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Effects of slackline training during active breaks and free-time activities break at school on children's attention: a comparison of two-intervention methods

Efectos del entrenamiento Slackline durante los descansos activos y las actividades de tiempo libre en la escuela sobre la atención de los niños: una comparación de dos métodos de intervención

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Abstract. Purpose: To describe the effects of two interventions, regular Physical Education classes plus free active break times and school Physical Education plus Slackline classes during free time, on the attention of schoolchildren. Methods: This is a quasi-experimental study with a quantitative approach. Two groups participated in the interventions: body balance training (Slackline group) (n: 10; age: 7,8±1,93) and free-time activities break (FTA group) (n: 10; age: 7,8±1,22). Attention was assessed using the D-2 test. Repeated measures ANOVA was used. The magnitude of the effect size was estimated by the partial squared eta - η^2_p. Results: When we analyzed the interactions between time*group, it was not possible to find significant changes attributed to the specificities of the one intervention group, with most results having a medium effect size ($\eta^2_p \geq 0.06 \leq 0.25$). The results of the paired analysis confirmed that both groups improved the results over time, but the slackline group showed changes with a slightly greater magnitude. Conclusions: Our results demonstrate that in free time, both free physical activities and body balance training are effective for children's attention. However, pairwise analysis revealed that both groups demonstrated improvements over time, with the slackline group showing slightly greater changes in magnitude.
Key words: Postural Balance, Physical Education and Training, Exercise, Psychomotor Performance, Cognition

Resumen. Objetivo: Describir los efectos de dos intervenciones, clases regulares de Educación Física más descansos activos y Educación Física escolar más clases de Slackline durante el tiempo libre, sobre la atención de los escolares. Métodos: Se trata de un estudio cuasiexperimental con enfoque cuantitativo. En las intervenciones participaron dos grupos: entrenamiento del equilibrio corporal (grupo Slackline) (n: 10; edad: 7,8±1,93) y descanso activo en el tiempo libre (grupo FTA) (n: 10; edad: 7,8±1,22). La atención se evaluó mediante la prueba D-2. Se utilizó ANOVA de medidas repetidas. La magnitud del tamaño del efecto se estimó mediante el eta cuadrado parcial - η2p. Resultados: Cuando analizamos las interacciones entre tiempo*grupo, no fue posible encontrar cambios significativos atribuidos a las especificidades de un grupo de intervención, y la mayoría de los resultados tuvieron un tamaño del efecto medio (η2p≥ 0,06 ≤ 0,25). Los resultados del análisis emparejado confirmaron que ambos grupos mejoraron los resultados con el tiempo, pero el grupo de Slackline mostró cambios con una magnitud ligeramente mayor. Conclusiones: Nuestros resultados demuestran que, en el tiempo libre, tanto las actividades físicas libres como el entrenamiento del equilibrio corporal son eficaces para la atención de los niños. Sin embargo, el análisis por pares reveló que ambos grupos demostraron mejoras con el tiempo, y el grupo de Slackline mostró cambios de magnitud ligeramente mayores.
Palabras clave: Equilibrio postural, Educación y entrenamiento físico, Ejercicio, Rendimiento psicomotor, Cognición.

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Introduction

Childhood, particularly the school years, comprises a significant phase of life marked by a crucial and delicate period of brain development (Andersen, 2003). During this period, children experience rapid growth and maturation of their cognitive (i.e., inhibitory control and attention), emotional, and physical abilities (Andersen, 2003; Diamond, 2013). The brain undergoes extensive neural connections and synapse formation, shaping the basis for learning, memory, and various cognitive processes (Kramer & Erickson, 2007). It is during this critical phase that children's brains are highly receptive to environmental stimuli from practices and behaviours such as physical activity and sedentary behaviour (Tomporowski & Pesce, 2019).

Attention is a crucial cognitive skill significantly influenced by behaviors like physical activity. This cognitive function allows individuals to focus on relevant information while filtering out distractions and is used throughout the process of acquiring theoretical or tacit knowledge. Considerably, there is substantial evidence supporting the correlation between physical activity during childhood and adolescence and cognitive performance, particularly in the domain of attention (Faigenbaum & McFarland, 2023; Fernandes M. de Sousa et al., 2019; Granacher et al., 2011).

In another way, studies have consistently shown a strong correlation between attention and academic performance (Polderman et al., 2010), where children with more developed attentional skills tend to have better academic outcomes (Sember et al., 2020). Selective and sustained attention allows students to focus on school tasks for longer periods, absorbing important information and avoiding distractions. Additionally, the ability to switch between different sources of information and maintain cognitive flexibility during learning activities is also related to academic performance (Mazzoccante et al., 2019). Therefore, effective strategies to improve children's attention can have a significant positive impact on their academic performance, providing a solid foundation for educational success.

In this line, based on evidence of positive effects in many different areas of child development, public health

recommendations for children and adolescents recommend accumulating at least 60 minutes of moderate to vigorous physical activity (preferably aerobic) daily, as well as muscle strengthening activities (more intense) at least 3 days a week (Bull et al., 2020). However, a large volume of evidence (Duarte Junior et al., 2022; Faigenbaum et al., 2020) also suggests, in addition to this amount of aerobic exercise and physical activity accumulated throughout the week, the development of muscle strength (i.e., body stability, strength of resistance, potency, etc.) and fundamental motor skills (jumping, rolling, balance) for continuous and autonomous development in physical activities throughout life (Faigenbaum & McFarland, 2023).

To the best of our knowledge, among all the aforementioned physical abilities and capacities, activities involving body balance (whether static or dynamic) have a high theoretical potential in relation to cognitive development (Sousa et al., 2019). While there is limited direct research specifically linking attention development with body balance activities, our hypothesis argues that engaging in activities that challenge postural balance can have indirect benefits for attention and cognitive function.

Body balance activities require focus, concentration, and coordination, and can help develop attention skills over time (Donath et al., 2017; Granacher et al., 2011). Evidence demonstrates that these activities involving the maintenance of stability during the execution of tasks, are directly related to the improvement of proprioception and sensory integration (Donath et al., 2013a, 2017). These sensorimotor skills are intertwined with cognitive processes, including attention (Sousa et al., 2019; Arumugam et al., 2019), as they involve the integration of sensory stimuli and motor responses. Thus, this range of evidence is not capable of answering whether dynamic balance activities in the school environment are effective strategies for the development of attention.

The school has a high potential to promote physical activity and a healthy lifestyle for decades. For example, simple strategies such as active breaks are recommended by organizations like UNESCO (UNESCO, 2015). It is estimated that spaces where children can engage in activities independently and freely hold potential for developing habits related to physical activity. This potential is now even greater and urgent, since, after a long period of social confinement due to the COVID-19 pandemic, some more recent evidence suggests that children have suffered direct effects, such as a lower development of attention, executive functions, and metacognition (Araújo et al., 2021; Phelps & Sperry, 2020; Xin et al., 2020). Therefore, we consider an urgent demand to increase knowledge about the effects of different methodological strategies to promote physical activity at school on variables such as attention (Liu et al., 2020). In this case, based on the gaps that still exist in knowledge about this topic, this study aims to describe the effects of two interventions, regular Physical Education classes plus free active break times and school Physical Education plus Slackline classes during free time, on the attention of schoolchildren. As highlighted previously, we believe that guided activities with an emphasis on body balance have a greater effect on attention than free physical activities.

Methods

Design and participants

This is a quasi-experimental study with a quantitative approach. We seek to describe the effects of two ways of intervening in elementary school on children's attention. Figure 1 describes the complete diagram of the experimental design, in addition to already presenting the two groups: body balance training (BBT) group and free-time activities break (FTA) group.

This study was approved by the ethics committee of the Faculty of Rehabilitation Sciences at Universidad Andres Bello (A-066), and prior to training, the director of the establishment authorized the conduct of the study. In addition, each student's tutor authorized their student's participation via informed consent, and each participant granted their interest in participating.

All students from an elementary school in Viña del Mar, Chile, were invited to participate voluntarily in the study (n = 46), and they could opt for one of the groups during break time. The students expressed willingness to participate in one of the two groups, so the allocation was carried out. The first group performed body balance training (slackline) during the active interval, and the second group performed free activities during the interval period.

The eligibility criteria were: 1) being regularly enrolled and attending school; and 2) being aged between 6 and 10 years. For the analyses, data from students who had non-attendance greater than 70% were excluded, and data from students with injuries and/or motor alterations required individual adaptations of intervention activities.

The total number of students at the elementary school invited to participate in this study was 46. From all of them, one did not meet the inclusion criteria (health condition incompatible with the activity) and three did not want to participate in any workshop. The remaining 42 students were invited to participate in the slackline workshop or in the free physical activity during active breaks. Thus, 20 students expressed their interest in participating in the slackline workshop and 22 preferred free activities. During the development of the interventions there were many absences mainly due to colds, so four students from the slackline group and six from the free activities group were excluded from the analysis because they did not have 70% of the attendance. And finally, the last reduction in the sample was due to students who did not appear for the second evaluation (see figure 1).

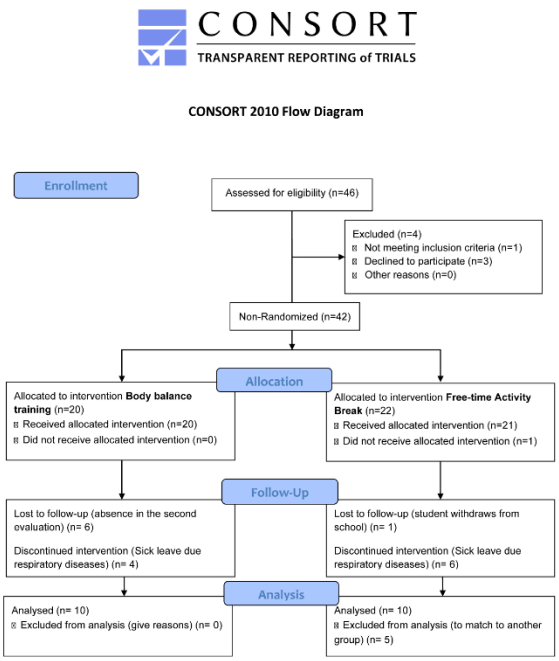

Figure 1. Flow diagram on experimental design.

General procedure

The two groups were evaluated with similarity in time and intervention-evaluation time interval. Interventions were carried out for 8 weeks. Post-intervention assessments were performed on the same days and times as the interventions (figure 2). Finally, attention was assessed of all participants, before and immediately after the last section of the intervention.

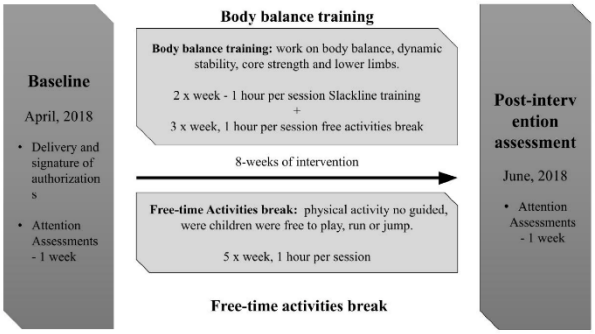

Figure 2. Overview of study design and the 8-week body balance training and free-time activities break interventions, Viña del Mar, Chile, 2018.

Body Balance Training (BBT group)

Body balance training consisted of teaching to move on slackline ribbons, maintaining control of body balance, varying positions from decubitus (prone and supine), to sitting, standing, and moving by walking or jumping on the ribbons. During the initial stages of the training, the participants familiarized themselves with the slackline ribbons, assisted by one of the monitors, starting with ribbons placed close to the ground, at a height of 30 cm and with a length of 3 m (see figure 3-a). As the participants demonstrated confidence and control over the ribbons, they were placed higher from the ground (50 cm) and with a greater distance (6 meters, see figure 3-b). Once this stage is mastered, participants are invited to progress using a single ribbon with a length of 6 (m) plus a rope with two hanging straps to reach the hands above head level for individual balance (see figure 3c–d). And in the last stage of training, the participants managed to walk between 6 m and 15 m without the help of a monitor, with a manual assistance rope for individual assistance if necessary.

Figure 3. Progression of body balance training using slackline ribbons

Free-time activities break (FTA group)

It consists of 1 hour of rest from academic activities, where unguided physical activity is carried out, 5 times a week. During this break, students have a recess period during which they must be outside (not in the classrooms), playing and interacting with their peers. It was designed to promote physical activity by allowing them to use balls, ropes, run and jump in the schoolyard. It should be noted that the amount of physical activity is the same in both groups: while the FTA group received their 1-h intervention 5 times a week, the BBT group received the 1h BBT intervention twice a week and the rest of the days this group participated in the FTA.

D2 attention test

The D2 test allows the measurement of selective attention, understood as the ability to selectively attend to certain relevant aspects of a task while ignoring irrelevant ones, doing as quickly and accurately as possible. Briefly, the d2 Test is a paper-and-pencil test, consisting of 14 rows (trials), each with 47 interspersed "p" and "d" characters. The target symbol is a "d" with two dashes (hence its name "d2"), regardless of whether the dashes appear both above the "d", below the "d", or one above and below the " d".

Therefore, a "p" with one or two dashes and a "d" with more or fewer dashes are distractors. The participant's task

was to mark as many target symbols as possible, starting from left to right, with a time limit of 20 seconds per row in the test (Bates & Lemay, 2004; Jiménez et al., 2012). The D2 test distinguishes several dimensions for the calculation of the concentration index, which are:

- Total Responses (TR): It is a score for the total number of items processed or attempted in the entire test. It is a quantitative measure of the total set of items that were processed, both relevant and irrelevant.

- Total Hits (TA): It is the total number of hits, the times that the letter "d" with two dashes was marked by the participant.

- Omissions (O): number of relevant elements not marked.

- Commissions (C): number of irrelevant elements marked.

- Total Effectiveness in the Test (TOT): It is the number of elements processed (TR) minus the total number of errors (O + C). It is a measure of the amount of work done after eliminating the number of errors made.

- Concentration Index (CON): This measure (concentration) is derived from the number of correctly marked relevant elements (TA) minus the number of commissions (C).

Statistical analysis

Data were checked for normality by the Shapiro-Wilk test, visual inspection of the histograms with distribution curves, Q-Q plots and box plots. Homogeneity was analyzed by the Levene test. Data were analyzed in two stages: 1) Descriptive statistics (mean and standard deviation) were calculated at baseline and post-intervention. The "Paired t test" was used to calculate the difference between paired observations (before and after). 2) To analyze the effects between baseline and post-intervention values, repeated measures ANOVA was used. The magnitude of the effect size was estimated by the "partial squared eta - η^2_p" and classified according to Cohen (1988) as: small ($\eta^2_p \leq 0.05$), medium ($\eta^2_p \geq 0.06 \leq 0.25$), large ($\eta^2_p \geq 0.26 \leq 0.5$) e very large ($\eta^2_p > 0.5$). Statistical analyses were performed stratified by sex in SPSS version 24.0 software, with a 5% probability of error in the analyses.

Results

For 8 weeks, 10 children participated in a body balance training program using Slackline as a strategy, with an average age of 7.8 ± 1.93 years, and 10 children participated in Free-time activities break group, with an average age of 7.8 ± 1.22 years, all of them from Viña del Mar, residing at the neighborhood of the school. The average number of complete sections was 11 out of a total of 14. At baseline, the groups showed no difference in anthropometric characteristics and selective attention results (p>0.05 for all outcomes; table 1). It is important to mention that although the BBT group presented a much lower omission (O) average, and in addition to presenting a slightly higher Total Effectiveness in the Test (TOT) on average than the FTA group, the general attention index results demonstrate that there is, at the moment baseline similarity between groups. The results on selective attention show high variability, but this phenomenon occurs in both groups.

Table 1.
Sample characteristics and attention indicators by D2 test in baseline.

	Body Balance Training group (n=10)		Free-time activities break group (n=10)		p-value
Characterization	$\dot{X}$	±SD	$\dot{X}$	±SD	
Age (years)	7,8	1,93	7,8	1,22	1
Height (cm)	126,7	6,4	127,79	6,79	0,79
Weight (kg)	28,74	6,99	29,61	7,39	0,716
BMI (kg/m^2)	17,71	3,08	18,1	3,8	0,857
D2 attention test	$\dot{X}$	±SD	$\dot{X}$	±SD	
TR	46,4	26,45	43,7	45,326	0,873
TA	18,8	11,526	16,1	23,082	0,746
O	12	16,303	25,6	30,486	0,229
C	31,1	26,308	41,6	24,541	0,368
TOT	31,7	27,052	29,2	30,944	0,85
CON	15,7	12,266	17,2	22,924	0,857

$\dot{X}$±SD: mean and standard deviation; TR: Total Responses; TA: Total Hits; O: Omissions; C: Commissions; TOT: Total Effectiveness in the Test; CON: concentration Index.

The significance level for changes over time (p-value (t)) considered that, regardless of the group, there were significant changes in the variables TR, TA, O, TOT, and CON. However, when we analyzed the interactions between time*group (p-value (i)), it was not possible to find significant changes attributed to the specificities of the one intervention group, with most results having a medium effect size ($\eta^2_p \geq 0.06 \leq 0.25$).

Table 2.
Interventions effects on selective attention in children.

d2 attention test	Body Balance Training group			Free-Time Activity group			η^2_p	p-value (t)	p-value (i)
	$\dot{X}$	±SD	Δ	$\dot{X}$	±SD	Δ			
TR	87,4	22,89	41,0	71,2	38,05	27,5	0,053	<0,001	0,328
TA	61,3	31,00	42,5	39,4	37,99	23,3	0,108	<0,001	0,157
O	7,2	9,53	-4,8	14,1	24,59	-11,5	0,042	0,044	0,384
C	22,2	24,43	-8,9	37,6	29,79	-4,0	0,005	0,443	0,769
TOT	75,2	30,32	43,5	58,4	39,19	29,2	0,057	<0,001	0,311
CON	51,0	33,73	35,3	39,0	35,88	21,8	0,067	<0,001	0,272

$\dot{X}$±SD: mean and standard deviation; Δ: pre-post mean difference; TR: Total Responses; TA: Total Hits; O: Omissions; C: Commissions; TOT: Total Effectiveness in the Test; CON: concentration Index.

The results of the paired analysis confirmed that both groups improved the results over time, but the slackline group showed changes with a slightly greater magnitude for all attention variables (figure 4). For TR, TA, TOT, and CON the differences in variations between groups were very high, all with an advantage for the BBT group.

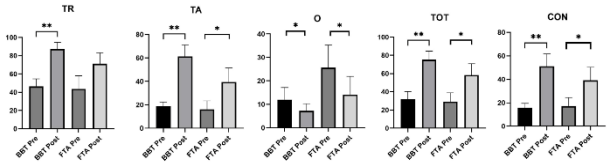

Figure 4. Paired analysis of individual attention variables differences.

Discussion

This study proposed to describe the effects of two interventions, regular Physical Education classes plus free active break times and school Physical Education plus Slackline classes during free time, on the attention of schoolchildren. Our main findings showed that the two interventions have positive effects (medium effect size: $\eta 2p \geq 0.06 \leq 0.25$) on the attention indicator, especially the assertive indicator of the D-2 test. Although we found no difference between groups in the post intervention assessment, the difference to baseline values were greater in the BBT group, in the magnitude of four attention variables. According to our findings, including free activity break times or slackline classes in addition to regular Physical Education, can result in boosting attention levels in children between 6 and 10 years old. This suggests that physical activity performed during school time, besides the Physical Education classes planned in the regular scholar curriculum, could be considered an adequate tool to stimulate and improve cognitive functions, such as attention, especially after the neglectful effects caused by the pandemic and confinement in the latter years.

General findings

Our results presented here sustain the premise that physical activity, in general, has a positive effect on children's cognition. Specifically, about attention, the influence of physical activity is widely supported by research too. Studies, such as the one conducted by Hillman et al. (2009), have demonstrated that participation in physical exercise programs during the school day can result in significant improvements in children's attention and cognitive function. Similarly, research conducted by Tomporowski et al. (2008) found that acute physical activity has the capacity to enhance aspects of attention, while the comprehensive review by Trudeau & Shephard (2008) highlighted the positive association between physical activity and cognition, including attention, in children and adolescents.

Furthermore, studies like Mahar et al. (2006) emphasize that even short intervals of physical activity throughout the school day can have a notable impact on children's attention and concentration. These collective findings indicate that the incorporation of physical activities in schools not only promotes physical well-being but also plays a vital role in supporting the development of children's attention and cognitive function.

Why balance training has even more effect than general physical activities

Although physical activity has largely been shown effects on cognitive functions (Ferrer-Uris et al., 2022), our results are showing that balance training has even more effect than general physical activities, which is in line with recent evidence related to the effects of balance training on executive functions: more specifically, balance training has been demonstrated positive effect on spatial orientation (Dordevic et al., 2017), spatial perspective (Hötting et al., 2021), inhibitor control (Wen et al., 2023) and also attention (Plaza, 2023). Beyond the molecular mediators involved in the neuroprotective mechanisms that are explaining the beneficial effects on executive functions through different types of exercise (de Menezes-Junior et al., 2022), it seems that to be able to keep corporal balance in unstable situations (as over a slackline ribbon or in ballet dancers), it demands concentration and sustained attention, involving a strong connection between motor and cognitive processes. This integration can lead to more efficient communication between different brain regions, as striatal network (Magon et al., 2016), as well as contributing to increasing the volume of crucial brain structures involved in these cognitive processes as hippocampal formation (Hüfner et al., 2010), which is beneficial for motor and executive functions.

Thus, based on our findings, we could suggest that incorporating a variety of physical activities, including balance training, into a child's routine can contribute to their overall cognitive and physical development. It's important to note that while there is evidence suggesting a positive relationship between balance training and executive functions, the extent of the effects can vary based on factors such as the type and intensity of the training, the individual child's baseline abilities, and the duration of the training program (Donath et al., 2013b).

Strengths and limitations

Our results show a great contribution to decision-making in the school environment, however it is important to note that this study has some methodological limitations: 1) by choice, we did not include a control group with the justification that we started with the premise of a positive effect, that is, we would not want to deprive a group of these effects; 2) for administrative reasons at the school, it was not possible to include more children in the sample, which left the sample size very limited; and 3) Non-random assignment to the groups could be considered a limitation of the study, as this factor may impact the internal validity of the results.

However, it is important to highlight some strengths of this study, such as including an intervention program that is uncommon in the school environment (slackline) and demonstrating its effectiveness and pedagogical possibility of application. Furthermore, we assessed attention,

which is an important cognitive ability and represents many abilities manifested in the school context.

Practical applications

Based on our study findings, we recommend incorporating both structured body balance training programs, specifically utilizing Slackline, in addition, it is possible, free physical activities during breaks to enhance children's attention. Structured programs should ensure consistency and adherence to the training protocol, while incorporating free physical activities allows children to engage in movement of their choice. Schools can allocate dedicated time for active breaks and create active break spaces equipped with balance tools like Slackline. While both approaches were effective, structured body balance training programs, including Slackline, showed slightly greater improvements in attention. Therefore, adopting a holistic approach that combines structured training and free play can optimize attentional development in children, supporting their cognitive and overall well-being.

Conclusion

Collectively, our study findings highlight the effectiveness of both free physical activities and structured body balance training, particularly with Slackline, in improving children's attention during free time. While significant improvements were observed across various attention variables regardless of the intervention group, the Slackline group showed slightly greater improvements in magnitude. This suggests that incorporating structured body balance training, such as Slackline, may yield more pronounced benefits for children's selective attention compared to free physical activity alone. Nonetheless, providing active break spaces for free activities also appears beneficial for enhancing attention in children.

Conflicts of Interest

The authors declare no conflicts of interest with regard to the research, authorship, and publication of this article.

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