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Acute Effects of 5-Minute Dance Active Break on Executive Functions, Mathematics, and Enjoyment in Elementary School Children

Dimitris Chatzopoulos[a,*], Eleni Mouchou-Moutzouridou[b], Panagiotis Papadopoulos[c], Georgios Katsanis[d], Vassilios Panoutsakopoulos[e]

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[a,*] **Corresponding Author:** Dimitris Chatzopoulos, School of Physical Education and Sport Science, Aristotle University of Thessaloniki, Thessaloniki, Greece.
E-mail: chatzop@phed.auth.gr
ORCID: https://orcid.org/0000-0001-5069-2613

[b] Eleni Mouchou-Moutzouridou, School of Physical Education and Sport Science, Aristotle University of Thessaloniki, Thessaloniki, Greece.
E-mail: mouchoue@phed.auth.gr

[c] Panagiotis Papadopoulos, School of Physical Education and Sport Science, Aristotle University of Thessaloniki, Thessaloniki, Greece.
E-mail: ppan@phed.auth.gr

[d] Georgios Katsanis, School of Physical Education and Sport Science, Aristotle University of Thessaloniki, Thessaloniki, Greece.
E-mail: gkatsanis@phed.auth.gr

[e] Vassilios Panoutsakopoulos, School of Physical Education and Sport Science, Aristotle University of Thessaloniki, Thessaloniki, Greece.
E-mail: bpanouts@phed.auth.gr
ORCID: https://orcid.org/0000-0002-9832-0314

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Abstract

Active breaks (AB) are short periods of physical activity in the classroom. The purpose of this study was to compare the acute effects of 5-minute dance break with an aerobic and a sedentary group on the executive functions, math performance and enjoyment of elementary school children. A total of 67 children (10.41±.13 years) of three fifth grade classes were randomly assigned to the three groups: dance (21 children), aerobic (24 children) and control (22 children). At the beginning and at the end of the intervention, all participants completed the Flanker task, the Digit Span test, the tower of London and a math test (mental calculations). In addition, the dance and the aerobic group were evaluated on their enjoyment level and physical activity intensity. At the end of the intervention both the dance and the aerobic group showed significant improvement in inhibition compared to pre-test. Moreover, the dance group showed higher levels of enjoyment compared to the aerobic group. The findings of the study suggest that even 5-minute dance break may positively affect children's inhibition and enjoyment. Children's enjoyment is crucial for AB participation and affects their academic performance. Therefore, children's enjoyment should also be considered in AB planning, and dance could be a suitable alternative compared to other AB physical activities (aerobic/strength activities).

Keywords:

Active Break, Executive Functions, Enjoyment, Mathematics, Elementary School

Introduction

Executive functions (EF) refer to a set of cognitive processes that are crucial for goal directed behavior (Baggetta & Alexander, 2016). According to Diamond (2013), there are three core EF: (a) working memory (ability to retain information in the brain and process it), (b) inhibition (ability to focus on a task by resisting impulses and distraction interference), and (c) cognitive flexibility (ability for quickly and flexible thinking to solve problems). EF assist young children in processing and learning new information and are related to mathematics and language abilities (Allen & Dowker, 2022; Micalizzi et al., 2019; Rocha et al., 2019).

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Recent studies reported that long-term regular physical exercise is beneficial not only for health-related variables (e.g. physical fitness, reduced obesity or bone health), but also for cognitive performance across different age groups (Liu et al., 2020; McPherson et al., 2018; Watson et al., 2017). The association between physical activity and cognitive performance is supported by evidence that motor and cognitive activities activate the same brain regions (McPherson et al., 2018). The mechanism underlying the positive effects of physical activity on cognitive performance is hypothesized to be the link between physiological arousal and cognitive functioning (Li et al., 2017). It is suggested that moderate to vigorous physical activity increases oxygenation and releases neurotransmitters that enhance attention, improving cognitive functions and overall school performance (Layne et al., 2021; McPherson et al., 2018).

Currently, active breaks (AB), i.e. short periods of physical activity inside the classroom, performed as a break from the lesson, are receiving great attention in the education field (Masini et al., 2020). The AB studies can be classified in two categories: (a) studies that investigate the effects of repeated, long-term AB (chronic AB, short physical activity bouts performed in multiple sessions per week and last several weeks or months), and (b) studies that investigate the acute effects of a single bout of physical activity inside the classroom (Donnelly et al., 2016). Regarding the effects of chronic AB, there is a consensus that they improve children's academic and behavioral outcomes (Egger et al., 2019; Mavilidi et al., 2022; Pesce et al., 2021; Vazou et al., 2021). However, the studies investigating the impact of a single session of exercise on cognitive functions have produced conflicting results. Some studies reported improvements in children's cognitive functions compared to the sedentary control group (Drollette et al., 2014; Ma et al., 2015; Schmidt et al., 2016), whereas other studies reported worsening effects (Egger et al., 2018; Gallotta et al., 2015), and others depicted no differences between AB and the sedentary control group (Calvert et al., 2019; Haas et al., 2022; Mavilidi et al., 2020; Yamazaki et al., 2018).

Possible explanations for the inconsistent results of the studies with a single bout of AB may be the duration and the type of AB interventions (e.g., aerobic, with or without cognitive engagement). For example, Howie et al. (2015), reported that durations of 10 and 20 min of moderate-to-vigorous intensity of AB improved math performance in 9 to 12 years old children compared to seated students (control). In contrast, there were no differences after the 5-min AB between the two groups (Howie et al., 2015). However, another explanation for the conflicting findings could be the level of enjoyment of the children in participating in AB. Most AB interventions include aerobic movements (e.g. marching/jogging on the spot, star jumps, various forms of hopping, push-ups), and these activities may not be appealing enough for children to initiate participation (Haas et al., 2022; Howie et al., 2015). The effectiveness of any survey depends directly on pupils' interest to participate, and many teachers reported that pupils are not interested in engaging in physical activities inside the classroom, such as running or jumping on the spot, because they do not find them appealing (Dinkel et al., 2017). Moreover, children's enjoyment is not only crucial for AB participation, but also determines the level of engagement in subsequent academic tasks and affects their academic performance (Brand & Ekkekakis, 2018; Özerk, 2020; Stevens et al., 2020). Hence, when developing an AB content, it is crucial to take into account not only the physical parameters of the AB (such as duration and intensity), but also the affective domain of the children (i.e., the appeal of the physical activities).

Dancing is a popular activity among children and combines physical activity with enjoyment (Chatzopoulos, 2019; Mouratidou et al., 2008). Moving in sync with the beat of the music has a positive influence on affective arousal and enjoyment (Bigliassi et al., 2017). Dancing activities are supposed to challenge both motor and cognitive systems (Kapodistria et al., 2021; Syarah et al., 2021). More, specifically, dancing requires learning new movements (mental effort), and synchronizing them with the music, and therefore it requires high cognitive engagement. Shen et al. (2020), reported that 8 weeks (3 times a week) of street-dance training improved the cognitive function of preschool children, and Zinelabidine et al. (2022) showed that an 8-week aerobic dance program improved cognitive performance in elementary school children. Moreover, Vazou et al. (2020), showed that a rhythmic program (moving to the beat with whole body movements, clapping and drumsticks) improved EF after 7 weeks (30 min, twice per week). While the results of studies regarding the positive chronic effects of dancing (i.e. long-term interventions) on cognitive function are consistent (Oppici et al., 2020; Rudd et al., 2021), there is no unanimity among the limited number of studies examining the acute effects of dance in the classroom (Liu et al., 2020). Fiorilli et al. (2021) compared the acute effects of a creativity program with a sedentary group, and reported significantly better performance of the dance group in attentive skills and math performance (each session lasted 15min). On the contrary, Egger et al. (2018) reported no significant effects of an acute dance program (20 min duration, consisting of the movements jump up, spin around and sit down in sync with the music) on the executive functions of second graders (7-9 years old). However, most of the primary school teachers are unwilling to implement active breaks of such long time durations in the classroom (Campbell & Lassiter, 2020; Chorlton et al., 2022; Dinkel et al., 2017). The biggest barrier in implementing AB of 15-20min is time in relation to curriculum pressures (tight academic schedule), and the majority of the teachers reported that AB durations of more than 5min are not feasible (Chorlton et al., 2022).

The aim of the present study was to compare the acute effects of a brief (5min) dance AB with an aerobic group (e.g., marching in place, star jumps), and a sedentary group on the EF, math performance and enjoyment in elementary school children. The first hypothesis was that the two intervention groups would perform better in EF and math compared to the sedentary one (control). The second hypothesis was that the dance group would perform better in EF and math compared to the aerobic group, because dancing is more mentally demanding than aerobic movements (e.g., running). This hypothesis was based on recent reviews which reported that cognitively challenging ABs ("mindful physical activity") showed better results compared to "plain" aerobic-exercise (e.g. star jumps, "mindless physical activity") (Diamond & Ling, 2019; Paschen et al., 2019). The third hypothesis was that the dance group would enjoy the participation in the AB more compared to the aerobic group, because dancing is more appealing than doing running or jumping on the spot.

Method

Participants

The sample size of the study was calculated using G*Power (version 3.1), by choosing in the field "Statistical test": "ANOVA, repeated-measures test, within-between interaction" (Faul et al., 2007). For the calculation of the sample size were used the following parameters: effect size f = 0.20 based on the meta-analysis of Greeff et al. (2018), α = 0.05, power = 0.8, number of groups = 3, number of measurements = 2, and correlation among repeated measures = 0.5. According to the analysis of G*Power, the optimal sample size is 66 children. Moreover, a dropout rate of 10% was considered, therefore, the minimum sample size should have consisted of 72 participants. The original convinience sample included 73 children from three fifth grade elementary classes of the same district. The classes were randomly assigned to the three conditions: dance, aerobic and control (Excel formula RAND). The data of seven children were excluded from statistical analysis because they did not took part in all requiered procedures (e.g. familiarization, pre- and post-testing). Therefore, the final sample size conprised 67 children (37 boys, 30 girls, age =10.41±.13 years). The dance group consisted of 21 children (12 boys, 9 girls, age =10.40±.24 years), the aerobic of 24 children (13 boys, 11 girls, 10.42±.14 years) and control 22 children (12 boys and 10 girls, age=10.39±.13).

According to the quardian reports the children were free of acute musculoskeletal injuries and had no diagnosed learning disabilities. The research was conducted in accordance with the ethical guidelines of local University. Informed consent was obtained from the guardian of the children, which also gave their oral assent. No child withdrew because of injury or any other adverse experience.

Measurements

The measurements were administered in the same fix order in all three groups: inhibition (Flanker-test), working memory (Digit-test), cognitive flexibility (tower of London), mathematics test, and enjoyment and intensity (conducted only in the dance and aerobic group). All measures were conducted in the computer classroom (one-two classrooms away from their classroom, transition time ~ 3-4min). The measurements were conducted by trained post-graduate students blinded to the treatments.

Inhibition

Inhibition was assessed with a computerized Flanker task with a fish as stimuli, using the Psytoolkit software (Stoet, 2010, 2017), (https://www.psytoolkit.org). The modified Flanker task with the fish differs from the adult version, as fish are used instead of arrows (Christ et al., 2011). There were two conditions with congruent and incongruent trials. During both conditions, five fish appear on the screen. On the congruent condition, all fish point in the same direction (left or right), whereas on the incongruent condition, the middle fish (target) and the flanking fish point in opposite directions. Children are instructed to indicate whether the target fish displayed in the center of the five fish is pointing either left or right, ignoring the direction of the other four fish. In case the target fish pointed left they had to press the A letter of the keyboard (the key was red colored), if the target fish pointed right, they had to press the L letter (the key was blue colored). There were a practice round consisting of eight trials, and two blocks of 32 trials with an equal number of congruent and incongruent stimuli presented in a randomized order, with a rest period of 30 sec between the two blocks (total 64 trials). Children were required to respond to the target as fast and accurately as possible. The task was presented as a game in which the children had to feed the hungry central fish (target). Following response execution, feedback was presented on the screen as either a smiley face (correct response) or a frowning face (incorrect response or no response). Incorrect trials, fast (< 200 ms), slow (> 3000 ms), or extreme responses (3 SDs from each children's mean reaction time) were not analyzed (McDermott et al., 2007). Mean reaction time (RT) of correct trials was used for statistical analysis. High RT scores indicate poor attention control.

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Working memory

Working memory was assessed with the Digit span test using the Psytoolkit software (Stoet, 2010, 2017), (https://www.psytoolkit.org). Numeric sequences are displayed on the screen, starting with two digits. The task requires participants to remember these sequences by clicking with the mouse the digits from a circle of digits. Two trials were administered for each sequence length; if participants were correct on either trial, then they advanced to the following sequence with the number of digits increasing by one. The task is ended when the children failed on two trials of the same length. Score is computed by counting the number of recalled digits in the presented order (Jones & Macken, 2015).

Cognitive flexibility

Cognitive flexibility was assessed using the Tower of London test (ToL) of Inquisit (Millisecond Software, www.millisecond.com) (Anderson et al., 1996). The test was downloaded on the computers of the school. On the screen is showed a set of three pegs and three colorful discs. Children are asked to arrange the three discs on the 3 provided pegs in a specific solution pattern, following specific rules (e.g. to move only one disc at a time, must be accomplished in a predetermined number of moves). The task consists of 1 practice and 12 trials with an increasing level of difficulty. The score of the correct configurations was used for data analysis (0-12 points). The test takes appr. 10min to complete.

Mathematics test – Mental calculation

The aim of the study was to examine the effect of an active break on mathematical performance. To achieve this, we employed a mathematics test that includes mental calculation tasks, as mental math is a fundamental topic in the mathematics curriculum worldwide (Lemonidis et al., 2018). To provide a tangible outcome for teachers, a timed mathematics test was administered. The children were asked to mentally calculate a series of 15 number operations: 5 additions, 5 subtractions, and 5 multiplications (Table 1) (Ligouras, 2012). All operations can be performed using holistic computation strategies, as the digits of the numbers are close to ten (7, 8, and 9). Our number system is based on 10, therefore the children have developed a strong intuition for numbers around 10, and it is easier to make calculations more intuitive. Moreover, when the digits of the numbers are close to 10, their magnitudes are similar, which makes mental calculations simpler (e.g. addition, subtraction or multiplication). The test requirements are age-related and structured according to the mathematics curriculum of fifth grade elementary school (Ligouras, 2012).

Table 1
Mathematics test

Nr	Addition	Subtraction	Multiplication
1	48+19	42-25	8*25
2	39+27	71-59	9*21
3	69+56	80-28	12*18
4	88+45	93-37	19*30
5	147+58	167-99	15*49

The operations in each column of the table have an increased difficulty: the first two operations are easy, the next two have a medium level of difficulty, and the last operation is difficult. For example, in the addition operations, the first two calculations yield a sum <100 (48+19, 39+27, easy calculations), the next two calculations yield a sum >100 (69+56, 88+45, medium difficulty) and the last operation is an addition with a three-digit number (147+58, difficult).

In the subtraction column, two operations are selected with a small difference (42 – 25, 72 – 59), two with a larger difference (80 – 28, 93 – 37), and one with a three-digit subtractor (167 – 99). Therefore, the first 2 operations are easy, the next 2 moderate, and the last one difficult. For the multiplications, 2 operations were chosen with a single-digit multiplier (8 * 25, 9 * 21) and 3 with double-digit multipliers (12 * 18, 19 * 30, 15 * 49), of which the last one is considered more challenging because 3 digits are larger than the number 3. Overall, each column of operations includes tasks of 3 difficulty levels.

The reliability of the test was determined by the test-retest method in a pilot study with 16 fifth grade children. The group was retested one week after the initial test and the intraclass correlation coefficient was very good ($ICC_{2,1}$=.88). The children of the reliability measurements were not included in the main study.

Enjoyment

The enjoyment of the physical activity was administered only in the dance and aerobic group, and was measured using the "interest – enjoyment" subscale of the Intrinsic Motivation Inventory (IMI) (McAuley et al., 1989). The "interest – enjoyment" subscale consists of four items (e.g., "I enjoyed the active break activities very much"), with a Likert scale from strongly disagree 1 to strongly agree 7. The questionnaire has been validated for the Greek population with fifth grade elementary school children (age 10 ± 0.5 years) by Diggelidis and Papaioannou (1999). Cronbach's α in the current study was acceptable for both groups (α > .77).

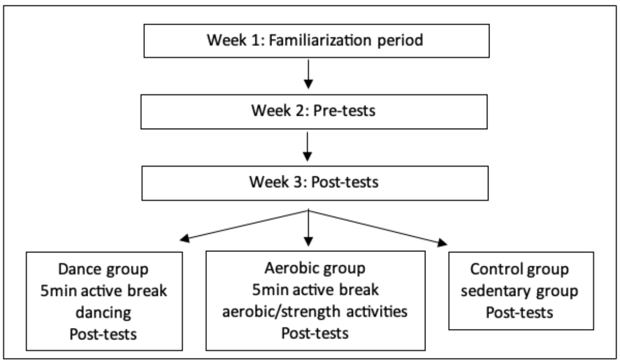
Physical activity intensity

The physical activity intensity of the two ABs groups was assessed using five Polar running watches (Polar model M200). Five children were randomly selected (Excel formula RAND), and the watches were placed before the start of the lesson. In the analysis was used the average heart rate (beats per minute, bpm) during the 5min of the AB (Antonopoulos et al., 2014).

Procedures

The total duration of the study was 3 weeks, and the three experimental conditions took place in the classroom. According to the school program, the scheduled time duration of the mathematics lesson consisted of 90min (10:00-11:30 a.m.). In the first week, all children were familiarized with the computerized testing procedures in the computer classroom, which was near their classroom. The pre-tests were administered during week 2 and the post-tests in week 3. Specifically, during week 2 children completed the pre-tests in the middle of the mathematics lesson (10:45 a.m.). In week 3 children from both intervention groups (dance and aerobic) completed the post-tests after the active break in the middle of the lesson. The children in the control group also completed their post-tests in the middle of the lesson in week 3 (without active break). The duration of the dance and aerobic active break was 5min.

Figure 1
Summary of study design



Intervention

The study included three groups: the dance group, the aerobic group, and the sedentary group (control). The classroom environment of the three classes was similar regarding class size, set-up, and teacher experience. Each class had its own teacher, with a teaching experience of 15 years. The content of the mathematics lesson during the intervention, was the same in all three classes and included the recapitulation of the topic "mental calculations" (part of the mathematics syllabus for fifth grade, second semester).

The content of the two AB programs (dance and aerobic activities) was selected by the study's authors, who are professors at the local university specializing in these fields, in collaboration with an experienced physical education teacher with dance qualification. The activities of the dance and aerobic groups were projected in pre-recorded videos with children of similar age (one boy and one girl), and the physical education teacher with dance qualification physically participated to encourage participation.

The choreography in the dance group and the activities in the aerobic group were demonstrated by the same instructor (a physical education teacher with dance qualification), and children were asked to copy the movements. The title of the song in the dance group was "Dance Monkey", by Tones and I (producer Konstantin Kersting), and the choreography was based on basic Zumba steps, e.g. toe tap, heel touch, tap side, lunges, various forms of march and jumping (https://www.youtube.com/watch?v=GRM9h8EQ6Bw).

The activities of the aerobic group were designed to maintain moderate to vigorous aerobic activity, and included aerobic and strength activities performed in minimum space, such as running on the spot, various forms of jumping, squat, and lunges (Fiorilli et al., 2021; Howie et al., 2015; Katsanis et al., 2021). Both AB groups finished with a stretching cooldown of deep breathing while holding the "Palm tree pose" (standing with separated feet and arms stretched overhead) (Chatzopoulos et al., 2015). The seated group (control) followed the regular mathematics lesson on the same topic, just like the two AB groups (mental calculations), and in the middle of the lesson performed the tests, except for the enjoyment test.

Statistical Analyses

Data was analysed using a two-way mixed ANOVA repeated measures design with the between-subject factor group (dance, aerobic and control group), and the within-subject factor time (pre vs. post). Homogeneity of variances (Levene) tests were conducted for all dependent variables. If the assumption of sphericity was violated, the Greenhouse-Geisser correction was employed. In the case of significant interaction, post hoc tests were conducted with Sidak correction to identify significant differences. The level of enjoyment expressed by the children participated in the dance and aerobic group was tested using t-test for independent samples. The physical activity intensity of the ABs was tested using the Mann-Whitney U- test.

Effect sizes of ANOVA are presented as partial eta square values (η_p^2 small effect: .02; medium effect: .13; and large effect: .26) and for t-tests as Cohen's d values (small effect: .2; medium effect: .5; large effect: .8). Effect size of the Mann-Whitney U- test was

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calculated using the formula $r = z/\sqrt{n}$, (z: standardised test statistic, n: total number of the sample for Mann-Whitney) (r=.1 small effect, .3 moderate effect and .5 and above large effect). All statistical analyses were conducted using IBM SPSS (version 28). Statistical significance was set at $p \le .05$.

Results

Table 2 presents the descriptive statistics for the dependent variables.

Table 2

Mean and SD of the dependent variables in pre- and post-tests

Task		Dance	Aerobic	Control
Flanker	Pre	844.46±159.91	817.79±154.82	836.22±162.59
	Post	833.28±173.24*	805.79±155.03*	814.13±157.32
Digit	Pre	4.04±.97	4.29±1.04	4.45±1.14
	Post	4.09±.83	4.41±.88	4.50±.91
Tower of London	Pre	8.42±1.20	9.04±.90	8.86±.94
	Post	8.57±1.16	9.16±.81	8.81±.85
Math	Pre	7.04±2.85	7.54±3.34	8.59±3.24
	Post	7.28±2.98	7.70±3.36	8.68±3.19
Enjoy-ment	Post	5.51±1.47	4.45±1.57	
Heart Rate	Post	126±7.58	139±8.6	

*: Significant difference between pre and post-test (p<.05).

Inhibition

At the beginning and at the end, there were no significant group differences (F = .17, p = .84, η_p^2 = .005, and F = .30, p = .73, η_p^2 = .009 respectively). There was a significant interaction between group (dance, aerobic and control) and time (pre- and post-test) of measurement (F = 3.64, p = .03, η_p^2=.10). At the end of the intervention the dance and the aerobic group performed significantly better compared to the beginning (t=2.2, p=.032, Cohen's d=.38 and t=2.48, p=.016, Cohen's d=.49 respectively). Whereas control group showed no significant improvement (t=.97, p=.33, Cohen's d=.33).

Working memory

At the beginning and at the end, there were no significant group differences (F = .80, p = .45, η_p^2 = .02, F = 1.27, p = .28, η_p^2 = .03 respectively). There was no significant interaction between group (dance, aerobic and control) and time (pre- and post-test) of measurement (F = .18, p = .83, η_p^2 = .006).

Cognitive flexibility

At the beginning and at the end, there were no significant group differences (F = 2.10, p = .13, η_p^2 = .06, F = .24, p =. 11, η_p^2 = .06 respectively). There was no significant interaction between group (dance, aerobic and control) and time (pre- and post-test) of measurement (F = .94, p= .39, η_p^2 = .02).

Mathematics test – Mental calculation

At the beginning and at the end, there were no significant group differences (F = 1.34, p = .26, η_p^2 = .04, F = 1.08, p = .34, η_p^2 = .03 respectively). There was no significant interaction between group (dance, aerobic and control) and time (pre- and post-test) of measurement (F = .35, p = .70, η_p^2 = .01).

However, according to the post hoc tests, the improvement (intra-group difference) between pre and post testing in the dance group was marginally not statistically significant (p = .06). The intra-group differences (comparison between pre- and post-measurement) for aerobic and control group were not significant (for aerobic p = .15 and control p = .45).

Enjoyment

Enjoyment was administered only in the two ABs conditions (dance and aerobic). Independent t-test revealed that the dance group enjoyed more the activity compared to the aerobic group (t = 2.30, p = .02, d = 1.52).

Physical activity intensity

The Mann-Whitney U- test showed that the aerobic group had a significant greater heart rate compared to dancing (U = 2.5, Z = 2.09, p = .03, r = .25). The maximal heart rate of children 10 years old is 210 (220—10). Therefore, the dancing activity elicited 60% of the maximal heart rate, and the aerobic activity 66%.

Discussion

The aim of this study was to investigate the immediate effects of two different types of AB (dance and aerobic) on EF, math performance and enjoyment of fifth grade elementary school children. The most common duration of AB interventions ranges around 10–20min (Ferreira Vorkapic et al., 2021; Mavilidi et al., 2022). However, classroom teachers are unwilling to apply such long durations due to the tight academic schedules (Campbell & Lassiter, 2020). The majority of the teachers consider an AB duration of more than 5min to be unrealistic (Chorlton et al., 2022). The unique contribution of this study is that the AB included only 5min dance activities (synchronized movements with the music), which was compared to a common type of aerobic AB used in previous studies (aerobic and strength activities) (Haas et al., 2022). According to the results of the study, the dance and aerobic groups showed a significant improvement in inhibition performance compared to pre-measurement. Considering the math achievement, the dance group showed marginally insignificant improvement (p =

.06). In terms of children's enjoyment regarding the two diverse types of AB, the dance group showed a significantly better level than the aerobic one.

The finding of our study that AB (dancing or aerobic exercise) improve the inhibition component of EF in elementary school children. stands in line with other studies with children and adolescents (Altenburg et al., 2016; Jäger et al., 2015; Niemann et al., 2013). The key similarity of these studies is the application of more than 10min of AB (Altenburg et al., 2016; Jäger et al., 2015). However, there is very little research examining the effects of ABs ≤5min on EF. Our study adds to the existing literature by demonstrating that even a 5min-single bout of physical activity has positive effects on inhibition. In contrast to our study Kubesch et al. (2009) reported no improvements in inhibition after a 5min classroom exercise break. On the contrary, Ma et al. (2015) reported that 4min of high-intensity AB can improve inhibition in 9- to 11-year olds. Furthermore, Cooper et al. (2016) reported that high-intensity 10X10s sprints improved the performance (response times) of the Stroop test (inhibitory control) in adolescents. The inconsistent results could be attributed to the different participant's age ranges, and/or the variability of the measurements. For example, in Kubesch et al. (2009) study the participants were 14 years old, whereas in our study, ten years old. Previous studies reported that the influence of age on inhibitory control could be affected by task-specific features, such as the type of stimuli and the type of interference (Bruin & Sala, 2018). Moreover, the attention span of children increases with age until 14-15 years when performance becomes more stable (it reaches a plateau in adolescence) (Dias et al., 2013). Therefore, young children may have more space for improvement compared to older ones (who have reached their maximal potential). For future studies, it would be interesting to examine the interplay of AB and age effects on inhibition by including a wide age range and different forms of inhibition measurements.

Our findings showed that both physical activity groups (dance and aerobic group, with and without cognitive engagement) improved their inhibition performance at the end of the intervention with small effects sizes. The mechanism that is hypothesized to explain these positive effects is that physical activity enhances cerebral blood flow, and increases the release of neurotransmitters, which are both factors that are assumed to positively influence cognitive performance after exercise (Yanagisawa et al., 2010). However, another explanation of the inhibition improvements after moderate exercise could be that inhibition is mostly measured with performance tasks based on reaction time (e.g. Flanker task). Therefore, improvements in reaction time after moderate exercise, which do not lead to exhaustion, could be the reason for better Flanker test performance. For instance, González-Fernández et al. (2022) reported improved reaction time performance after warm-up compared to no warm-up group. To shed light on this hypothesis, future studies could apply a simple reaction test and a Flanker task before and after AB.

Recent reviews reported that cognitive demanding AB ("mindful physical activity") may lead to greater gains in EF than "plain" aerobic-exercise (e.g. star jumps, "mindless" physical activity) (Diamond & Ling, 2019; Paschen et al., 2019). However, this hypothesis was not confirmed in our study. Although dancing is more cognitive demanding (as it requires movement sync with music), compared to aerobic movements (e.g. running on the spot), there were no significant differences between the dance and the aerobic group. In line with our study, Fiorilli et al. (2021) reported no significant difference between a 15min creativity group (creative tasks, such as dramatization of brief stories) and a fitness group (strength and aerobic activities such as squats, jumping jacks, lunges, and running on the spot) in Stroop test in grades 3, 4, and 5. Similar findings were reported by Schmidt et al. (2016) by comparing a physical activity group with high cognitive demands (touching numbers randomly painted on the ground in ascending order as quickly as possible) to physical activity with low cognitive demands (10min of running at different speeds). In addition, Egger et al. (2018) reported that an AB with cognitive engagement may even deteriorate children's shifting performance. In contrast to these results, intervention studies that manipulated the level of cognitive engagement reported larger effects in favor of the physical activity condition with high cognitive engagement (Benzing et al., 2016; Diamond & Ling, 2019). However, one basic problem with cognitive engagement as a factor, is its subjectivity. For example, in our study it was easy for some children to synchronize their movements with the music, whereas for others it was more difficult. Therefore, it is not easy to systematically manipulate the cognitive engagement component of a task since it is individually determined. For future AB studies it would be interesting not only to manipulate the cognitive engagement of the children in the AB conditions, but also to record their perceived cognitive engagement (Schmidt et al., 2016).

Dancing is among children's most favored activities, and it is closely related to enjoyment (Kapodistria et al., 2021; Lykesas et al., 2020). Enjoyment increases children's motivation for learning, reduces their anxiety and influences their math performance in a positive way (Mavilidi et al., 2020; Vazou et al., 2020). Therefore, it was expected that the dance group would present higher scores in enjoyment and Math than the aerobic and the sedentary groups. However, this hypothesis was partially confirmed, and although the dance group showed higher enjoyment compared to the aerobic group, there were no significant differences between the three groups in Math performance. These insignificant findings of our study are in line with other studies (Mavilidi et al., 2020; Todd Layne et al., 2021). On the contrary, Fiorilli et al. (2021) and Howie et al. (2015) reported positive effects of ABs on math performance. More specifically, Howie et al. (2015) reported that 10min of moderate-to-vigorous aerobic activity improved math scores compared to a sedentary group in 9- to 12-year-old children, but no improvements after 5min. Moreover, Fiorilli et al. (2021) reported that a 15min AB including strength and aerobic activities improved math performance of children (aged 9.61 ± 0.82 years), whereas there was no improvement in the creative group (dramatization of brief stories). The lack of improvement in the creative group was attributed by Fiorilli et al. (2021) to the low physical activity intensity in this group. Previous studies, indicate that moderate to vigorous intensity (70%-85% of maximal heart rate) has the greatest effect on cognitive performance (Etnier et al., 2016; Hötting et al., 2016; Jäger et al., 2015). In our study, the dancing activities elicited only 60% of the predicted maximal heart rate, and the aerobic activity 66%. Nevertheless, the low intensity dance group showed marginally insignificant improvements in Math (p=.06). The low heart rate levels, in the dance group (which showed higher enjoyment levels), might not have been enough for optimal arousal. Perhaps a future study with a higher intensity dance group would show better results. More research is needed to illustrate the interaction between intensity and enjoyment of AB in academic performance.

A limitation of the study was that this was a class-level intervention for organizational needs with different class-teachers. Due to the educational system in Greece, each class has its own class-teacher in Mathematics lesson, so perhaps the different teaching style of the teachers influenced the findings of the study. Moreover, the measurements were applied in a fixed order: inhibition was measured first, then working memory and cognitive flexibility, and finally the math performance. Perhaps the children were tired after the first measurements, and this may have affected their performance in the other tests. For future studies it is recommended to apply the measurements in a counterbalance order.

Conclusions

The current study compared the effects of dance AB and aerobic on EF, mathematics performance, and enjoyment of fifth grade children. Although the AB classes (dance and aerobic) did not produce differences in mathematics compared to the sedentary class, the improvements in inhibition in both AB classes suggest that only 5min of AB may facilitate changes in EF components. Furthermore, the dance group indicated higher enjoyment levels compared to the aerobic group. Children's enjoyment in the classroom is considered a key factor in improving EF and academic performance (Diamond & Ling, 2019). Therefore, a dance AB that improves children's enjoyment may also improve their academic performance (e.g., mathematics). Moreover, due to the pressure of time and the tight academic schedules, classroom-teachers are reluctant to implement AB of more than 5min (Chorlton et al., 2022). Therefore, for future AB interventions to be feasible and effective in a school setting, these two factors should be considered: (a) teachers' concern regarding instructional time and (b) children's enjoyment in AB activities.

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