovalutata soprattutto dagli gli studenti universitari. Esaminando la letteratura riguardante l'integrazione di interventi di attività fisica nel contesto educativo, sono emerse le pause di attività fisica. In questa revisione narrativa, descriviamo la fattibilità di incorporare le pause movimento nelle classi universitarie in riferimento all'accettabilità, la praticità e l'efficacia. Inoltre, descriviamo gli effetti delle pause attive relativamente ad aspetti fisici e cognitivi sia per l'intervento acuto che cronico. Nonostante non sia stato possibile trarre conclusioni definitive a causa dell'eterogeneità degli strumenti utilizzati, sembra che le pause di attività fisica in classe siano fattibili e possano essere inserite nelle classi universitarie per aumentare il coinvolgimento degli studenti. Studi futuri dovrebbero utilizzare misure oggettive per determinare gli effetti sui livelli generali di attività fisica e sugli aspetti cognitivi.

KEYWORDS
Physical activity, students, feasibility, cognitive outcomes
Attività fisica, studenti, fattibilità, risultati cognitivi

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Introduction

According to the World Health Organization, regular physical activity (PA) is fundamental to sustaining physical and mental health (WHO, 2020). Despite its many benefits, PA remains overlooked, especially among young people. Research indicates a decline in regular PA, particularly among university students (Hallal et al., 2012). This trend increases the risks of overweight, diabetes, and cardiovascular disease (Telleria-Aramburu et al., 2022) and reflects the educational system's limited role in promoting PA (Deng et al., 2023). Additionally, extensive research has shown that PA interventions can enhance students' cognitive, metacognitive, and academic outcomes, including improving working memory, attention, processing speed, and academic performance (Haverkamp et al., 2020).

As university students navigate the transition from adolescence to adulthood, improving their life habits is crucial for their long-term well-being (Wang et al., 2019). Ecological models of health behavior change suggest that aspects of the environment play a crucial role in shaping health behaviors (Stokols, 1996). Given the large amount of time university students spend in classroom environments, the university classroom may be an ideal setting for intervention. Appropriately allocating attention during effortful tasks, such as listening to a lecture, is essential for durable learning (Shiffrin & Schneider, 1977). However, as time on task increases, minds naturally tend to wander, leading to a decline in focus as the lecture progresses (Bunce, Flens, & Neiles, 2010). Reduced attention during a lecture negatively impacts memory performance and can impair academic achievement (Wammes, Seli, Cheyne, Boucher, & Smilek, 2016). In line with this, pedagogical research finds that attention degrades after between 10 and 30 minutes on task (Wammes et al., 2016). Since lectures are the primary content delivery method in most university courses, strategies to maintain attention throughout the lecture (i.e., classroom movement breaks) are crucial for better learning outcomes.

Classroom movement breaks a physical activity intervention in the classroom.

While there are no set definitions for active break, the following definition was provided to maintain consistency and clarity throughout this narrative review. Classroom movement break (CMB) is a short (3 to 10 minutes each) mental and physical break during which students participate in structured PA. CMB can include a variety of exercises: aerobic exercises (e.g., jumping jacks, running in place, high knees); strength training exercises (e.g., bodyweight squats, push-ups, planks, lunges); flexibility and balance and coordination exercises (e.g., single-leg stands, heel-to-toe walks) and or simple movement activities (walking or marching in place, arm circles, toe touches, skipping). Previous research has focused on the effects of these breaks implemented in primary (Masini et al., 2020) and secondary (Daly-Smith et al., 2018) classrooms. In schools, CMBs have been found to have positive effects on PA levels of children, increasing the time spent in moderate-to-vigorous PA, as well as step count. Academic performance and classroom behavior, such as time spent on task behavior during lessons, were also improved (Masini et al., 2020; Watson et al., 2017). CMBs were found to be an acceptable intervention for children and feasible to implement for teachers (Watson et al., 2019). However, it remains to be seen whether the benefits of CMBs can be extended to students with higher academic degrees.

Aim

To summarize the information collected so far, we aimed to conduct a narrative review of the published studies concerning the feasibility and effects of PA on physical and cognitive outcomes in university/college classrooms. Research in this area has concentrated on the effects of chronic PA on brain and cognitive functions; several studies have extended this work to examine the influence of a single bout — or dose — of PA on cognition. In line with this, the second aim of this narrative review is to highlight common themes and critical limitations that researchers may find relevant for advancing studies on the effects of chronic and acute bouts of PA on cognition.

Search Strategy

The online search expression we used to locate published studies for this review was "movement break* OR exercise* break* OR active lesson* OR acute exercise * OR CMB * OR PAL, AND college student*OR university student* OR higher education OR higher learning". We used three online databases: (a) Science Direct, (b) PubMed, (c) Web of Science. We did not delineate any specific year for the research. In addition, we conducted a further general Internet search (i.e., Google Scholar) using these search expressions. Studies were excluded when they did not meet
key inclusion criteria.

Inclusion criteria. Inclusion criteria for articles in this literature search were as follows: (a) from peer-reviewed journals; (b) written in English language; (c) investigations of the effect of active breaks on feasibility, sedentary, physical outcomes (physical activity, upright time), or cognitive outcomes (concentration, focus/attention, well-being, cognitive functions); (d) involved studies with university or college students.

Exclusion criteria. The following types of studies were excluded from our review: (a) those not involving students; (b) study that includes participants with learning disorders; (c) studies that included nutritional interventions.

Feasibility

Bowen and colleagues (2009) identified eight areas of interest that need to be investigated by feasibility studies: demand, acceptability, implementation, practicality, adaptation, integration, expansion, and limited efficacy testing. The authors recommend deciding which area to focus on depending on the aim of the study. About our hypothesis, we chose acceptability (engagement, satisfaction, and levels of disruption) and practicality (ease of scheduling and conducting breaks) to establish if CMBs were feasible for university students. Based on these areas, Keating and colleagues (2020) reported that the positive responses of participants were primarily centered around enjoyment. The authors noted that the short break (lasting 4 min) included in a 2-h lecture was fun to complete and improved energy levels afterward (Keating et al., 2020). Also, Peiris and colleagues (2021), who proposed 10 min CMB scheduled after 20 min of sedentary time during 2-h classes over three weeks, reported that students felt "refocused," "more energetic," "engaged," and "more awake," and expressed interest in introducing movement breaks in their future classrooms (Peiris et al., 2021). Bellis and colleagues (2021) showed that classes with CMBs were more enjoyable than those that did not, as a result of allowing for social interaction and acting as icebreakers between students and professors and amongst the students themselves. Consequently, well-being is improved; in fact, students who took a CMB declared that they are more balanced and motivated and agreed that activity breaks increased their general sensation of well-being (Bellis et al., 2021). Additionally, a study evaluating CMBs proposed every 45 min of 2 h lecture for four weeks during the COVID-19 pandemic showed that students found these breaks more important during online lectures than in-person lectures (Bellis et al., 2021). However, before starting the training, participants expressed concerns that incorporating CMBs in the classroom would cause disorder and disrupt the learning environment (Stapp & Prior, 2018). Keating and colleagues (2020) also reported that using qualified fitness instructors to deliver the break exercises further enhanced the appropriateness of the intervention and avoided the sense of discomfort sometimes attributed to a peer or colleague leading the CMBs. Another area of emphasis for students was the timing of exercise breaks. CMBs that did not coincide with a topic change were perceived as disruptive; however, when breaks were well-timed, students could reinforce the knowledge learned and feel refreshed for the next part of the lesson (Peiris et al., 2021). Studies also reported that it should be used more often in longer classes and can be implemented in the middle of class rather than at the beginning or end of lectures (Bellis et al., 2021). Conversely, Stapp and Prior (2018) found that incorporating one activity break at the beginning of the day allows students to "wake up and focus on something." However, the research is contrasting, as there is still concern that these breaks may interrupt concentration and damage productivity (Castro, Bennie, Vergeer, Bosselut, & Biddle, 2020). There

is limited research in the university context regarding the duration of breaks. The duration often depends on the type of activities included and the goals of the intervention. Felez-Nobrega and colleagues (2018) suggested that taking frequent breaks from sedentary time (e.g., every 20 minutes) could be a practical "starting point" for reducing mental fatigue caused by prolonged cognitive activities and potentially enhancing academic performance. However, other studies have confirmed that 20 minutes is too long (Ferrer & Laughlin, 2017). In another study, students affirmed that 4-minute activity breaks during 2-hour lectures were acceptable (Keating et al., 2020).
While CMBs in university classrooms are generally well-received and beneficial, some shared dislikes and challenges were reported by Keating and colleagues (2020): limited space (students reported that the limited space available in classrooms often made it difficult to perform specific exercises comfortably and safely); warm classroom conditions (warm temperatures in the classroom were mentioned as a factor that made physical activity less enjoyable and more strenuous); poor audio quality (in studies where activity breaks were presented through videos, students noted that poor audio quality made it hard to follow the instructions); clothing restrictions (some students found that their clothing was not suitable for PA, which hindered their ability to participate in the activity breaks).

Physical Outcomes
Previous studies extensively document the effects of CMBson PA levels, revealing significant short- and long-term benefits. One of the primary measures of PA in studies examining CMB is the number of steps taken by participants. Keating et al. (2020) conducted a study on university students. They reported that students who participated in the short activity break (lasting 4 min) included in a 2-h lecture accumulated more steps throughout the day than those who did not, highlighting the effectiveness of activity breaks in promoting PA. Similarly, Ferrer and Laughlin (2017) demonstrated that a 20-minute CMB was presented every 15 - 20 minutes for one semester in university classes, which resulted in higher energy expenditure and step count among students. Also, Peiris and colleagues (2021) showed that in classes with CMB (10 min duration scheduled after 20 min of sedentary time over three weeks), students spent 13 minutes less time in sedentary activities and took 834 more steps when compared to classes without CMB. However, they reported that students felt that the activity breaks did not significantly improve PA globally. Despite this, students affirmed that they would continue doing them during their independent study because they reported discomfort when seated for prolonged periods (Peiris et al., 2021). Lynch, O'Donoghue, and Peiris (2022) showed that students who completed 10 min of CMB for one semester reported a small effect on weekly PA levels, considering guidelines suggested at least 150–300 min of moderate intensity PA each week (WHO, 2020). Similarly, using the

pedometers, Stapp and Prior (2018) showed that students who participated in CMB did not report a significant increase in PA levels compared to the control group. The data showed that students were in the middle range of the low activity step index; this is not the best result, but it does indicate that students were not at the sedentary level (Stapp & Prior, 2018). Given that previous studies have demonstrated a correlation between low PA and weight gain, particularly during the early years of university, which often leads to continuous weight gain throughout a student's university years, implementing CMBs could be a potential intervention to enhance students' current and future health outcomes (Vadeboncoeur, Townsend, & Foster, 2015). Another essential aspect is that CMBs can alleviate physical tension from prolonged sitting periods among university students. Extended sitting can lead to various musculoskeletal issues, such as back pain, neck stiffness, and overall discomfort. In line with this, König, Parthey, and Kroke (2015) examined the effectiveness of CMBs, which were instructed by trained students at the halfway point of lectures, and reported that students felt a decrease in muscular tension and fatigue after the CMBs.

Cognitive outcomes

Chronic and acute effects of PA on cognitive functioning

There are two different methodological approaches to investigating the relationship between PA and cognitive outcomes, leading to distinct lines of research. The mechanism(s) responsible for cognitive enhancement are likely different for acute compared to chronic exercise. The first approach focuses on the instant changes in cognitive functioning following acute bouts of aerobic activity, where cognitive performance metrics like accuracy, response time, and speed on cognitive tests are measured directly after the activity (Tomporowski, 2003). The second examines the effects of chronic exercise (i.e., constitutes exercise bouts that last a period per session, multiple sessions per week) to enhance cardiorespiratory fitness, which may subsequently lead to enduring cognitive benefits assessed post-program (Tomporowski et al., 2008; Tomporowski et al., 2015).

Acute effects

Within studies assessing changes in cognition following a bout of PA, meta-analytic reviews generally support the conclusion that single bouts of PA have beneficial aftereffects on cognition (Lambourne & Tomporowski, 2010). Pastor-Vicedo and colleagues (2024) investigated the effects of a 10-minute CMB on vigilance in students using a psychomotor vigilance task. They found that after 10 minutes of moderate-intensity PA, students improved their attention, responding faster to the task than in the control condition. Niedermeier and colleagues (2020) also showed that a single ten-minute break might help restore the basal visual attentional domain after prolonged sedentary periods. Fenesi and colleagues (2018) demonstrated improved on-task attention and memory for lecture content in the CMB group compared to non-exercise breaks or no breaks. More in-depth, the authors suggest that CMB is beneficial for learning because it helps to mitigate the natural decrease in attention that occurs when lecture length increases. This result has important implications for including CMBs in university classrooms, as they are considered a helpful tool for long-duration learning during situations in which attention becomes increasingly exhausted (Wammes, Boucher, et al., 2016). However, it is essential to note that the literature in this area varies in the characteristics of PA, which appear to influence the extent to which cognition is impacted (Chang et al., 2012; Lambourne & Tomporowski, 2010). The moderators were selected based on their previous identification as essential variables in examining the effects of PA on cognitive performance. These moderators include exercise intensity, timing of assessment of cognitive function, type of cognitive task, and the initial fitness level of the participants (Chang et al., 2012). The intensity of the PA bout can produce different effects. While this subject is debated and is connected to other factors, such as duration, the relationship between intensity and cognitive improvement may follow an inverted U function (Pontifex et al., 2019). This means moderate intensity yields the most significant effects, while low and vigorous intensities yield more minor effects (Pontifex et al., 2019). The second moderator is the timing of the assessment of cognitive functions. When cognitive functions are assessed during the PA bout, the effects are predominantly negative, such as increased response time to a cognitive task (Lambourne & Tomporowski, 2010). However, when cognitive functions are assessed after a delay (i.e., at least one minute between the end of PA and the assessment), meta-analytic evidence shows small-to-moderate beneficial effects on cognitive functions, particularly in the executive domain (Chang et al., 2012; Lambourne & Tomporowski, 2010). The relationship between acute exercise and cognitive performance may also depend on the nature of the cognitive task. Etnier et al. (1997) reported that acute exercise greatly affected motor skills, academic achievement, and composite scores from various tests. However, it had negative effects on tasks related to reasoning and verbal skills. In Etnier et al.'s review, many acute exercise studies used reaction time tasks (Fleury & Bard, 1987; Hogervorst et al., 1996; McMorris, 1995) and visual recognition tasks (Bard & Fleury, 1978). Recently, researchers have begun to examine the effects of acute exercise on executive function or frontal-lobe-dependent measures (Chang & Etnier, 2009a, b; Dietrich & Sparling, 2004; Sibley et al., 2006; Tomporowski et al., 2005). This shift may reflect an interest in analyzing the transient hypofrontality hypothesis (Dietrich, 2006) and past meta-analytic evidence suggesting that cognitive task type moderates the effects of both acute and chronic exercise (Colcombe & Kramer, 2003; Etnier et al., 1997; Lambourne & Tomporowski, 2010). Another moderator of interest is the initial fitness level of the participants (Chodzko-Zajko, 1991; Tomporowski, 2003b; Tomporowski & Ellis, 1986). It is assumed that the effects of a PA bout on cognition might differ, especially for participants who are accustomed to PA and have higher aerobic fitness. There are two diverging proposed directions: Individuals with high aerobic fitness might be able to cope with the physiological demands of a PA bout more effectively and thus gain more considerable cognitive benefits from it (Chang, Labban et al., 2012; Pontifex et al., 2019). Alternatively, ceiling effects in the cognitive assessment might result in smaller benefits for these individuals than those with lower aerobic fitness (Pontifex et al., 2019).

Chronic effects

As far as we know, only a few studies analyze changes in cognition following a chronic PA in university/college students. Felez-Nobrega and colleagues (2018) suggest that interruptions in prolonged periods of sitting time every 10-20 minutes via short breaks may optimize cognitive operations. Also, Peiris and colleagues (2021), in a mixed-method study, reported that students felt higher concentration and alertness in classes with CMBs; this result was confirmed by quantitative analysis that reported significantly higher levels of alertness in classes with CMBs when compared to classes without movement breaks (Peiris et al., 2021). Also, tutors noted improvements in concentration and alertness in students involved in CMBs (Peiris et al., 2021). The cognitive benefits associated with CMBs regarding focus and attention can be partly attributed to the physiological effects of PA. Interrupting long periods of sitting while engaging in low to moderate PA leads to metabolic, endocrine, and vascular changes, which may enhance cognitive function by reducing postprandial hyperglycemia, insulin resistance, and inflammatory markers while improving hormonal regulation and blood flow to both cortical and peripheral arteries (Chandrasekaran, Pesola, Rao & Arumugam, 2021). Despite these cognitive benefits and their physiological basis, CMBs did not significantly improve academic performance in the reviewed studies, except for Felez-Nobrega and colleagues (2018), who highlighted an improvement in cognitive operations associated with academic performance. This lack of improvement could be due to the limited number of studies measuring academic performance, or it can be due (just like with acute effects) to the influence of some moderators. These moderators include PA's intensity, timing, and duration during the breaks. For instance, cerebral blood flow increases with incremental exercise until about 60% of maximum intensity, after which it levels off and eventually declines as maximal intensity approaches. Therefore, exercise intensity should be sufficient to increase cerebral blood flow without being too intense or prolonged, which could lead to hypoxia and reduced blood flow. Additionally, the timing of CMBs is critical. A study with office workers showed that cerebrovascular blood flow drops due to sedentary behavior were countered by 2-minute bouts of light walking every 30 minutes but not by an 8-minute walk every 2 hours at the same pace. Three minutes of low to moderate-intensity activity after 30 minutes of sedentary behavior is considered the minimum effective dose for glucose regulation.

Discussion

This narrative review highlights the promising potential of incorporating PA, specifically CMBs, into university and college classrooms to enhance student's physical and cognitive outcomes. The feasibility of CMBs is supported by several studies demonstrating student engagement, enjoyment, and increased energy levels (Keating et al., 2020; Peiris et al., 2021). These findings aligned with results from systematic reviews in primary school children (Bedard, St John, Bremer, Graham & Cairney, 2019)and adolescents (McMichan, Gibson, & Rowe, 2018). However, some logistical challenges, such as limited space, warm classroom conditions, and break structure, must be considered when CMBs are implemented (Keating et al., 2020). To facilitate the implementation of CMBs, Dallolio and colleagues (2023) proposed a list of steps that can be followed to plan an activity breaks program. For example, authors proposed to familiarize with different types of breaks that can be utilized (Dallolio, 2023). Also, it is essential to reflect on the duration, the number of students who will participate, the classroom space, and the purpose of the CMBs. It is also important to inform students about the benefits of including CMBs in the lessons and take their opinions/suggestions on the activity. Furthermore, preliminary evidence is that CMBs increase the number of steps taken during class time and that students spend less time in sedentary activities, as seen in school-aged students (Daly-Smith et al., 2018). However, the amount of change may not affect overall health unless it has a carry-over effect on behavior. In the studies included in this review, students completed an average of 10 min of PA. Although this is insufficient to achieve the minimum levels of PA recommended by WHO (at least 150–300 min of moderate-intensity physical activity per week), it indicates that students were not at the sedentary level (Bull et al., 2020; Stapp & Prior, 2018). One study indicated that the intervention had a positive impact on out-of-class behavior. Students reported a noticeable increase in their overall PA and became more mindful of their activity habits. Additionally, they reduced sedentary behavior by frequently interrupting prolonged sitting periods with movement (Paulus et al., 2021). To effectively influence health, it is essential to integrate long-term behavior change and health promotion strategies alongside CMB interventions. A recent systematic review of sedentary behavior among university students emphasized the importance of incorporating elements such as awareness of negative health outcomes, behavioral self-regulation training, habit formation techniques, and ensuring the social acceptability of breaking up sedentary behavior. These components increase the likelihood of sustained behavior change (Castro et al., 2021). Therefore, integrating CMB interventions with educational and behavioral change strategies can impact health outcomes positively.

PA has shown potential for enhancing cognitive performance. However, there are significant differences in acute bout or chronic PA effects. Concerning the benefits of short bouts of PA, this narrative review highlighted improved concentration, alertness, and response times, underscoring the potential for this type of break to mitigate the mental fatigue associated with long lectures. Despite the exact mechanisms underlying changes in cognitive function following a short bout of PA remain unclear, increased arousal is frequently cited as a potential factor contributing to these cognitive benefits (Lambourne & Tomporowski, 2010; Pontifex et al., 2019). Physiologically, heightened arousal may lead to an increased release of catecholamines, which could trigger the cognitive enhancements associated with PA (Ludyga et al., 2016). Chronic PA, on the other hand, suggests that interruptions in prolonged periods of sitting time may improve concentration and alertness. The rationale for why this type of break improved concentration and alertness may partially be explained by the effort-recovery model (Meijman & Mulder, 1998). This model recommends that stress and fatigue are reversible with a pause. For this reason, it seems that the CMB did enable a sufficient pause from the mentally demanding task to permit recovery and, as a result, improvements in concentration and alertness (Meijman & Mulder, 1998). Despite the observed benefits for concentration and well-being, the evidence that CMB directly enhances academic performance is limited. This may be due to several factors, including the variability in how CMBs are implemented (e.g., the duration and intensity of physical activities) and differences in how academic performance is measured.

In conclusion, the current narrative review does not exhaust the available literature but instead uses examples to conclude and suggests the importance of PA interventions, such as CMBs, in university/college classrooms. Further research is essential to determine PA programs' optimal frequency and duration in university classrooms. Such research should consider various age groups and target populations (including students from minority or low socioeconomic backgrounds and students diagnosed with disorders).

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