INTEGRATING COGNITIVE CONTENTS IN PHYSICAL EDUCATION CLASSES: EFFECTS ON COGNITIVE VARIABLES AND EMOTIONAL INTELLIGENCE

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Original scientific paper
DOI 10.26582/k.55.1.10

Abstract:

The aim was to analyse the effect of a 4-week programme integrating cognitive contents in Physical Education (CogniPE) on cognitive performance (CP) and emotional intelligence (EI) of adolescents. A randomised controlled trial was conducted with a control group (CG, n=58), which performed physical exercises at low intensity (i.e., stretching or pilates), an experimental group 1, which performed small-sided games of team sports (EG1, n=62), and experimental group 2, which performed CogniPE (EG2, n=60). Intensity of exercises and scores were registered after each station to classify and motivate the teams. Selective attention and concentration increased by 11.9% and 9.2% in EG1, and by 18.2% and 14.4% in EG2, respectively, compared to CG. Mathematical calculation improved by 15.9% and 18.7% in EG1 and EG2, compared to CG. In EI, well-being improved by 10.9% in EG1, sociability improved by 12.8% in EG1 and 15.9% in EG2 compared to CG. It is concluded to use CogniPE in school context.

Key words: *cognitive performance, mathematical calculation, physical exercise, secondary education, sociability*

Introduction

Beyond traditional teaching methodologies, emergent innovative pedagogical models based on physical activity (PA) are appearing in educational systems in an attempt to enhance cognitive and emotional aspects in young people (Beck, et al., 2016; Benzing, Heinks, Eggenberger & Schmidt, 2016; Ruiz-Ariza, Suárez-Manzano, López-Serrano & Martínez-López, 2019; Schmidt, Jäger, Egger, Roebers & Conzelmann, 2015; Schmidt, et al., 2019). Among other benefits, the literature has shown the effects of integrating PA in academic lessons, based on the embodied learning theory, to improve executive functions, mathematical, linguistic, or scientific contents (Donnelly & Lambourne, 2011; Mullender-Wijnsma, et al., 2016; Schmidt, et al., 2019). However, these research studies were usually focused on young children and inside classrooms. Nevertheless, the inverse analysis from the physical education (PE) point of view has scarcely been analysed. In this sense, it is well known that the PE class is one of the most important contexts where young people practice PA in a controlled way (Ruiz-Ariza, et al., 2019), and several programmes between eight and 30 minutes have shown that PE classes could promote integral health benefits and better cognitive performance (CP) and emotional intelligence (EI) (Costigan, Eather, Plotnikoff, Hillman & Lubans, 2016; Kubesch, et al., 2009; Ruiz-Ariza, et al., 2019). However, PE is usually mostly based on physical stimulus, and the effects of integrating intentionally specific cognitive content within PE classes are unknown.

Furthermore, the cognitive demand inherent to games or physical exercises in PE is already known to enhance cognitive variables (Best, 2010; Schmidt, et al., 2015). This cognitive demand is defined as the degree to which the allocation of attentional resources and mental effort are needed to perform difficult skills in contexts such as sport games (Schmidt, Benzing, & Kamer, 2016). According to Budde et al. (2008), cognitive demand is supposed to lead to better attention by preactivating the same cognitive processes during the physical exercise as those used in a subsequent cognitive task. For example, playing a team sport requires the ability to discriminate between different visual stimuli and to make appropriate motor decisions. To enhance the cognitive result, participants in team sports can perform physical–cognitive exercises involving exactly the same mechanisms (Schmidt et al., 2016). Results from basic research seem to support this theory, in which particularly complex motor tasks should be used to develop the relationship between physical action and cognition (Schmidt, et al., 2016).

Regarding the integration of cognitive aspects in PA, some experimental research studies have already altered the cognitive demands of PA in young people showing controversial results. Depending on the kind of cognitively engaging PA, several studies have examined these effects. For example, one study, conducted by Schmidt et al. (2015), investigated the effects of two qualitatively different chronic PA interventions of a 6-week PE programme with high cognitive engagement based on team games, a low cognitive engagement (aerobic exercise) and a CG with low physical exertion and low cognitive demand, on executive functions in 10-12-year-old children. One year later, Schmidt et al. (2016) examined four groups of children between 11 and 12 years: 1) PA with high cognitive demands (HR = 154 bpm); 2) sedentary condition with high cognitive demands (HR = 102 bpm); 3) PA with low cognitive demands (HR = 144 bpm); and 4) sedentary CG with low cognitive demands. Other researchers have studied the effects of a less cognitively engaging PA (Budde, et al., 2008); a less cognitively engaging PA and a passive control group (Gallotta, et al., 2012); or a less cognitively engaging PA, a cognitively engaging sedentary condition and a passive control group (Jäger, Schmidt, Conzelmann & Roebers, 2015). Some of them have found positive benefits on CP in the cognitively engaging group (Budde, et al., 2008), while others have shown no difference regarding the control sample (Jäger, et al., 2015), or even unfavourable effects compared to PA without cognitive demand (Gallotta, et al., 2012). In accordance with the above, different PE interventions should be cognitively demanding, integrating and combining cognitive content within PE classes in a single study design, to challenge higher-order cognitive processes and to continue analysing the effects on important CP and EI variables.

On the other hand, the use of group dynamic in PE (non-static groups, modified inter–intra sessions to facilitate the cooperation among participants) is more favourable for social contact and the inter–intra relationship among young people (Ruiz-Ariza, et al., 2019). Physical activity controlled with group heart rate monitoring and performed in groups (i.e., team sports), has been shown to provide increases in motivation, promotion of continued play and playful entertainment, group decision-making and increases in self-efficacy and pro-social behaviours, with direct impact on CP and EI (Martínez-López, De la Torre-Cruz, Suárez-Manzano & Ruiz-Ariza, 2018; Ruiz-Ariza, et al., 2019). Thus, to know whether a 4-week programme integrating cognitive contents in PE (CogniPE) affects important variables of CP and EI, could be important in promoting novel educational strategies to enhance specific integral benefits from PE classes.

Based on the above reasoning, the aim of this study was to analyse the effect of two PE programmes (team sports and CogniPE) on the CP and EI of Spanish adolescents, independently of age, body mass index (BMI), maternal education, daily study time, or extracurricular PA at moderate to vigorous intensity (MVPA). These variates have been previously associated with the dependent variables of this study, and recent studies have used them as covariates (Dohrn, Kwak, Oja, Sjöström & Hagströmer, 2018; Ruiz-Ariza, Casuso, Suarez-Manzano & Martínez-López, 2018, Ruiz-Ariza, Suárez-Manzano, Mezcua-Hidalgo & Martínez-López, 2022). We hypothesised that young people performing CogniPE would show higher cognitive and emotional levels than their peers performing traditional programmes of PE (individual low-intensity activities or team sports).

Methods

Design

The study used a quantitative randomised controlled and blind trial with a control group (CG, n=58), which performed individual PA at low intensity (i.e., stretching or Pilates), an experimental group 1, which performed small-sided games of team sports (EG1, n=62), and another experimental group 2, which performed CogniPE (EG2, n=60).

Participants

A total sample of 180 adolescents from three Andalusian schools (Spain) took part in this study. The adolescents (49.4% girls) were 14.61±1.14 years of age (range=13–16), and had a BMI of 20.58±3.55 kg/m^2 (range=15.95–32.48) (see Table 1). Adolescents with some physical pathology or medical contraindication to performing PA were excluded from this study. Those diagnosed with learning disabilities (e.g., ADHD) were not included among the eligible students. Despite this, they performed the PA corresponding to their group, but these data were not included in the analysis. The final sample was formed of students who completed the cognitive or EI data and carried out the total intervention period correctly. Thirty-five participants did not complete the cognitive or EI data and 11 left the study during the intervention. The structure used for group formation and intervention characteristics are shown in Figure 1.

Table 1. Anthropometric, sociodemographic, cognitive, and emotional characteristics at the beginning of the study. Values are presented as mean and standard deviation or percentage. EG1 = small-sided games, EG2 = CogniPE

Variable		All (n=180)	CG (n =58)	EG1 (n=62)	EG2 (n =60)	p-value
Age (years)		14.61 ± 1.14	14.41 ± 1.20	14.55 ± 1.16	14.87 ± 1.03	0.086
Sex (%)	Girls Boys	89 (49.4) 91 (50.6)	25 (43.1) 33 (56.9)	28 (45.2) 34 (54.8)	36 (60.0) 24 (40.0)	0.131
Body weight (kg)		57.25 ± 11.87	57.33 ± 9.94	56.89 ± 11.13	57.55 ± 14.29	0.953
Body height (m)		1.68 ± 0.07	1.67 ±0 .08	1.67 ± 0.06	1.64 ± 0.05	0.144
BMI (kg/m²)		20.58 ± 3.55	20.39 ± 2.69	20.30 ± 3.36	21.04 ± 4.39	0.463
Computer at home (n)		2.61±1.47	2.53±1.17	2.77 ± 1.92	2.47±1.03	0.226
Maternal education (%)	No studies Primary school Secondary school University	35 (19.4) 28 (15.6) 56 (31.1) 61 (33.9)	13 (22.4) 14 (24.1) 16 (27.6) 15 (25.9)	8 (12.9) 4 (6.5) 24 (38.7) 26 (41.9)	14 (23.3) 10 (16.7) 16 (26.7) 20 (33.3)	0.057
Daily study time (min/day)		65.45 ± 41.22	58.89 ± 44.74	73.27 ± 40.19	63.71 ± 37.96	0.149
MVPA (days/week, range: 0-7)		3.23 ± 1.67	2.91 ± 1.86	3.37 ± 1.66	3.38 ± 1.46	0.224
Memory (range 0–15)		3.98 ± 2.32	3.83 ± 0.70	3.97 ± 0.73	4.2 ± 1.10	0.377
Selective attention [number of processed elements – (omissions + mistakes)]		135.85 ± 37.09	131.33 ± 46.34	142.00 ± 35.20	140.33 ± 35.71	0.422
Concentration (number of hits – number of mistakes)		125.99 ± 36.55	121.09 ± 45.03	128.84 ± 36.03	127.80 ± 33.25	0.459
Mathematical calculation (n operations/min)		6.71 ± 2.42	6.34 ± 1.72	6.97 ± 2.20	6.78 ± 2.23	0.358
Linguistic reasoning (n words/min)		20.12 ± 5.21	20.88 ± 4.19	20.68 ± 4.88	21.40 ± 5.21	0.653
Emotional intelligence (1-7)	Wellbeing	4.18 ± 0.74	4.07 ±0.71	4.28 ± 0.84	4.17 ± 0 .64	0.311
	Self-control	3.92 ± 0.70	3.74 ± 0.59	4.04 ± 0 .70	3.87 ± 0 .53	0.019
	Emotionality	3.75 ± 0.61	3.70 ± 0.57	3.64 ± 0 .48	3.86 ± 0 .54	0.237
	Sociability	4.07 ± 0.73	4.07 ± 0.69	4.05 ± 0.78	4.10 ± 0 .74	0.928

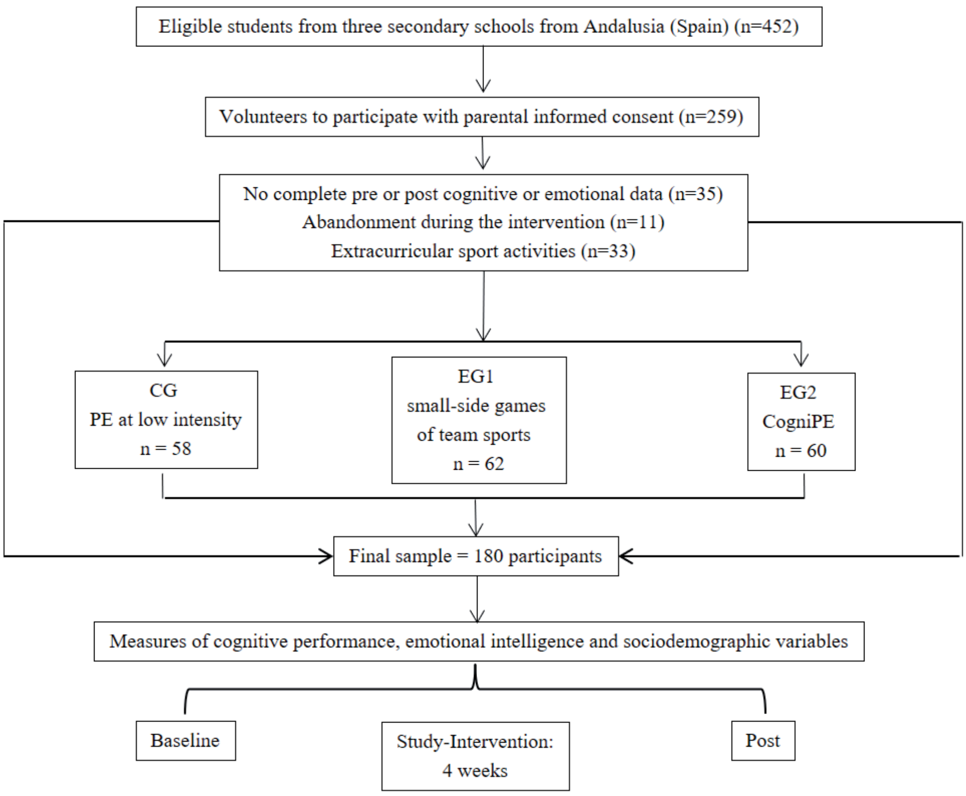

Figure 1. Study flow. CG = control group; EG = experimental group.

Measures

Cognitive performance

Memory

To assess memory, an 1-minute *ad hoc* test was used, from the original ideas of Wechsler (1945) and Tombaugh (1996), and from the memory test included in the Spanish adaptation of the RIAS test (Santamaría-Fernández & Fernández-Pinto, 2013). A poster of 15 Spanish playing cards, randomly selected, was projected for 20 seconds on a 3x2 metre screen. Immediately afterwards, the participants had 40 seconds to record, on a standardized sheet of paper, the largest number of remembered cards. The total number of correct answers (range 0–15) was counted. Before the test, it was verified that all the participants knew the structure and content of the 40 cards of the Spanish deck. This memory test has been previously used by Ruiz-Ariza et al. (2018). The reliability test–retest (48 h, n = 19) was 0.892.

Selective attention and concentration

Selective attention and concentration capacity were assessed under stress induced by a completion time using the Spanish version of Brickenkamp's d2 Test (Seisdedos, 2012). The d2 Test assesses performance in terms of visual perceptual speed and concentration capacities by assessing the individual's ability to selectively, quickly and accurately focus on certain relevant aspects in a task while ignoring other irrelevant aspects. The complete duration of the test is four minutes and 40 seconds. Selective attention capacity was calculated using the following formula:

[number of processed elements – (omissions + mistakes)].

In addition, the concentration was calculated with:

(number of hits – number of mistakes).

The reliability test–retest (48 h, n = 19) was 0.800.

Mathematical calculation

To analyse mathematical calculation an *ad hoc* test was used. This test was based on previous studies, such as the test by Passolunghi and Siegel (2004), who checked the processing capacity, speed and resolution of mathematical operations. This test included two groups of additions and subtractions with six digits (i.e., 8 – 6 + 5 + 8 – 6 = 9). Participants had one minute to perform as many operations as possible, and the total number of hits was counted. This test has been previously used by Ruiz-Ariza et al. (2018). Test–retest reliability (48 h, n = 19) was 0.851.

Linguistic reasoning

To evaluate the reading speed and semantic comprehension of participants (linguistic reasoning), an *ad hoc* test was developed based on Lervåg and Aukrust (2010), and the Neale Analysis of Reading Ability [NARA test]. The test showed 30 rows of four words each. In each row of words, three belonged to the same semantic field, whereas the fourth had no relation to the others (e.g., car, dog, motorbike, lorry). The order of these was randomly established. For a minute, the students had to cross out the highest number of words that had no relation to the others (intruder words). The total number of correctly crossed out words was counted. This test has been previously used by Ruiz-Ariza et al. (2018). The reliability test–retest (48 h, n = 19) was 0.865.

Emotional intelligence

To assess EI, this study used the Trait and Emotional Intelligence Questionnaire Short Form (TEIQue-SF) designed by Petrides (2009). This version has been used in the Spanish context with an internal consistency of alpha = 0.82 (Cejudo, Díaz, Losada & Pérez-González, 2016). The TEIQue-SF is composed of 30 items with seven possible responses to each statement, ranging from *completely disagree* = 1 to *completely agree* = 7. This test assesses four factors: 1) well-being: 5, 20, 9, 24, 12, and 27, e.g., *On the whole, I'm pleased with my life*; 2) self-control: 4, 19, 7, 22, 15, and 30, e.g., *I'm usually able to find ways to control my emotions when I want to*; 3) emotionality: 1, 16, 2, 17, 8, 23, 13, and 28, e.g. *I often find it difficult to show my affection to those close to me*; and 4) sociability: 6, 21, 10, 25, 11 and 26, e.g., *I would describe myself as a good negotiator*. Items 3, 18, 14 and 29 contribute only to the global average trait EI score (data not shown). The results obtained in this questionnaire rendered Cronbach's alpha coefficients of 0.89, 0.82, 0.78, and 0.74, respectively. The total alpha was 0.83. The reliability test–retest (48 h, n = 21) in items showed high results (Rho = 0.791 and Rho = 0.888 for the lowest and highest respectively, all p<.001).

Intervention

The duration of sessions was 50 minutes (5 min of warm-up + 40 min of main part + 5 min of final part), two sessions a week during PE classes, over four weeks (eight sessions in total). The CG carried out individual physical exercises at low intensity (40%: ≤ 90 bpm), i.e., stretching, sensory games and Pilates (Jago, Jonker, Missaghian & Baranowski, 2006; Ruiz-Ariza et al., 2019). The EG1 performed small-sided games of team sports, i.e., indoor football, handball, basketball or hockey (Cooper, et al., 2018; Kubesch, et al., 2009). The class was split into four groups of 6−8 students, each group was in a station carrying out a reduced version of a team sport, i.e., usual small-sided basketball match 3 vs 3 or 4 vs 4. Each group had to rotate towards their right after 10 minutes of playing the respective sports game. The EG2 performed CogniPE based on group physical tasks enriched with specific cognitive demand, e.g., players holding hands must find all the right resolutions of arithmetic tasks among different numeric cards on the floor. The tasks were offered by the teacher in several boxes with different colours and numbers. Before the resolution, players had to jump several obstacles and first travel a distance of 10 metres. An example of a CogniPE session can be observed in Table 2. In addition, each team was scored according to their intensity (%HR max) and their scores in each exercise. Participants wore heart rate monitors (Seego Realtracksystems® [Spain]) to motivate the exercise intensity. Each participant from the EGs had a prize for the intensity during the exercise, e.g., for the intensity of between 60% (≈120 bpm) and 80% (≈160 bpm) of HRmax, during at least the 80% of total session, three points were awarded (Ardoy, et al., 2014; Martínez-López, et al., 2018; Ruiz-Ariza, et al., 2019). These points and the points achieved after the CogniPE sessions were summed in a final classification. The CogniPE sessions were delivered by PE teachers specialised in this research method. Data from 33 students were not included due to the fact that they practised extracurricular sport activities.

Confounders

Age and BMI were controlled. This last measure was calculated as weight/height (kg/m^2). An ASIMED® B-type-class III (Spain) and a portable height measure SECA® 214 (Germany) were used, respectively. Both measurements were performed on barefoot individuals dressed in light clothing. Maternal educational level was classified into one of four categories (1 = No studies, 2 = Primary school, 3 = Secondary school, 4 = University). The daily study time was recorded by an item that requested the number of minutes of study during the extracurricular period on each day of the week. For the final measure, the average of seven days of the week was obtained. Finally, the Adolescent Physical Activity Measure questionnaire was used to know the weekly MVPA (Prochaska, Sallis, & Long, 2001). Two items were used to assess MVPA: at least 1-h a day in the previous week and a typical week. The response scale was the same for both items: 1 = no days, 2 = one day, 3 = two days, 4 = three days, 5 = four days, 6 = five days, 7 = six days, and 8 = seven days. A mean of the responses to both items was used. Similar to previous studies (Martínez-López, et al., 2015), internal consistency of PA items was high (Cronbach's alpha = .828).

Procedure

The participants' CP and EI were measured at two time points during the first school hour in the morning in the groups: at baseline and after four weeks. Previously, at the beginning of the data collection, a signed written consent was obtained from the participants' parents. Pre- and post-tests were performed in the usual classroom with individual desks. During the pretest, a sociodemographic sheet was also completed. All tests were paper-and-pencil tests and were group-administered. During testing, one specialised researcher gave instructions and kept track of time, while two research assistants each observed the possible

Table 2. Description of an example session of CogniPE. Work at each station has a duration of 10 minutes

	CogniPE session
Station 1	Players holding hands must find all the right resolutions of arithmetic tasks among different numeric cards on the floor. The tasks are offered by the teacher in several boxes with different colours and numbers. Before the resolution, players must jump over several obstacles and run a distance of 10 metres. The winner will be the team with more correct resolutions at the end of the game.
Station 2	With shuttle-run displacements, players must solve cognitive tasks (puzzles, tangrams, guess-the-hidden image). Each team can choose the task and the winner would be the team with the most completed tasks at the end of the game. They have the pieces in a side and take them to the resolution zone, 10 metres away. Just one piece for displacement. They need to place the pieces as fast as possible.
Station 3	Each team has a t-shirt with a different number (1, 2, or 3). They must pass the ball between them. Passes between t-shirt number 1 and 2, will be summed. Passes with '3', are multiplied by this number. When a team achieves 50 points, they will gain a point. The winner will be the team with the most points at the end of the game.
Station 4	Rows of four words each on the floor, covered with a cone. In each row of words, three belong to the same semantic field while the fourth has no relation to the others (e.g. red, green, orange, knife). For the game, the players have to run towards the rows (10 metres), pick up one cone, and look for the word that has no relation with the others (intruder word). In each displacement, players can only discover one cone. They must memorise the words and communicate it to their colleagues. When they discover all the words, they must agree on the intruder word, and write it on a sheet of paper. The total number of correctly answered rows will be counted at the end of the game. The winner will be the team with the most points at the end of the game.

doubts and any possible disturbances (e.g., noise outside the classroom, confused students, mistakes in some sheet copies, or students having an empty pen). To ensure the adequate PE teachers' behaviour and students' engagement in learning, it is very important to carry out the specific instruction targeted at the teacher involved (Derri, Vasiliadou, & Kioumourtzoglou, 2015). Following the above, to perform the programme in PE classes, each PE teacher was instructed about the CogniPE programme two times per week, for four weeks. A one-day training programme was provided before the start of the intervention by the researchers who developed the programme. This study was approved by the Bioethics Committee of the University of Jaén (Spain), reference CEIH211015. The design complies with the Spanish regulations for clinical research in humans (*Law 14/2007, July 3rd, Biomedical Research*), with the regulations for private data protection (*Organic Law 15/1999*), and with the principles of the *Declaration of Helsinki* (2013 version, Brasil).

Data analysis

The comparison of the continuous and categorical variables according to participation in programmes was carried out through one-factor analysis of variance (ANOVA) and Chi^2, respectively. Homoscedasticity and normality of the distribution of variables was tested by the Levenne and Kolmogorov-Smirnov tests, respectively (all cases p>.05). To study the relationship between variables, Spearman's correlation was used. The repeated measures analysis of covariance (ANCOVA) 3 Group (CG, EG1, EG2) x 2 Time (pre, post) was used to analyse the effects of this intervention. All CP and EI measures were used as dependent variables, the group was used as the fixed factor, and age, BMI, maternal education, daily study time and MVPA as confounders. *Post-hoc* analysis was adjusted according to Bonferroni. Analyses were carried out separately for each dependent variable. When there were differences between the groups at the beginning of the study, the pre-measure was included as a covariate. The effect size was computed and reported as a partial η^2 value for the ANOVA evaluations. To quantify the magnitude of changes between and within the groups in the dependent variables, we calculated the effect sizes Cohen's d. A Cohen's d value ≥ 0.8 indicates a large effect size, a Cohen's d value ≥ 0.5 < 0.8 indicates a medium effect size, and a Cohen's d value ≥ 0.2 < 0.5 indicates a small effect size (Cohen, 1998). For all the analyses, a 95% confidence level was used (p<.05). The percentage of change between the groups after the intervention was calculated as:

[(corresponding EG post-measurement – CG post-measurement) / CG post-measurement] x 100.

The analyses were completed using the statistical software package SPSS (v.22 for Windows).

Results

Descriptive analysis of variables and intensity of the programmes during the application

Table 1 shows the sociometric, cognitive and emotional values of participants. Participants spent 2.61 ± 1.47 hours in front of a computer at home, carried out a mean of 3.23 ± 1.67 days/week of MVPA and studied daily 65 ± 41 min. The participants memorised 3.98 ± 2.32 words/min, carried out 6.71 ± 2.42 mathematical operations/min and associated 20.12 ± 5.21 words/min. Only 34% of their mothers had undergone university studies. Within EI, the well-being factor got the highest score (4.18 ± 0.74, range: 1−7). Only the self-control factor showed differences between the groups (p=.019) at the beginning of the study. No initial differences were found between the CG and experimental groups in other socio-anthropometric, cognitive or emotional measures (all p>.05). On the other hand, the average intensity during the application of the programmes was different in each group (heart rate = 101.9 bmp, 147.4 bmp and 137.8 bmp for CG, EG1 and EG2, respectively).

Bivariate analysis between anthropometric, sociodemographic and cognitive−emotional measures

Table 3 shows the results of Spearman's correlation between variables. Age was positively related to BMI (Rho = 0.250, p<.05) and attention (Rho = 0.236, p<.05). Girls demonstrated higher attention (Rho = 0.213, p<.05) and daily studying time (Rho = 0.334, p<.05). Mothers with a higher educational level were related to children with higher concentration, mathematical calculation and linguistic reasoning (Rho = 0.329 for the highest, p<.01). Attention and concentration were highly correlated (Rho = 0.969, p<.001) and, at the same time, both were associated with mathematical calculation and linguistic reasoning (Rho = 0.509, p<.05 for the highest). Well-being was positively associated with linguistic reasoning (Rho = 0.2012, p<.05), and negatively with BMI (Rho = 0.283, p<.01), whereas emotionality was negatively associated with memory (Rho = -0.249, p<.05). Finally, sociability was positively related to self-control and emotionality (Rho = 0.350, p<.01 for the highest).

ANCOVA analysis of the effect of the intervention on cognitive performance and emotional intelligence variables

Figures 2, 3 and 4 show the results of ANCOVA analysis when each cognitive and EI measure was used as the dependent variable, the group (CG, EG1,

Table 3. Bivariate correlation of Spearman between the studied variables (n = 180)

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Age	1												
2. BMI	.250*	1											
3. Maternal education	-.098	.109	1										
4. Daily study time	-.127	.334**	.039	1									
5. MVPA	-.096	-051	.150	-.052	1								
6. Memory	.016	-.165	-.060	.004	-.102	1							
7. Atenttion	.236*	.213*	.037	.128	.099	.184	1						
8. Concentration	.193	.198	.019	.163	.121	.169	.969**	1					
9. Math calculation	.043	.117	.014	.329**	.183	.243*	.361**	.345**	1				
10. Linguistic reasoning	.164	.118	-.156	.236*	.163	.260*	.458**	.467**	.509**	1			
11. Well-being	.140	.083	-.283**	.009	.220*	-.015	.181	.191	.028	.212*	1		
12. Self-control	.080	-.107	.007	.006	.097	-.091	-.193	-.162	-.194	-.074	-.026	1	
13. Emotionality	-.085	-.072	-.084	.058	-.058	-.249*	-.058	-.017	.083	.005	.108	.385**	1
14. Sociability	-.032	-.021	-.012	.263*	.278*	-.148	-.195	-.207	.092	-.072	.158	.307**	.350**

Note. **Correlation is significant at level 0.01 (bilateral). *Correlation is significant at level <0.05 (bilateral). BMI = body mass index. MVPA = moderate to vigorous physical activity.

EG2) as fixed, and age, BMI, maternal education level, daily study time and MVPA as confounders. The interest analysis in memory (Figure 4A) showed a main time effect (p=.012) but not main group effect nor interaction between time and study groups (all p>.05). Results in selective attention (Figure 4B) showed a main time effect (p<.001), a main group effect F(1,177) = 5.024, p=.008, *partial* η^2 = 0.054, *1-β* = 0.810 and an interaction group x time effect near to significance F(2,177) = 2.752, p=0.066, *partial* η^2 = 0.030, *1-β* = 0.538. After 8 sessions, GE1 and GE2 increased selective attention (Pre: 142.0 ± 35.25 vs Post: 159.47 ± 33.62, p=.012; and Pre: 140.33 ± 35.71 vs Post: 168.48 ± 41.64, p<.001, respectively). Additionally, selective attention improved by 11.9% in EG1 and by 18.2% in EG2 compared to CG (EG1: 159.47 ± 33.62 vs CG: 142.52 ± 39.16, p=.023, *Cohen's d* = 0.464 and EG2: 168.48 ± 41.64 vs. CG: 142.52 ± 39.16, p<.001, *Cohen's d* = 0.644, respectively). Finally, concentration (Figure 4C) showed a main time effect (p<.001) and a main group effect F(1,177) = 4.391, p=.014, *partial* η^2 = 0.047, *1-β* = 0.75. After 8 sessions, concentration improved by 9.2% in EG1 and by 14.4% in EG2 compared to CG (EG1: 147.01 ± 36.03 vs CG: 134.57 ± 45.03, p=.036, *Cohen's d* = 0.305 and EG2: 154.38 ± 39.36 vs. CG: 134.57 ± 45.03, p<.007, *Cohen's d* = 0.468, respectively).

Data on mathematical calculation (Figure 3A) showed a main group effect F(1,177) = 4.149, p=.017, *partial* η^2 = 0.045, *1-β* =0.727 and an interaction group x time effect near to significance F(1,177) = 2.764, p=.066, *partial* η^2 = 0.030, *1-β* = 0.540. After 8 sessions, EG1 and EG2 increased mathematical calculation (Pre: 6.97 ± 2.20 vs Post: 7.72 ± 2.51, p=.011; and Pre: 6.78 ± 2.23 vs. Post: 7.91

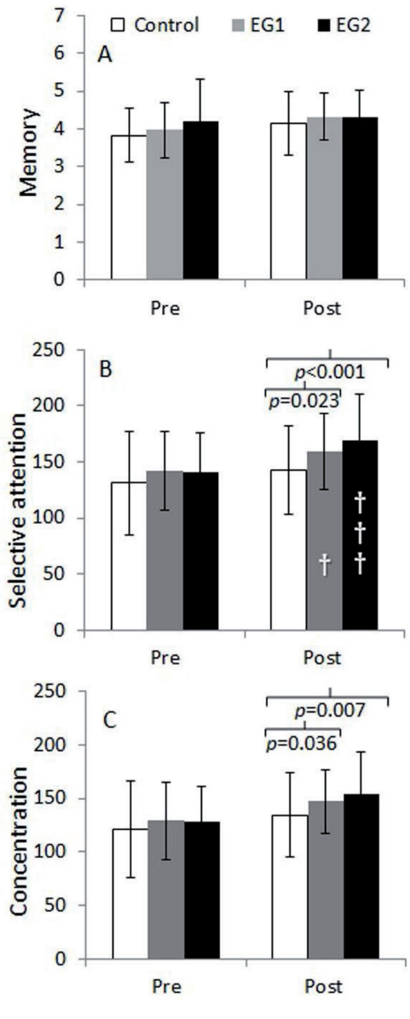

Figure 2. ANCOVA analysis in memory, selective attention, and concentration after 8-session physical activity programmes in adolescents. Data expressed as mean and SD. EG1 = small-sided games of team sports; EG2 = CogniPE programme. † and ††† denote p<.05 and p<.001, respectively, compared to pre-measure in the same group.

± 2.15, p<.001, respectively). Additionally, mathematical calculation improved by 15.9% in EG1 and by 18.7% in EG2 regarding to CG (EG1: 7.72 ± 2.51 vs. CG: 6.66 ± 2.10, p=.009, *Cohen's d* = 0.458; and EG2: 7.91 ± 2.15 vs. CG: 6.66 ± 2.10, p<.001, *Cohen's d* = 0.588, respectively). Results in linguistic reasoning did not show any main or interaction effect (all p>.05, Figure 3B).

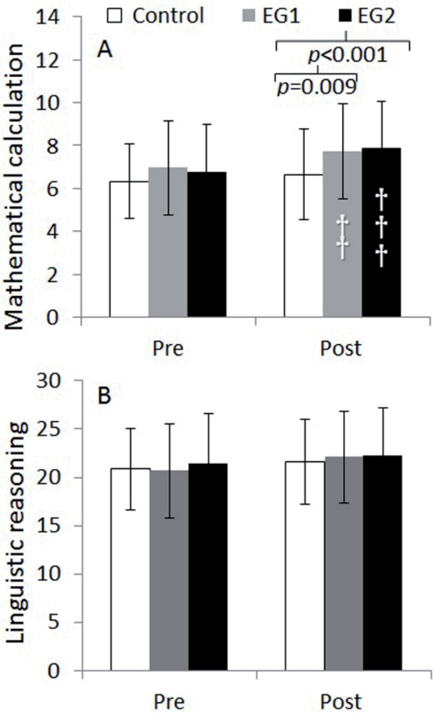

Figure 3. ANCOVA analysis in mathematical calculation and linguistic reasoning after 8-session physical activity programmes in adolescents. Data expressed as mean and SD. EG1 = small-sided games of team sports; EG2 = CogniPE programme. †† and ††† denote p<.01 and p<.001, respectively, compared to pre-measure in the same group.

Results in EI are shown in Figure 4. Well-being showed a main time effect (p=.022), and main group effect F(1,177) = 4.826, p=.009, *partial* η^2 = 0.052, *1-β* = 0.794. After 8 sessions, EG1 increased in well-being by 10.9% compared to CG (EG1: 4.55 ± 0.60 vs CG: 4.10 ± 0.61, p<.001, *Cohen's d* = 0.743). Data about sociability showed a main time effect (p=.001), main group effect F(1,177) = 4.414, p=.013, *partial* η^2 = 0.048, *1-β* = 0.755, and a group x time interaction F(1,177) = 7.898, p=.001, *partial* η^2 = 0.082, *1-β* = 0.951. After 8 sessions, sociability improved in EG1 (Post: 4.40 ± 0.80 vs. Pre; 4.05 ± 0.78, p=.005) and in EG2 (Post: 4.52 ± 0.94 vs. Pre: 4.05 ± 0.78, p<.001). Additionally, the EG1 improved by 12.8% and the EG2 by 15.9% in sociability regarding to CG (EG1: 4.40 ± 0.80 vs. CG: 3.90 ± 0.62, p=.005, *Cohen's d* = 0.741; and EG2: 4.52 ± 0.94 vs. CG: 3.90 ± 0.62, p<.001, *Cohen's d* = 0.778, respectively). Results in self-control (Figure 4B) and emotionality (Figure 4C) did not show any main nor interaction effect (all p>.05).

Discussion and conclusions

This study analysed the effect of four weeks of two programmes of PE (team sports and CogniPE) on the CP and EI of Spanish adolescents aged between 13 and 16 years. Main results have shown that the selective attention, concentration and math-

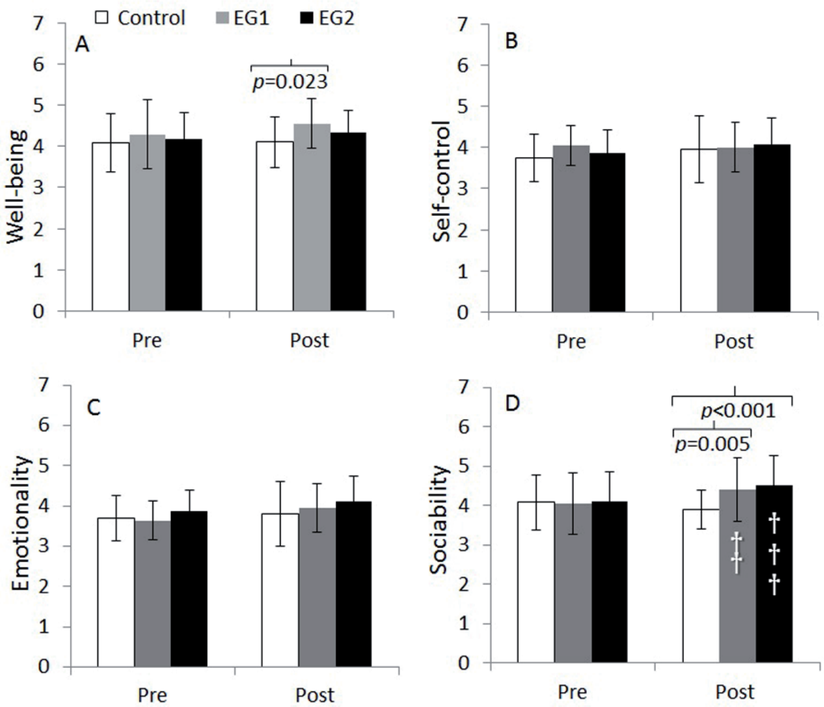

Figure 4. ANCOVA analysis in emotional intelligence after 8-session physical activity programmes in adolescents. Data expressed as mean and SD. EG1 = small-sided games of team sports; EG2 = CogniPE programme. †† and ††† denote p<.01 and p<.001, respectively, compared to pre-measure in the same group.

ematical calculation improved after eight sessions of small-sided games of team sports. Furthermore, when the programme was based on CogniPE, the percentage of improvement was larger. With regard to IE, it has been proven that well-being expresses significant improvements after small-sided games of team sports. Sociability shows improvement after both interventions, being higher in the CogniPE group. No negative effects have been observed and no injury occurred during the programmes.

The results of this study show that selective attention and concentration increased by 11.9% and 9.2%, respectively, in small-sided games of team sports, and 18.2% and 14.4% in CogniPE, relative to CG. These findings confirm, in part, the authors' previous hypothesis and are similar to the study by Martínez-López et al. (2018), in which a monitored intervention of 16 minutes of C-HIIT during 12 weeks at the beginning of PE classes showed positive effects on attention or concentration. It has also been found that the maintenance of on-task attention in the face of distraction was improved by an aerobic endurance exercise-based 30 min PE programme, but not by a short aerobic movement break of 5-min in 13-14-year-old German students (Kubesch, et al., 2009). This suggests that a duration of between 16 and 30 minutes is decisive for improving students' attention. Moreover, more specifically, some authors have confirmed that interventions mixing PA and cognitive contents improve sustained attention (Donnelly & Lambourne, 2011). In line with our results, the studies conducted by Schmidt (2015 and 2016), found that cognitive variables of attention and speed processing improved to a greater extent in the cognitive demand group after just three weeks of intervention. Pesce et al. (2013) and Crova et al. (2014) also support the above hypothesis and showed that the receptive attention and inhibition improved in the long term way after both 6-month interventions with cognitively enriched PA versus non-cognitively enriched PA, in 5-10-year-old children and in 9-10-year-old overweight children, respectively. In adolescents, Benzing et al. (2016) showed a positive relationship between PA with higher cognitive demand and executive functions after 15 minutes of intervention. In this regard, we found that the CogniPE group showed better improvements in attention than the small-sided games group compared to the CG (+6.3%) and concentration (+5.2%). These results show that PA with cognitive engagement could be the most interesting approach in benefiting CP in children. However, contrary to the above conclusions, Gallotta et al. (2012) reported that children's attention was lower in the condition that mixed cognitive and physical exertion. Furthermore, Egger, Conzelmann & Schmidt (2018) found deteriorative effects on children's executive functions after applying 20 min of physically and cognitively challenging PA. Even Jäger et al. (2015) found no main effect for PA nor for cognitive engagement conditions. Despite our positive results, the controversy in the literature questions whether physical exertion, cognitive engagement or both in combination are most beneficial for children's attention-concentration, and more interventional studies with an exhaustive control of variables are necessary.

On the other hand, the mathematical calculation improved by 15.9% in small-sided games of team sports and 18.7% in CogniPE compared to CG after four weeks of intervention. Other studies, such as the one carried out by Martínez-López et al. (2018), showed that the C-HIIT applied in PE classes produced improvement in mathematical calculation, above all in inactive adolescents (Martínez-López, et al., 2018). This could show that the simple PA stimuli could be enough to positively affect maths variables. More specifically, when the programme is mixed with physically active lessons of 20-30 min/day x 2-3 days/week x 21-22 weeks, it increased mathematical scores (Mullender-Wijnsma, et al., 2016). This is similar to our results, which showed that both PA through small-sided games of team sports and CogniPE programmes can develop maths aspects in young people, although to a greater extent in the latter one (+2.8%). Similar to the above, Beck et al. (2016), investigated whether an intervention of 60 min/day x 3 days/week x 6 weeks of fine or gross motor activity integrated into maths lessons could improve mathematical performance. Three groups were included: a CG, which received non-motor enriched conventional mathematical teaching, and two EGs, which received mathematical teaching enriched with fine and gross motor activity, respectively. All groups improved their mathematical performance, but in line with our findings, the improvement was significantly greater in the gross motor maths group compared to the fine one. The gross motor group performed inter-limb movements, and static-dynamic movements involving a large range of movement (e.g., skipping, throwing, crawling, one-legged balance). In a similar way to our CogniPE proposal, the gross motor movements were performed while solving maths problems during the lessons (Beck, et al., 2016). Therefore, based on all these evidence, combining PA and maths content during PE classes could improve the mathematical performance of young people.

As regards the EI, the well-being factor improved by 10.9% compared to CG after eight sessions of small-sided games of team sports. In addition, sociability improved after both interventions, with small-sided games of team sports improved by 12.8% and with CogniPE by 15.9% compared to CG. Compared with other studies, for example 16 minutes of C-HIIT in PE classes also improved well-being and sociability in adolescents (Ruiz-Ariza, et al., 2019). These authors attribute justifiably these results to enjoyment and social contact during the games. Our findings are also similar to those obtained by Costigan et al. (2016), who showed a positive chronic effect on psychological well-being among adolescents after a programme of 8-10 minutes of high intensity (>85%), with a work-to-rest ratio of 30:30 seconds, 3 sessions/week, during two months. Other studies have also found a specific association between moderate intensity PA and well-being (Ruiz-Ariza, de la Torre-Cruz, Redecillas-Peiró, & Martínez-López, 2015) or sociability (Ruiz-Ariza, et al., 2018) in adolescents. And Azevedo, Burges-Watson, Haighton & Adams (2014) found a positive significant effect of a dynamic 12-month follow-up dance intervention on psychological well-being, which increased positive emotions and socio-emotional balance. Thus, playing small-sided games could have an intrinsic positive motivation that improves well-being. For its part, thinking while playing could decrease the enjoyment during the practice, with worse results in well-being, however the social contact in solving some of the cognitive tasks during the exercise could have the most effects on sociability.

Some of the mentioned effects could be explained through several mechanisms. The assumption of cognitive stimulation hypothesis is that coordinative demanding and non-automated sport-related activities activate the same brain regions that are used to control higher-order cognitive processes (Best, 2010; Schmidt, et al., 2015). Based on the theoretical assumption of shared information processes in both motor and cognitive control, this hypothesis explains intervention effects in terms of the specific activation of these processes during PA, which promotes cognitive benefits (Schmidt, et al., 2015). In addition, connecting information deriving from two different sources might have resulted in a greater cognitive load in the PA enriched with cognitive demand than in the team sport condition, for example, thinking in solving maths tasks is probably more cognitively challenging than simply playing team sports (Schmidt, et al., 2019). Also, doing an activity of running towards different numbers according to a mathematical problem result requires the ability to discriminate between different responses, reaction to visual stimuli, and appropriate motor decisions making. In this sense, physical and cognitive tasks involve exactly the same cognitive processes in a single exercise (Schmidt, et al., 2015). As another explanation, children's level of cognitive exertion can be linked to mental effort (Chen, Castro-Alonso, Paas & Sweller, 2017). Hence, the multimodal information arising from the external learning environment of movement requires greater attention and concentration, resulting in a substantial depletion of children's attentional resources, even if they are not aware of the additional mental effort they are investing (Schmidt, et al., 2019). The great effect found for cognitive intervention could also be related to the embodied cognition and the cognitive load theory. The use of learning processes during body movements can transform abstract information into concrete and tangible concepts (Mavilidi, et al., 2018). The sensorimotor experiences in the embodied learning condition allow incoming information to be processed simultaneously through different systems (Schmidt, et al., 2019). From the perspective of cognitive load theory, this way of information processing is associated with a relative expansion of the available processing capacity, enrichment of the resulting cognitive schema, and consequently better learning performance (Mavilidi, et al., 2018). In this sense, it is argued that embodying knowledge through motor actions contributes to the construction of higher-quality mental representations, facilitating recall, and enhancing memory and learning (Madan & Singhal, 2012).

Although the results of the present study did not find an effect of CogniPE intervention on memory, linguistic reasoning, self-control and emotionability, the majority of studies show that memory increases after exercise (Budde, et al., 2008). For example, a current chronic study shows that six weeks of a PA programme resulted in improvements in working memory (Moreau, Kirk, & Waldie, 2017). Sjöwall, Hertz, and Klingberg (2017) found in a 2-year school-based intervention in preadolescent children (ages 6-13) that the increase in the number of weekly PE classes (aimed at increasing cardiorespiratory fitness) from 2 to 5 days per week did not affect working memory. With regard to linguistic reasoning, in agreement with the present study's data, Ardoy et al. (2014) did not find any effect on the verbal reasoning factor. However, a current systematic review showed that 60% of studies found beneficial effects on linguistic skills (Carson, et al. 2016). More specifically, a long-term programme based on 20-30 min/day x 2-3 days/week x 21-22 weeks, did not increase language performance (Mullender-Wijnsma, et al., 2016). However, Barnard, Van Deventer, and Oswald (2014) analysed the role of active teaching programmes in linguistic skills over eight weeks using two conditions: 1) an integrated academic skills and physical development programme; and 2) a moderately intensive PA programme. The results indicated that both programmes showed progress in language. Therefore, the above disagreement shows the need to continue studying the effects of other specific programmes on these variables.

Furthemore, during CogniPE we noticed that it was rather difficult for some participants to continuously play and think at a recommended intensity. In fact, the average intensity during the application of the programmes was different in each group. The heart rate for CG was 101.9 bmp, 147.4 bmp for EG1 and 137.8 bmp for EG2. This difference between EGs could be due to the stimuli in EG2 requiring participants to think during the exercise, and maybe they paused their PA for some seconds during the execution of cognitive tasks. The intensity level and duration of stimuli vary widely across the studies, with heart rates ranging from 120 (Budde, et al., 2008) to 160 bpm (Best, 2010) and activity durations ranging from 10 (Budde, et al., 2008) to 50 min (Gallotta, et al., 2012). For example, Cooper et al. (2018) showed in their intervention of 60 min games-based activity (basketball) that participants' heart rate was 158±11 bpm. This intensity was higher than in our EG2, maybe for the same continued stimuli during 60 min without changes or breaks. Also, although it was indicated that none of the participants carried out extracurricular PA during the weeks of the study, this was measured with a self-report measurement (MVPA questionnaire). Finally, positively influencing a participant's enjoyment could be relevant for CP–EI, since changes in positive affect have been previously found to mediate the relationship between cognitive-engaging activities and children's attention (Schmidt, et al., 2016), interpreted as being additional support for mood being a facilitator for cognitive processing.

It is concluded that a 4-week programme of CogniPE improves attention, concentration and mathematical calculation, besides increasing variables of emotional intelligence, such as sociability in young people. It is suggested that PE teaching units integrating CogniPE promote cognitive and emotional aspects in children. Additional intervention studies are required to learn more details of the acute effects of including cognitive content in PE, as well as influencing other important variables of physical and academic performance.

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Submitted: May 13, 2022
Accepted: August 11, 2022
Published Online First: May 2, 2023

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