Journal of Physical Education and Sport ® (JPES), Vol. 21 (1), Art 40, pp. 406 - 415, January 2021
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Effects of physical warm-up on the attention of adolescent students

VICTOR SILVA-CAPELLA[1]; RÓMULO JACOBO GONZÁLEZ-GARCÍA[2]; CARLOS PÉREZ-CAMPOS[3]
[1,2,3,]Department of Teaching and Learning of Physical, Plastic and Musical Education [Physical Education Area], Catholic University of Valencia San Vicente Mártir SPAIN

Published online: January 30, 2021
(Accepted for publication January 22, 2021)
DOI:10.7752/jpes.2021.01040

Abstract
The purpose of this study was to analyze the effects of two different types of physical warm-up on selective attention (AS) and concentration of physical education (PE) students. Warm-up was used as a tool for this optimization; different variables were applied to compare their effects on students' attention and concentration. Attention is a frequently studied variable that is associated with success in different settings including academic and sports. The participants of this study were 160 students (77 girls and 83 boys), who were between 12 and 17 years old. The students were randomly divided into two experimental groups (n = 106) and a control group (n = 54). As a study procedure, an experimental group (n = 55) performed a physical warm-up based on 10 min of repetitive exercises of moderate intensity that were directed by a direct command and had low cognitive demands. The other group (n = 51) performed a physical warm-up of equal duration and intensity; however, the warm-up was based on an open and playful task with many stimuli and a high need for fast decision-making. Then, the D2 test was used to observe students' attention and concentration. The obtained results showed no significant differences in attention and concentration according to the type of performed warm-up ($p > .05$). However, differences were observed in the effects of these cognitive functions with respect to other variables such as sex, age, or school year ($p < .05$). The lack of effectiveness in testing the proposed warm-ups suggests the need to continue experimenting with different variables (e.g., volume, intensity, teaching style, and stimuli) to determine their possible effects on students' attentional capacities.
KeyWords: **Physical education, warm-up, selective attention, concentration**

Introduction

There is now a wealth of research that demonstrates the great benefits, both physical and psychological and social, to be gained from school-based physical education (PE) classes (Ferkel et al., 2019; Klein and Hollingshead, 2015; Kulinna et al., 2018; Thorburn, 2017).

However, a WHO report (2018) states that more than 80% of the world's adolescent population does not achieve the recommended level of physical activity (PA), set at least one hour per day of moderate to extreme intensity. According to this same source, this situation shows an improving trend, 56% of WHO Member States have implemented policies to reduce this physical inactivity, which has been agreed to reduce by 10% by 2025. In this sense, many teachers of PE in Secondary Education have demanded a more significant teaching load in their subject to develop the contents in an optimal way (Albarracín et al., 2014).

Attention.

Attention is a widely studied concept in today's science, especially in recent years. (Khan and Hillman, 2014). This essential cognitive ability is related to success in academia, sports, and social studies (Perlman et al., 2014; Rabiner et al., 2016). Also, it is related to several aspects of learning and memory storage, being a crucial requirement when learning and remembering stored information (Hillman et al., 2003). Therefore, we can deduce the great importance of this capacity in children and adolescents, a population that is in a constant formation stage.

The definitions of cognitive constructions, such as attention, are ambiguous (Frey et al., 2015). Considering that these definitions are prone to be blurred and evolve, this study will follow the pragmatic vision. Summerfield andEgner (2009) define attention as a mechanism that "relieves the computational burden by prioritizing the processing of that subset of information that is considered to be most relevant to the objectives of the organism (p. ...)". Fuentes Melero andGarcíaSevilla, (2008), from a more general perspective, define attention as the mechanism directly involved in the processes of selection, distribution and maintenance of psychological activity. On the other hand, selective attention (SA) refers to the processes that allow an individual to select and focus on a particular stimulus for its subsequent processing while at the same time suppressing irrelevant or distracting information (Stevens and Bavelier, 2012). It is essential to know that the neural regions involved in the effective deployment of HA show a prolonged period of structural development, which can last at least 30 years of a person's life (Gogtay et al., 2004). This slow maturation of the influential neural

Corresponding Author: VICTOR SILVA-CAPELLA, E-mail: silva_0093@hotmail.com

architecture for selective attention suggests that, during the school stage, the students' HA is in the process of development (Tsujimoto, 2008).

Research in this line has also shown that this capacity is sensitive to changes in the environment. Thus, children from lower socioeconomic backgrounds show reduced SA values about their peers from higher socioeconomic environments (Stevens et al., 2009). Similar results have been obtained in a study by D'Anguilli et al. (2008) with an adolescent population. This finding suggests that there are individual differences during development in the ability to deploy SA. More generally, the results indicate that the capacity to control SA is developmentally sensitive. Although this capacity is practically available, its control may not be exploited to the same degree by all children.

In this sense, Stevens and Bavelier (2012), have investigated the possibility that attention is trainable in itself, concluding affirmatively with its malleability properties. Likewise, Rueda et al. (2005), in their pre/post attention training study, indicated that children who underwent training showed evidence of improvements in a neurophysiological measure of selective attention. It is essential to recognize that many factors determine academic performance. According to Stevens and Bavelier (2012), the appropriate deployment of HA has a cascade of beneficial consequences on neural processing and, therefore, can have significant effects on several domains for academic foundations. Similarly, a review by Rueda et al. (2010) has linked aspects of self-regulatory attention with implications for educational and socio-emotional functioning. Besides, these same authors also found improvements in standardized measures of IQ following a program of attention training. Another study, seeking a more comprehensive analysis, developed an eight-week preschool care training program that included both activities for children and strategies for parents. Results indicated that after training, parenting practices improved, parental stress decreased, and behavior, cognition, and brain functions that support children's attention improved significantly over the control group (Neville et al., 2013).

To the extent that AS skills are relevant to academic foundations and can be improved, they represent a fundamental education approach. Their power to influence student learning outcomes and teach them to "learn how to learn" is evidenced by children's progress in traditional academic content (Stevens and Bavelier, 2012). It is important to mention a concept that goes hand in hand with this ability. We refer to concentration. According to Buehner et al. (2006), the ability to maintain attention at a high level of intensity and precision is called concentration. That is to say, once we have selected the stimulus (through selective attention), concentration is responsible for using the greatest amount of neuronal resources for that stimulus, preventing energy from being spent on distracting stimuli. This ability to concentrate becomes vital in the present study, while cognitive research shows its influence on success in any performance field (Moran, 2012). These concepts can lead to confusion in the scientific literature due to the great diversity of theories and views derived from attention. Even selective attention has often been defined as concentration.

In the field of Physical Education, attention has also been the object of study by various authors, insisting on the relationship between physical activity and attention in samples of children or adolescents (Aguayo et al., 2018; Gallotta et al., 2015; Kulinna et al., 2018; Reigal et al., 2020). However, the results of these investigations are very different, depending on the variables analyzed. For example, focusing on physical condition (understood as a chronic aspect), several studies relate greater selective attention to a higher level of physical fitness, especially aerobic capacity (Guiney and Machado, 2013). Similarly, Reigal et al. (2020), relate a higher number of weekly hours of physical activity performed by adolescents with better cognitive functioning, specifically of AS. On the other hand, it has also been recently shown that children's mental functions can improve acutely after a session of physical activity (Gallotta et al., 2015). However, this improvement may depend on aspects such as the duration of physical activity (McNaughten andGabbard, 1993), the intensity (Budde et al., 2010), or the nature of the activity (Budde et al., 2008). In a review, Janssen et al. (2014), comparisons are made between exercise intensity and its acute effects on attention, determining that an inverted "U" relationship can be found. With too high an intensity, the positive impact on attention is lost, and similarly with too light an intensity. Also, Budde et al. (2010) showed more significant advantages in the cognitive performance of adolescents after performing moderate-intensity PA (50-65% HR max.) compared to high-intensity PA (70-86% HR max.).

Concerning the duration of PA, Janssen et al. (2014) analyze studies carrying out a physical activity of between 10 and 45 minutes, show how most studies that worked with a duration of less than or equal to 20 minutes conclude to find significant effects on attention. On the contrary, in Pirrie and Lodewyk's study (2012), no attention effects are seen after 45 minutes of physical activity.

Finally, about the type of physical activity carried out, Budde et al. (2008) show more significant benefits in attention and concentration of an adolescent sample after carrying out 10 minutes of coordination exercises than after carrying out 10 minutes of ordinary physical education (carrying out both activities at the same intensity). In this sense, the scientific community affirms the influence of physical activity in improving attention. However, it is essential to bear in mind that physical activity is an aspect that contains various variables (volume, intensity, nature, context...). Hence, one of the main objectives of current science is to analyze this relationship "physical activity - attention," according to the different possible variables (Kulinna et al., 2018; Pérez-Lobato et al., 2016).

Warm-up

Just as the relationship between physical activity and cognitive performance or the relationship between warm-up and sports performance has been widely studied, sufficient documentation has been found on warm-ups and its benefits on cognitive functions as such (Elsworthy et al., 2013). At a general level, according to Woods et al. (2007), warm-ups are intended to perform two main functions: improve the dynamics of a muscle so that it is less prone to injury and prepare the person for the demands of exercise. These functions are carried out thanks to certain physiological changes such as acceleration of metabolic processes, reduction of muscle viscosity, dissociation of oxygen from haemoglobin at higher plasma oxygen concentrations (which provides more oxygen to the muscles), increased blood flow due to vasodilation or increased nerve transmission (McArdle et al., 2010). However, as with the AF-Care relationship, there is also a great deal of interest in understanding the effects of its various variables, such as duration or intensity. To know which warm-up is the most effective for the objectives previously set up, Bishop (2003), establishing an increase in muscle temperature as the main objective of warm-up, states that an intensity of more than 60% of maximum oxygen consumption (VO2max) reduces the concentration of high-energy phosphates, which would worsen performance in the main task. He, therefore, suggests using intensities of between 40-60% VO2max to increase muscle temperature without affecting subsequent performance.

On the other hand, numerous studies focus on the optimal duration of the warm-up and varied results (Krčmár, et al. 2016; Obetko et al. 2020). For example, in some studies, specific improvements were observed only after a 10-minute warm-up (Jamshidi et al., 2016), whereas another study by Manchado et al. Similarly, Pardeiro andYanci (2017) observed how a 25-minute warm-up led to a decrease in physical performance in football players, while Dumitru (2010) observed improvements after 20- and 30-minute warm-ups. In conclusion, the different studies on optimal warm-up duration suggest that the warm-up should be long enough to increase body temperature but short enough not to decrease physical performance (Woods et al., 2007). Of course, intensity should also be considered to meet this objective.

After presenting the different benefits of warming up before physical activity and analyzing the variables that lead us to perform the optimal warm-up, it is highlighted the lack of scientific literature that relates the warm-up to the improvement of cognitive abilities. Some examples of these cognitive variables are attention, which would provide valuable information in physical education and the competitive field. That said, this study will analyze the acute influence of different warm-ups on the capacity for selective attention and concentration in the school environment.

Material & methods

Participants

The sample used is made up of 160 students from a secondary school in Valencia. It should be stressed that all the participants presented an optimal state of health for the test, without physical impediments or psychological pathologies.

Table 1. Frequency descriptors in percentages for all variables analyzed

VARIABLE	VALID PERCENTAGE (N=160)		
Gender	Male	Female	
	51,90%	48,10%	
Age	12-13 years	14-15 years	16-17 years
	55,60%	18,10%	26,30%
Warm-up	Warn-up 1	Warm-up 2	Control group
	34,40%	31,90%	33,80%

Instruments

For the data collection, Test D2 (Brickenkamp, 2012) was used, a scientific recognition tool that belongs to the category of instruments that seek to measure basic psychological processes. This particular test provides an estimate of selective attention and mental concentration. The test can be taken collectively and lasts 4 minutes and 40 seconds (not including explanations or completing the initial questionnaire). The test grid has 14 rows with 47 characters each, making 659 items that the participant should perceive and analyze quickly. These elements contain the letters "d" or "p" and may be accompanied by one or two small lines at the top and/or bottom of each letter. The subject's objective is to carefully and quickly review, from left to right, the stimuli in each row and mark with a diagonal line the letters "d" with two lines (located above, below, or one above and one below).

These elements will compose the relevant stimuli (i.e., the important ones and therefore be selected). All other combinations (the "p" with or without lines and the "d" with one or no line) are considered as irrelevant or distracting stimuli and, therefore, should not be selected. For this selection of information to be made quickly, the participants will have 20 seconds to work on each row. At the end of the test, the results are divided into different variables:

Table 2. Variables extracted from test D2

SIGLAS	VARIABLES	CONTENIDO	PROPOSITO
TR	Total responses	The number of elements crossed out in total.	Measures the processing speed and the amount of work done
TA	Total hits	The number of relevant elements crossed out.	Measures processing accuracy
O	Omissions	The number of relevant elements attempted but not marked.	Measures processing accuracy
C	Commissions	The number of irrelevant elements marked.	It measures the accuracy of processing and inhibitory control.
TOT	The total effectiveness of the test	TR – (O + C)	Measures the overall effectiveness of the test
CON	Concentration index	TA-C	Indicates the concentration index
VAR	Variation rate	Highest TR in a row - lowest TR in a row	It indicates the rate of change (stability of attention).

Fuente: Brickenkamp (2012)

Procedure and data collection

Once the initial explanations were completed, the students were divided into three random groups, using the Oxford method. The warm-ups were organised in three separate spaces controlled by a supervisor. Each group left with its corresponding supervisor, who was responsible for explaining what the warm-up consisted of (2') and ensuring that the objectives of the warm-up were met.

The variables of the proposed warm-ups were designed for differing only in the nature of their activities, i.e., the duration was the same for all three groups (10'), and the intensity was considered moderate (except in the control group, which did not carry out any physical activity).

The following are the warm-ups carried out:

Warm-up 1: Consists of three sub-areas: Firstly, static joint mobility (2'), where the students arrange themselves in a circle and imitate the supervisor's exercises without making any movement. These simple exercises consist of the ankles' mobility, knees, hips, waist, wrists, and neck. Each joint is worked on for 20". The students then run for 3 minutes continuously around an indoor football pitch at a rate of 60%. The race ends with dynamic joint mobility (5'). Two homogeneous rows are formed, and, on this occasion, the students must cover a distance of 10 meters (indicated with cones). At the same time, they carry out the different joint mobility exercises suggested by the supervisor: arms in front, arms behind, arms crossed, waist rotation, knee lifts, heels to buttocks, side run (x2), cross leg run (x2), back runs, jumps looking for height, run on one leg (x2), straight strides, diagonal strides, 50-100% progression, sprint, sprint coming out from the back and sprint from sitting. At the end of each exercise, you return in a continuous race to the starting position.

Warm-up 2: This warm-up is based on the traditional game of "pillar," although with some peculiarities. The whole game takes place in the space of 15x15 meters, where a student must catch the rest (this one has a bib in his hand to identify himself). When someone is caught, he receives the bib and becomes the one who pays. On the other hand, there is also a ball that the person who has it cannot be caught. In this way, students can pass the ball around with their hands to avoid being caught. Also, the person who pays cannot touch the ball. After a third of the time has passed, there will be two payers and two balls, which will increase the difficulty of the task. Finally, after 2/3 of the playing time, there will be three payers and three balls, which will increase the difficulty again. Given the small playing space and the large number of stimuli that students must attend to quickly and accurately, this task is very cognitively demanding.

Control group: The students do not carry out any physical activity. They go with their supervisor to sit in a circle and whisper. These students make up the control group.

Table 3. Main characteristics of the warm-ups carried out

Duration	10’	10’	10’
Intensity	Moderated (60-75%)	Moderated (60-75%)	-
Method of teaching	Direct control	Assignment of tasks	-
Level of decision-making	Null	High	-
Number of stimuli to be perceived	Scarce (imitate the supervisor)	High (partners, opponents, balls, space...)	
Nature of the stimuli	Static (easy to perceive)	Dynamic (difficult to perceive)	
Nature of the task	Analytical task	Task Play	

Statistical analysis

SPSS statistical software (version 25, SPSS Inc., Chicago, IL) was used for data analysis. First, the results were focused on extracting, through descriptive statistical analysis, different values such as means, frequencies (absolute, relative, and cumulative relative), standard deviation, asymmetry, and kurtosis. On the

other hand, for the analyses focused on comparing variables and the search for significant differences, the Student T-test (parametric analysis for two independent samples) was used first for those checks involving only two variables. Secondly, in those cases where the comparison was composed of 3 or more groups, an analysis of variance was performed using the ANOVA parametric test, with a posthoc analysis using Tamhane adjustment.

Results

Initially, the general results extracted from the sample according to the course and gender variables are presented in Table 4. Standard deviations, ranges, and the absolute number of subjects for each case are incorporated in this table.

Table 4. Means and standard deviations in Test D2 measurements

GRADE	GENDER		TR	TA	O	C	TR+	TR-	CON	VAR
1ª	Male	M	352,09	136,57	11,57	3,48	31,48	18,09	133,09	13,39
		SD	50,84	18,49	9,29	4,65	4,33	4,24	18,77	4,28
		R	189	73	32	22	15	17	76	19
		N	23	23	23	23	23	23	23	23
	Female	M	330,57	127,5	11,93	2,32	29,93	16,57	125,18	13,36
		SD	51,55	20,82	9,36	2,6	4,36	5,48	22,08	4,52
		R	221	90	40	8	22	27	92	19
		N	28	28	28	28	28	28	28	28
	TOTAL	M	340,27	131,59	11,76	2,84	30,63	17,25	128,75	13,37
		SD	51,86	20,13	9,24	3,67	4,37	4,97	20,83	4,37
		R	237	91	40	22	22	27	93	19
		N	51	51	51	51	51	51	51	51
2ª	Male	M	333	126,93	14,07	2,71	32,71	16,36	124,21	16,36
		SD	56,05	21,25	14,2	2,95	6,15	4,72	22,33	7,76
		R	209	87	67	14	26	21	92	34
		N	28	28	28	28	28	28	28	28
	Female	M	332,92	121,68	19,32	3,28	33,8	15,2	118,4	18,6
		SD	51,74	28	22,24	4,48	6,83	6,17	29,3	9,25
		R	218	123	109	20	22	26	122	38
		N	25	25	25	25	25	25	25	25
	TOTAL	M	332,96	124,45	16,55	2,98	33,23	15,81	121,47	17,42
		SD	53,54	24,56	18,44	3,72	6,44	5,43	25,76	8,49
		R	229	130	110	20	26	27	130	38
		N	53	53	53	53	53	53	53	53
3º	Male	M	413,06	150,56	22,56	1,38	37,31	20,44	149,19	16,88
		SD	67,77	30,97	20,67	1,31	6,3	7,31	31,3	7,09
		R	268	110	68	4	23	30	112	27
		N	16	16	16	16	16	16	16	16
	Female	M	443,6	152	33,6	4	39,4	22,2	148	17,2
		SD	56,83	30,06	28,23	9,27	5,46	4,44	37,62	5,65
		R	184	98	74	30	18	14	128	16
		N	10	10	10	10	10	10	10	10
	TOTAL	M	424,81	151,12	26,81	2,38	38,12	21,12	148,73	17
		SD	64,41	30,02	23,94	5,8	5,97	6,32	33,13	6,46
		R	283	120	76	30	23	30	150	27
		N	26	26	26	26	26	26	26	26
4ª	Male	M	426,06	158	21,06	1,25	39,12	23,31	156,75	15,81
		SD	62,25	24,16	15,24	1,48	5,61	4,35	24,33	5,99
		R	236	82	61	5	18	14	83	19
		N	16	16	16	16	16	16	16	16
	Female	M	405,86	142,79	28,79	1,29	38,64	20	141,5	18,64
		SD	73,8	23,01	23,35	1,94	5,94	4,59	23,63	6,1
		R	261	79	71	6	20	15	80	24
		N	14	14	14	14	14	14	14	14
	TOTAL	M	416,63	150,9	24,67	1,27	38,9	21,77	149,63	17,13
		SD	67,46	24,47	19,49	1,68	5,67	4,7	24,83	6,11
		R	263	92	74	6	20	16	93	24
		N	30	30	30	30	30	30	30	30

Note: H: Male, M: Female, T: Total, R: Range, TR: total responses, TA: total hits, O: omissions, C: commissions, CON: concentration index, TR+: line with highest no of elements attempted, TR-: line with lowest no of elements attempted, VAR: variation or difference index (TR+)-(TR-).

Firstly, in Table 5, it can be seen that the scores, according to the gender of the subjects, are different. In this case, the male scores are better than the female ones, both in "total work", "concentration" and "variation" (since, in the latter, a lower value corresponds to better attention). As regards significance, the results of the t-test for independent samples allow us to verify that statistically significant differences exist according to gender for the results of the D2 Test of Attention and Concentration in the variable "Concentration" [t (158)= 2.02; p<.05]. In this case, male students have shown a higher concentration in the test (M=137.7; DT=26.6) than female students (M=128.9; DT=28.7). However, from this same protocol, no statistically significant differences can be established for the variables "Total work" [t(158)= 1.55; p>.05] and "Variation" [t(158)=-.920; p>.05], so in these variables, both boys and girls show a similar degree of attention in Test D2.

Table 5. Results of Test D2 according to gender

	Gender	Mean	Standard Deviation	F	Sig.
Total work	Male	352,92	65,371	,142	,707
	Female	336,83	65,306		
Concentration	Male	137,76	26,660	,290	,591
	Female	128,91	28,740		
Variation	Male	15,53	6,510	,969	,326
	Female	16,52	7,100		

Concerning the analyses carried out among three or more independent groups, carried out through the single factor ANOVA test, the relationship between age and the results of the test of care is first detailed. In table 6, the results corresponding to each age range can be seen, in which a clear trend can be seen that reflects better results as age increases. As for the significance of these differences, the results of the single factor ANOVA test allow us to check that there are statistically significant differences both in the total work done [F (2, 157)= 24.23; p<.05] and in the concentration [F (2, 157)= 13.059; p<.05]. However, in the variation no significant differences are determined [F (2,157)= 1,419; p>.05]. Concretely, in the post hoc comparisons of the real work done, we found statistically significant differences (p>.05) between the ranges 12-13 years and 14-15 years, between 12-13 years and 16-17 years, and between 14-15 years and 16-17 years. In contrast, for post hoc comparisons of concentration, we only found significant differences between the age ranges 12-13 and 16-17 and between 14-15 and 16-17. Therefore, we would not find significant differences between 12-13 and 14-15 years.

Table 6. Results of Test D2 according to age

	Age	Mean	Standard deviation	F	Sig.
Total work	12-13 years	319,66	54,355	24,234	,000
	14-15 years	352,00	68,612		
	16-17 years	394,52	56,638		
	Total	345,18	65,631		
Concentration	12-13 years	125,89	23,327	13,059	,000
	14-15 years	131,90	34,136		
	16-17 years	150,74	25,164		
	Total	133,50	27,947		
Variation	12-13 years	15,20	6,604	1,419	,245
	14-15 years	17,14	8,543		
	16-17 years	16,93	5,701		
	Total	16,01	6,797		

Finally, the analysis of the test results of the warm-ups carried out is presented in Table 7. In this case, there are no observable trends or statistically significant differences for the total work carried out [F (2, 157)= 1.051; p>.05], the concentration [F (2, 157)= 1.515; p>.05], or the variation [F (2, 157)= 0.601; p>.05].

Table 7. Test D2 results as a function of warm-up.

		Mean	Standard deviation	F	Sig.
Total work	Warm-up 1	355,53	66,715	1,051	,352
	Warm-up 2	338,92	65,829		
	Control group	340,54	64,255		
	Total	345,18	65,631		
Concentration	Warm-up 1	138,45	28,354	1,515	,223
	Warm-up 2	132,63	25,606		
	Control group	129,28	29,344		
	Total	133,50	27,947		
Variation	Warm-up 1	16,09	5,648	,601	,549
	Warm-up 2	15,22	6,373		
	Control group	16,67	8,168		
	Total	16,01	6,797		

Discussion

Many studies determine the influence of physical activity on cognitive processes such as attention, especially in the school setting (Janssen et al., 2014; Khan and Hillman, 2014; Kulinna et al., 2018; Reigal et al., 2020). However, different effects can be found depending on the type of physical activity performed. For example, Aguayo et al. (2018) found greater positive effects on attention and concentration after a session of pre-sport games physical activity than a session of aerobic physical activity. Similarly, Budde et al. (2008) showed significant improvements in attention and concentration (using Test D2) in adolescents immediately after a coordination exercise physical education class, compared to another physical education class based on group sports. On the other hand, Pirrie andLodewyk (2012) studied the effects of moderate to vigorous-intensity physical activity on different cognitive processes (planning, attention, simultaneous processing, and subsequent processing). Contrary to the initial hypothesis, they did not find beneficial effects on attention, simultaneous or successive processing. These results could be due, according to an extensive review on these effects, to the type of physical activity performed, i.e., variables such as intensity, duration, or the nature of the activity itself can be defining in producing acute effects on attention or other cognitive processes (Janssen et al., 2014). In the present study, two intentionally opposed types of physical activity have been selected, one based on mainly aerobic aspects with a low cognitive involvement (reduction of external stimuli, elimination of decision making, elimination of social interactions...) and the other based on a high cognitive demand (a large number of stimuli to be perceived, interaction with peers and adversaries, norms, high decision making, short decision time...) seeking to study the effects of two opposite activities from a cognitive point of view.

Given the importance of physical activity variables in the effects on attention, Best (2010) talks about the fact that predominantly aerobic and repetitive exercises probably imply less cognitive activity. Specifically, he suggested that executive functions, due to the lesser need to direct cognition to the achievement of difficult goals or coordinate different parts of the body to execute complex movements. This finding leads to the idea that a physical activity composed by: (1) a greater amount of stimuli to be perceived and interpreted, and (2) an open nature where the student must process and select a great number of possibilities; could more probably generate better acute effects in the cognitive functions (eg. attention).

Regarding the duration of the physical activity proposed in this study, it has been decided to work with ten minutes. This decision has a clear sense: to use these activities as a warm-up before the session. In this way, an optimization of the attention in the main part of the physical education session is pretended.

Most studies look for conclusions related to academic performance after the physical education class or physical activity, in general, is finished (Aguayo et al., 2018; Gallotta et al., 2015; García-Hermoso et al., 2020; Klein and Hollingshead, 2015). However, no studies are found that focus on optimizing learning of both declarative and procedural knowledge of the physical education subject itself. For this reason, pursuing the analysis of the effects of short-term physical activity would allow us to use these exercises in more diverse situations, such as, in this case, warm-up.

There is some research on the duration of physical activity. Janssen et al. (2014) organize numerous works in their analysis to study the effects on the attention of different durations of physical activity (between 10 and 45 minutes) in children from 4 to 18 years old. Surprisingly, most studies that worked with a duration of 20 minutes or less have acutely found significant effects on attention, including here positive conclusions regarding specific works of 10 minutes duration. In contrast, studies included in this review, such as Pirrie and Lodewyk (2012), find no effect on attention after 45 minutes of physical activity. Regarding the analyses extracted from the present study related to the type of previous physical activity (in this case, considered warm-up), no significant differences have been found in the results of any of the attention test parameters. Hence, it seems that the capacity of selective attention and concentration of the students in the sample has not suffered visible changes after the performance of one warm-up or another. The warm-up students' experimental group effectiveness was similar to that of the control group of students simply sitting and talking to each other.

Together with the scientific literature referenced in this text, these results suggest the need to continue analyzing different types of physical activity. Activities with different times and intensities are necessary since many studies that find benefits suggest that effective strategies can be found that improve attention span and therefore benefit the educational process. On the other hand, as has been observed, other variables' influence has also been analyzed to increase rigor and establish a known context. The first of these that has considered has been gender. At present, it is well known that the biology of men and women presents differences, so inequalities can also be observed at a functional level. Moreover, several studies have also shown gender differences in cognitive tasks. However, there is little research in the case of selective attention (Merritt et al., 2007).

Roselló andMunar Roca (1994), after their research in this area, concluded that the few differences in selective attention found between the male and female gender may be significantly conditioned by personality. Differences between both genders may be related to the degree of activation, which may determine the degree of attentional capacity. However, these differences are usually not very significant, except for some aspects. For example, it seems that men correctly perceived 10% more signals in terms of vigil might be capacity than women. In contrast, from the experimentation with the Stroop test, they found a lower degree of interference in women, which improves the execution of the test. In this test's execution differences between gender, Merritt et al. (2007) also found differences from experiments using Posner's basic signaling paradigm. Here, women

showed greater ability in endogenous signaling tasks, but not in tasks with exogenous signaling. Men, on the other hand, showed a benefit when faced with invalid signals. In short, at times, slight differences in attention skills between the genders seem to be found, but the data are not sufficiently precise to draw clear conclusions (Brickenkamp, 2012). About the present study, significant differences have been found (p=.045) in the concentration variable of Test D2, being higher in male subjects. However, after reviewing the scientific literature, this statement should be taken with caution and, it should be understood that secondary factors such as motivation or competitiveness of students for the subject or for taking the test may have influenced.

Finally, the evolutionary development of subjects and their influence on attention skills must also be highlighted. In this study, we have taken as a reference for this development the students' variable age. The results extracted from these variables show us a clear relationship between the evolutionary development of the students and their capacity of attention and concentration, presenting statistically significant differences in the variable "age" (analyzed through the ranges: 12-13 years, 14-15 years and 16-17 years).

These results are corroborated by many researches focused on the evolutionary process of cognition in human beings, especially in the early stages of life. Furthermore, using different measures of observation and event-related potentials (ERP), more significant changes in the development of selective and sustained care during the childhood period are indicated (Reynolds and Romano, 2016). In this line, Ridderinkhof and Van der Stelt (2000) discovered that the processes necessary for attention selection are available already from childhood. However, the speed and efficiency of these processes increase as the child enters adolescence. Therefore, it can be concluded that this stage of life will be particularly sensitive to cognitive development.

Conclusions

This study aims to find methods for making a physical education class that will encourage and optimize the students' learning process. Specifically, we have used warm-up as a tool for this optimization, applying different variables to compare its effects on the students' attention and concentration. Concerning the specific results extracted from this research, certain trends can be indicated. Firstly, the gender of the students seems to have a particular influence on the attention skills, specifically on concentration. The disparity of results in this area regarding gender differences highlights the need for further research. On the other hand, the human being's evolutionary development has already been clearly recognized as one of the most influential factors in cognitive and, precisely, attentional skills. The present study results can corroborate this already established statement, seeing a clear progression in the abilities of students from twelve to seventeen years old. Furthermore, the profound sensitivity in cognitive development during these ages makes it crucial to find valid and reliable methods to support and optimize this progression. Finally, the central aspect of this study, which focuses on recognizing the acute impact of different types of physical activity (short duration and moderate intensity) on student attention, shows a trend indicating that:

- an aerobic and joint mobility warm-up, with a direct command teaching style and little cognitive involvement, does not determine significant changes in attentional skills in the post-activity moment.

- a more open, dynamic, and playful warm-up, with a large number of stimuli with which to interact and, therefore, a high level of cognitive involvement, has also not shown any tendency towards acute improvement in attention.

Together with the clarifications in the current scientific literature, these conclusions encourage further study of the effects of different methods and forms of physical activity to find ways of using physical activity effectively to benefit individuals. Similarly, it is essential to encourage experimentation in this field, given the positive impact on education, sport, or merely human development. This greater involvement in the field of physical activity can be extrapolated to the study of warm-up, which is a great unknown in terms of cognitive effects.

Conflicts of interest

The authors declared no potential conflicts of interest concerning the research, authorship, and/or publication of this article.

References

Aguayo, B., Román, P., Sánchez, J., Vallejo, A. (2018). Acute Effect of a Physical Education Class on the Attention of 12 to 14 Year Old Children..*RevistaIberoamericana de Diagnóstico y Evaluación – e AvaliaçãoPsicológica*, *49*(4). https://doi.org/10.21865/RIDEP49.4.10

Albarracín, A., Moreno, J. A.,Beltrán, V. J. (2014). The current situation of physical education according to its teachers: A qualitative study with teachers from the Region of Murcia..*Cultura, ciencia y deporte: revista de ciencias de la actividadfísica y del deporte de la Universidad Católica de San Antonio*, *9*(27), 225-234.

Best, J. R. (2010). Effects of Physical Activity on Children's Executive Function: Contributions of Experimental Research on Aerobic Exercise. *Developmental review : DR*, *30*(4), 331-551.

Bishop, D. (2003). Warm up II: Performance changes following active warm up and how to structure the warm up. *Sports Medicine (Auckland, N.Z.)*, *33*(7), 483-498. https://doi.org/10.2165/00007256-200333070-00002

Brickenkamp, R. (2012). *d2: Test de atención*. TEA.

Budde, H., Voelcker-Rehage, C., Pietrabyk-Kendziorra, S., Ribeiro, P.,Tidow, G. (2008). Acute coordinative exercise improves attentional performance in adolescents. *Neuroscience Letters*, *441*(2), 219-223. https://doi.org/10.1016/j.neulet.2008.06.024

Budde, H., Voelcker-Rehage, C., Pietrassyk-Kendziorra, S., Machado, S., Ribeiro, P., Arafat, A. M. (2010). Steroid hormones in the saliva of adolescents after different exercise intensities and their influence on working memory in a school setting. *Psychoneuroendocrinology*, *35*(3), 382-391. https://doi.org/10.1016/j.psyneuen.2009.07.015

Buehner, M., Krumm, S., Ziegler, M.,Pluecken, T. (2006). Cognitive abilities and their interplay: Reasoning, crystallized intelligence, working memory components, and sustained attention. *Journal of Individual Differences*, *27*, 57-72. https://doi.org/10.1027/1614-0001.27.2.57

D'Angiulli, A., Herdman, A., Stapells, D., Hertzman, C. (2008). Children's Event- Related Potentials of Auditory Selective Attention Vary With Their Socioeconomic Status. *Neuropsychology*, *22*, 293-300. https://doi.org/10.1037/0894-4105.22.3.293

Dumitru, D. C. (2010). The Importance of a Specific Warm-up on the Performance of the Handball Goalkeeper. *Journal of Physical Education & Sport / CitiusAltiusFortius*, *28*(3), 23-31.

Elsworthy, N., Dascombe, B., Burke, D. (2013). The effects of a physical warm-up on cognitive performance. *Journal of Science and Medicine in Sport*, *16*, e74-e75. https://doi.org/10.1016/j.jsams.2013.10.178

Ferkel, R. C., Hutchinson, Z. T., Razon, S., True, L., Zupin, D., Jones, L. M., Judge, L. W. (2019). The Benefits of Health-Related Fitness Education in Secondary PE. *Physical Educator*, *76*(4), 883-906.

Frey, J. N., Ruhnau, P., Weisz, N. (2015). Not so different after all: The same oscillatory processes support different types of attention. *Brain Research*, *1626*, 183-197. https://doi.org/10.1016/j.brainres.2015.02.017

Fuentes Melero, L.,GarcíaSevilla, J. (2008). *Manual de Psicología de la Atención. Unaperspectivaneurocientífica*.

Gallotta, M. C., Emerenziani, G. P., Franciosi, E., Meucci, M., Guidetti, L.,Baldari, C. (2015). Acute physical activity and delayed attention in primary school students. *Scandinavian Journal of Medicine & Science in Sports*, *25*(3), e331- e338.

García-Hermoso, A., Hormazábal-Aguayo, I., Fernández-Vergara, O., González-Calderón, N., Russell-Guzmán, J., Vicencio-Rojas, F., Chacana-Cañas, C.,Ramírez-Vélez, R. (2020). A before-school physical activity intervention to improve cognitive parameters in children: The Active-Start study. *Scandinavian Journal of Medicine & Science in Sports*, *30*(1), 108-116. https://doi.org/10.1111/sms.13537

Gogtay, N., Giedd, J., Lusk, L., Hayashi, K., Greenstein, D. (Dede), Vaituzis, A., Nugent, T., Herman, D., Clasen, L., Toga, A., Rapoport, J., Thompson, P. (2004). Dynamic Mapping of Human Cortical Development during Childhood through Early Adulthood. *Proceedings of the National Academy of Sciences of the United States of America*, *101*, 8174-8179. https://doi.org/10.1073/pnas.0402680101

Guiney, H., Machado, L. (2013). Benefits of regular aerobic exercise for executive functioning in healthy populations. *Psychonomic Bulletin & Review*, *20*(1), 73- 86. https://doi.org/10.3758/s13423-012-0345-4

Hillman, C. H., Snook, E. M., Jerome, G. J. (2003). Acute cardiovascular exercise and executive control function. *International Journal of Psychophysiology: Official Journal of the International Organization of Psychophysiology*, *48*(3), 307-314. https://doi.org/10.1016/s0167-8760(03)00080-1

Jamshidi, M., Jahromi, M. K., Salesi, M., Chari, M. H.,Dashtiyan, A. A. (2016). *The Effect of Three Methods of Warm-Up on the Anaerobic Power, Agility, Speed, Flexibility and Fatigue Index of Elite Female Volleyball Players*. 9.

Janssen, M., Toussaint, H. M., van Mechelen, W.,Verhagen, E. A. (2014). Effects of acute bouts of physical activity on children's attention: A systematic review of the literature. *Springerplus*, *3*, 410-410. https://doi.org/10.1186/2193-1801-3-410

Khan, N. A., Hillman, C. H. (2014). The relation of childhood physical activity and aerobic fitness to brain function and cognition: A review. *Pediatric Exercise Science*, *26*(2), 138-146. https://doi.org/10.1123/pes.2013-0125

Klein, E., Hollingshead, A. (2015). Collaboration between Special and Physical Education: The Benefits of a Healthy Lifestyle for All Students. *TEACHING Exceptional Children*, *47*(3), 163-171.

Krčmár, m., Imonek, j., Poláčková, b. (2016). Impact of different warm-up modalities on the height of countermovement vertical jump and its practical applicability. *Journal of Physical Education & Sport*, 16(2), 481-488.

Kulinna, P. H., Stylianou, M., Dyson, B., Banville, D., Dryden, C., Colby, R. (2018). The Effect of an Authentic Acute Physical Education Session of Dance on Elementary Students' Selective Attention. *BioMed Research International*, *2018*. https://doi.org/10.1155/2018/8790283

Manchado, C., García-Ruiz, J., Cortell-Tormo, J. M.,Tortosa-Martínez, J. (2017). Effect of Core Training on Male Handball Players' Throwing Velocity. *Journal of Human Kinetics*, *56*, 177-185. https://doi.org/10.1515/hukin-2017-0035

McArdle, W. D., Katch, F. I.,Katch, V. L. (2010). *Exercise Physiology: Nutrition, Energy, and Human Performance*. Lippincott Williams & Wilkins.

McNaughten, D.,Gabbard, C. (1993). Physical exertion and immediate mental performance of sixth-grade children. *Perceptual and Motor Skills*, *77*(3 Pt 2), 1155-1159. https://doi.org/10.2466/pms.1993.77.3f.1155

Merritt, P., Hirshman, E., Wharton, W., Stangl, B., Devlin, J., & Lenz, A. (2007). Evidence for gender differences in visual selective attention. *Personality and Individual Differences*, *43*(3), 597-609. https://doi.org/10.1016/j.paid.2007.01.016

Moran, A. (2012). *Concentration: Attention and Performance*. Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199731763.013.0006

Neville, H. J., Stevens, C., Pakulak, E., Bell, T. A., Fanning, J., Klein, S., Isbell, E. (2013). Family-based training program improves brain function, cognition, and behavior in lower socioeconomic status preschoolers. *Proceedings of the National Academy of Sciences of the United States of America*, *110*(29), 12138-12143. https://doi.org/10.1073/pnas.1304437110

Obetko, M., Peráček, P., Mikulič, M., &Babic, M. (2020). Effect of selected types of warm-up on disjunctive reaction time of soccer goalkeepers. *Journal of Physical Education and Sport*, 20(4), 1903-1908.

Pardeiro, M.,Yanci, J. (2017). Effects of warm-up on physical performance and psychological perception in semi-professional soccer players. *RICYDE. RevistaInternacional de Ciencias del Deporte*, *13*, 104-116. https://doi.org/10.5232/ricyde2017.04802

Pérez-Lobato, R., Reigal, R. E., Hernández-Mendo, A. (2016). Relationships between physical practice, physical fitness and attention in an adolescent sample. *Revista de Psicología del Deporte*, *25*(1), 179-186.

Perlman, S. B., Hein, T. C., Stepp, S. D., LAMS Consortium. (2014). Emotional reactivity and its impact on neural circuitry for attention-emotion interaction in childhood and adolescence. *Developmental Cognitive Neuroscience*, *8*, 100-109. https://doi.org/10.1016/j.dcn.2013.08.005

Pirrie, M.,Lodewyk, K. (2012). Investigating links between moderate-to-vigorous physical activity and cognitive performance in elementary school students. *Mental Health and Physical Activity*, *5*, 93–98. https://doi.org/10.1016/j.mhpa.2012.04.001

Rabiner, D., Godwin, J., Dodge, K. (2016). Predicting Academic Achievement and Attainment: The Contribution of Early Academic Skills, Attention Difficulties, and Social Competence. *School Psychology Review*, *45*, 250-267. https://doi.org/10.17105/SPR45-2.250-267

Reigal, R. E., Moral-Campillo, L., Morillo-Baro, J. P., Juárez-Ruiz de Mier, R., Hernández-Mendo, A., Morales-Sánchez, V. (2020). Physical Exercise, Fitness, Cognitive Functioning, and Psychosocial Variables in an Adolescent Sample. *International Journal of Environmental Research and Public Health*, *17*(3), 1100. https://doi.org/10.3390/ijerph17031100

Reynolds, G. D., Romano, A. C. (2016). The Development of Attention Systems and Working Memory in Infancy. *Frontiers in Systems Neuroscience*, *10*. https://doi.org/10.3389/fnsys.2016.00015

Ridderinkhof, K. R., Van der Stelt, O. (2000). Attention and selection in the growing child: Views derived from developmental psychophysiology. *Biological psychology*, *54*, 55-106. https://doi.org/10.1016/S0301-0511(00)00053-3

Rosellói Mir, J.,Munar Roca, E. (1994). The attention mechanism: Study of individual differences. Journal of general and applied psychology*: Revista de la Federación Española de Asociaciones de Psicología*, *47*(4), 383–390.

Rueda, M. R., Rothbart, M. K., McCandliss, B. D., Saccomanno, L., Posner, M. I. (2005). Training, maturation, and genetic influences on the development of executive attention. *Proceedings of the National Academy of Sciences of the United States of America*, *102*(41), 14931-14936. https://doi.org/10.1073/pnas.0506897102

Stevens, C., Bavelier, D. (2012). The role of selective attention on academic foundations: A cognitive neuroscience perspective. *Developmental Cognitive Neuroscience*, *2 Suppl 1*, S30-48. https://doi.org/10.1016/j.dcn.2011.11.001

Stevens, C., Lauinger, B., Neville, H. (2009). Differences in the neural mechanisms of selective attention in children from different socioeconomic backgrounds: An event-related brain potential study. *Developmental science*, *12*(4), 634-646. https://doi.org/10.1111/j.1467-7687.2009.00807.x

Summerfield, C., Egner, T. (2009). Expectation (and attention) in visual cognition. *Trends in cognitive sciences*, *13*, 403-409. https://doi.org/10.1016/j.tics.2009.06.003

Thorburn, M. (2017). Intelligence, Practice and Virtue: A Critical Review of the Educational Benefits of Expertise in Physical Education and Sport. *Sport, Ethics & Philosophy*, *11*(4), 453-463.

Tsujimoto, S. (2008). The prefrontal cortex: Functional neural development during early childhood. *The Neuroscientist: A Review Journal Bringing Neurobiology, Neurology and Psychiatry*, *14*(4), 345-358. https://doi.org/10.1177/1073858408316002

WHO. (2018). *Actividadfísica*. https://www.who.int/es/news-room/fact- sheets/detail/physical-activity.

Woods, K., Bishop, P., Jones, E. (2007). Warm-up and stretching in the prevention of muscular injury. *Sports Medicine (Auckland, N.Z.)*, *37*(12), 1089-1099. https://doi.org/10.2165/00007256-200737120-00006