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Depressive Symptomatology and Physical Exercise Despite Physical Harm or Injury in University Students

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Abstract

The aim of the present study was to examine the relationship between depressive symptomatology and persistence in physical exercise in the presence of physical harm or injury. Data obtained from 345 university students (52.50% female) aged 18-37 years (M_{age} = 21.67; SD_{age} = 3.48) who reported engaging in recreational exercise at least once a week were analysed. The data were analysed using regression analyses using a robust maximum likelihood (RML) estimation method. These analyses accounted for the effects of age, gender, body mass index, perceived health status, frequency of physical exercise, and level of risk of eating disorders. In the first regression analysis, depressive symptomatology (β = .193, 95% CI = .098 to .288, p < .001) explained a significant proportion of variance in exercising in the presence of physical harm or injury (18.30%). In the second regression analysis, exercising in the presence of physical harm or injury (β = .186, 95% CI = .111 to .261, p < .001) explained a significant proportion of variance in depressive symptomatology (18.80%). The present findings suggest the need to further examine the variables that could condition the relationship between depressive symptomatology and exercising in the presence of physical harm or injury, as well as the possible causal nature of this relationship.

Keywords: depressive disorders, eating disorders, exercise addiction, exercise dependence, morbid exercise.

Introduction

The term *problematic exercise* has been introduced to refer to all forms of physical exercise that are not necessarily healthy (Sicilia et al., 2022). This term refers to a complex phenomenon that, in any of its multiple manifestations, can compromise some of the benefits derived from exercise (Alcaraz-Ibáñez et al., 2022b). One of the most frequently investigated possible manifestations of problematic exercise is that defined according to the six criteria proposed for behavioural addictions. These include *salience* (i.e., exercise becomes the central activity in the person's life, to the extent that it dominates their thoughts, feelings and behaviour), *conflict* (i.e., the occurrence of conflict between the person and those around them, with other social/professional activities, or with themselves arising from exercise habits), *mood modification* (i.e., use of exercise as a way of experiencing positive feelings, to the extent that the activity becomes a form of coping), *tolerance* (i.e., the need for higher volumes of exercise to obtain the desired effects that were obtained in the past with lower volumes of exercise), *withdrawal* (i.e., experiencing negative mood states such as irritability or sadness and/or negative physical effects such as pain or muscle tension when exercise is stopped or drastically reduced) and *relapse* (i.e., the tendency to repeat excessive past exercise patterns after periods of self-control) (Terry et al., 2004).

One issue that has been a matter of great controversy in the context of the study of behavioural addictions, and particularly with regard to exercise addiction, is whether to consider this phenomenon as a psychopathological process in its own right or, alternatively, as a co-morbidity of other mental disorders (Starcevic & Khazaal, 2017). Irrespective of this debate, the results of several review studies suggest that depressive processes are one of the mental health problems most closely related to various behavioural addictions (Elhai et al., 2017; Starcevic & Khazaal, 2017). This relationship has been based on a twofold possibility. First, that engaging in a pleasurable behaviour (e.g., exercise) as a way of coping with the discomfort inherent in depressive processes could lead to the emergence of addictive patterns in the performance of the behaviour. Secondly, that some of the processes underlying the addictive patterns of behaviour (e.g., the existence of conflicts or the presence of withdrawal symptoms) could impair the person's mood to the point of increasing the presence of depressive symptomatology (Gámez-Guadix, 2014).

The results of a recent study comprising a study population of regular exercisers (defined as those who engaged in physical activity at least once a week; Lichtenstein et al, 2018) revealed a positive relationship between self-reported levels of exercise addiction and depressive symptomatology, which was independent of gender, age, body mass index (BMI), or risk status in terms of risk of eating disorder (ED) (Alcaraz-Ibáñez et al., 2022a). In this regard, evidence suggesting that the instrument used in this study (i. e., Exercise Addiction Inventory, EAI; Terry et al., 2004) might reflect an over-involvement in activity that is not necessarily pathological (Szabo et al., 2015), led the authors to consider two other possible confounding variables: (i) frequency of exercise and (ii) perceived level of health. Confirming the non-problematic nature of the presence of high EAI scores, these were positively related to both exercise frequency and perceived levels of health (Alcaraz-Ibáñez et al., 2022a).

An alternative approach to using EAI to characterise problematic exercise patterns is to consider some context-specific exercise behaviours that, although not part of the generic criteria proposed for behavioural addictions (Szabo et al., 2015), unambiguously imply harm. An example of this would be persisting with exercise despite suffering some kind of physical harm or injury (Lichtenstein & Jensen, 2016; Pálfi et al., 2021). However, the relationship between this behaviour and depressive symptomatology has not been investigated to date.

The present study was designed to replicate the findings of a recent study that examined the relationship between depressive symptomatology and exercise addiction (Alcaraz-Ibáñez et al., 2022a), considering exercise performed in the presence of physical harm or injury instead of the latter variable. In line with the hypotheses tested in the above-mentioned baseline study, it was expected that, after accounting for the effects of several potential confounding variables (i.e., risk of ED, frequency of exercise, perceived health status, gender and BMI), there would be a positive relationship between depressive symptomatology and exercise in the presence of physical harm or injury. Given

the potential bidirectional nature of the relationship under examination (Gámez-Guadix, 2014), the relationship between the two variables of interest was expected to exist irrespective of whether they were configured as dependent or independent in the statistical analyses.

Methodology

Participants

A total of 385 students enrolled in a public university in southern Spain were invited to participate in the study. In line with the study proposal whose results are to be replicated (Alcaraz-Ibáñez et al., 2022a), participants were considered eligible if they reported engaging in recreational exercise (i.e. exercise for which no financial compensation is received) at least once a week at the time of the study (Lichtenstein et al., 2018). The adoption of this inclusion criterion meant that 40 of the potential participants in the sample whose data were analysed were excluded. Participants mainly performed exercise modalities aimed at improving endurance (e.g., running or cycling, 30%), team sports or individual sports not specifically aimed at improving endurance (26%), exercise modalities aimed at improving general health and fitness (e.g., those carried out in fitness centre settings, 22%), strength-oriented exercise modalities (e.g., weight training or crossfit, 12%), and multiple modalities (10%) Thus, the sample ultimately analysed comprised a total of 345 participants (52.50% female), whose ages and BMIs ranged respectively between 18 and 37 years (M_{age} = 21.67; SD_{age} = 3.48) and 16.59 and 34.63kg/m^2 (M_{BMI} = 23.03; SD_{BMI} = 3.02). Participants identified themselves as Caucasian (96%), North African (3%) and Latino (1%).

Materials and Resources

Practice of physical exercise in the presence of physical harm or injury. Assessed using a Spanish adaptation of the English item previously proposed for this purpose (*i. e., I exercise in spite of pain and injuries*) (Lichtenstein & Jensen, 2016) (Responses were provided using a 5-point Likert scale ranging from 1 (*Strongly Disagree*) to 5 (*Strongly Agree*).

Depressive symptomatology. Assessed using the depression subscale of the Spanish version of the Brief Symptom Inventory-18 (BSI-18; Derogatis, 2000). Scored on a 5-point Likert scale ranging from 0 (*not at all*) to 4 (*extremely*), the 6 items included in the instrument assess distress generated by the presence of depressive symptoms (i.e., apathy, sadness, self-loathing, anguish, hopelessness and suicidal ideation) experienced during the past 7 days. Composite reliability and internal consistency indices of ρ = .93 and α = .89, respectively, were obtained in the present study.

Risk of eating disorder (ED). Assessed using the Spanish version (Garcia-Campayo et al., 2005) of the SCOFF questionnaire (Morgan et al., 1999). Answered dichotomously (i.e., yes or no), the five items included in this instrument reflect key features of anorexia and bulimia nervosa (e.g., the presence of intrusive thoughts about food). Two or more positive responses indicate the presence of risk of ED (Morgan et al., 1999). Sensitivity values of 80% and specificity values of 93% have been reported in this context for SCOFF (Botella et al., 2013).

Frequency of exercise. Assessed using the following two items (Prochaska et al., 2001): (i) "During the last 7 days, on how many of those days have you exercised for at least 30 minutes?" and (ii) "In a typical week, on how many days do you usually exercise for at least 30 minutes?". In a similar manner to that proposed by previous work in the context of the study of potentially problematic patterns of physical exercise, the composite score of both items was considered (Alcaraz-Ibáñez et al., 2019). Composite reliability and internal consistency indices of ρ = .94 and α = .92, respectively, were obtained in the present study.

Perceived health status. Assessed using the Spanish version (Alonso et al., 1995) of the SF-1 derived from the short version of the Health Status Questionnaire (Ware Jr. & Sherbourne, 1992). Scored on a 5-point Likert scale ranging from 0 (*excellent*) to 5 (*poor*), this single item ("Overall, would you say your health status is...") provides a simple index of perceived general health status. Once the scores are reversed, higher scores imply higher levels of perceived health.

Sociodemographic variables. Participants provided their gender, age, ethnicity, main mode of physical exercise, height and weight, the latter two variables being used to calculate BMI (kg/m^2).

Procedure

Firstly, approval was obtained from the ethics committee of the University of Almeria (UALBIO2017/009). At the beginning of a teaching session, potential participants were then invited to collaborate in a study aimed at finding out about exercise habits and the students' perception of health. After being informed of the voluntary, anonymous, non-monetary and non-academically compensated nature of their participation, those potential participants who gave their consent completed a questionnaire in paper format. This task took no more than six minutes. The study was conducted in accordance with the ethical principles for biomedical research involving human subjects, as set out in the World Medical Association Declaration of Helsinki (as amended in 2013).

Statistical Analysis

A similar analytical approach to the one used in the study whose results were to be replicated (Alcaraz-Ibáñez et al., 2022a) was adopted, considering in this case the practice of physical exercise in the presence of physical problems or in situations of injury instead of the symptoms of behavioural addictions adapted to the context of exercise. First, descriptive statistics and correlations (r) between the study variables were obtained. Differences (d) were then calculated by gender and level of ED risk for the different study variables, which were interpreted as trivial (.00 to .20), small (.20 to .50), moderate (.50 to .80), or large (> .80) (Cohen, 1988).

The measurement model for the two specified latent variables (i.e., depressive symptoms and frequency of physical exercise) was then examined using Confirmatory Factor Analysis (CFA) techniques using Mplus 7 software(Muthén & Muthén, 1998-2015). Given the ordered categorical nature of the variables of interest, this analysis was carried out using the Weighted Least Squares Mean and Variance-adjusted (WLSMV) robust estimation method (Li, 2015). Missing values (< 1%) were accounted for using the imputation methods implemented for this purpose in the Mplus 7 software. Values in the Comparative Fit Index (CFI) above .96, in the Root Mean Square Error of Approximation (RMSEA) below .08 and in the Weighted Root Mean Residual (WRMR) below 1.00 were considered indicative of an excellent fit of the data to the model (Yu, 2002). Latent factor scores for depressive symptoms and frequency of physical exercise were derived from the CFA results described above using the FSCORES function implemented in the Mplus 7 software (Muthén & Muthén, 1998-2015). These latent scores were used to examine the multivariate relationships of interest. This way of proceeding enabled measurement errors to be considered without needing to set up all possible latent variables as such in the regression models tested, thereby allowing for a ratio between cases and estimated parameters higher than the minimum recommended (Kline, 2011). Thus, depressive symptoms and exercise in the presence of physical harm or injury were respectively considered as dependent variables in two regression models specified in Mplus 7 in which age, gender, BMI, perceived health status and level of risk for ED were included as independent variables. Depending on the presence of both dichotomous variables (e.g., gender or level of risk of ED) and continuous variables (e.g., latent factor scores) and also taking into account the nested nature of the data (given that the data were obtained from different groups of students), the regression analyses described above were performed using the Maximum Likelihood Robust (MLR) method and the COMPLEX function implemented in the Mplus 7 software (Muthén & Muthén, 1998-2015).

Results

Descriptive statistics, correlations between the study variables, and differences in the variables according to gender and level of risk of ED are shown in Table 1. 22% of the participants were at risk of developing an ED according to the results of the screening instrument used (Morgan et al., 1999). Physical exercise in the presence of physical harm or injury correlated (i) negatively with age (r = -.14, p = .01) and (ii) positively with perceived health status (r = .10, p = .05), frequency of exercise (r = .23, p < .001) and depressive symptomatology (r = 14, p = .01). In turn, depressive symptomatology was negatively correlated with perceived health status (r = -.18, p = .01). Differences of moderate significance were observed that favoured (i) men in levels of exercise practice in the presence of physical harm or injury (d = 0.47) and (ii) women in levels of depressive symptomatology (d = 0.47). These differences favoured participants classified as being at risk of developing an ED over those who were not for (i) depressive symptomatology (d = 0.76) and (ii) levels of exercise in the presence of physical harm or injury (d = 0.18), the significance of the differences being moderate and trivial, respectively.

Table 1
Descriptive statistics, analysis of differences and correlations between the study variables.

	Gender					ED Risk					Complete sample (*N* = 345)							
	Female (*n* = 181)		Male (*n* = 164)			No (*n* = 268)		Yes (*n* = 77)										
	M	*SD*	*M*	*SD*	*d*	*M*	*SD*	*M*	*SD*	*d*	Range	*M*	*SD*	1	2	3	4	5
1. Age	21.75	2.94	21.58	4.00	-0.05	21.73	3.38	21.47	3.82	-0.08	18-37	21.52	3.16	-				
2. BMI	22.45	3.30	23.67	2.52	0.41	22.51	2.80	24.87	3.06	0.83	16.59-34.63	22.94	2.76	.02	-			
3. Perceived health status	3.84	0.75	4.12	0.70	0.39	4.06	0.69	3.66	0.82	-0.56	1-5	4.01	0.70	-.05	-.18**	-		
4. Frequency of exercise	3.47	1.53	4.13	1.69	0.41	3.74	1.65	3.95	1.60	0.13	1-7	3.88	1.58	-.13	.01	.17**	-	
5. Depressive symptomatology	1.11	0.96	0.75	0.81	-0.40	0.79	0.80	1.45	1.07	0.76	0-4	0.77	0.81	.04	.03	-.18**	-.04	-
6. Exercise in the presence of physical harm or injury	1.62	1.05	2.16	1.23	0.47	1.83	1.14	2.04	1.26	0.18	1-5	2.62	0.79	-.14*	-.02	.10	.23***	.14*

Note. BMI = Body Mass Index, ED = Eating Disorder, *d* = Effect size of differences.
*$p < .05$; **$p < .01$; ***$p < .001$.

Table 2
Linear regression analysis predicting exercise performance in the presence of physical harm or injury and depressive symptomatology.

	Model 1: R^2 = .183 DV: Exercise in the presence of physical harm or injury					Model 2: R^2 = .188 DV: Depressive symptomatology				
	β	CI 95%		*SE*	*p*	β	CI 95%		*SE*	*p*
		LB	UB				LB	UB		
Age	-.147	-.295	.001	.076	.052	.068	-.034	.169	.052	.191
Gender	.267	.166	.369	.052	< .001	-.200	-.284	-.117	.043	< .001
BMI	-.084	-.232	.064	.076	.268	-.057	-.164	.050	.055	.299
Perceived health status	.050	-.058	.159	.055	.363	-.115	-.208	-.021	.048	.016
Frequency of exercise	.198	.127	.268	.036	< .001	-.058	-.167	.051	.056	.295
ED Risk	.068	-.088	.233	.079	.394	.281	.192	.371	.046	< .001
Depressive symptomatology	.193	.098	.288	.049	< .001	-	-	-	-	-
Exercise in the presence of physical harm or injury	-	-	-	-	-	.186	.111	.261	.038	< .001

Note. DV = Dependent variable, β = Standardised regression coefficient, CI 95 % = Confidence interval at 95 %, SE = Standard error, LB = Lower bound, UB = Upper bound, BMI = body mass index, ED = Eating disorder. Being female (in the context of gender) and having been classified as "not at risk" (in the context of ED risk level) were considered as the reference categories for the dichotomous variables.

The following fit indices were obtained for the measurement model: χ^2 = 58.238, gl = 19, χ^2/gl = 3.065, p < .001; CFI = .994; RMSEA = .077 [90% CI = 055 to .100], p = .023; WRMR = 0.773. The results of the two regression models specified are presented in Table 2. The results of the first of these models showed that being male (β = .267; 95% CI = .166 to .369; p < .001), frequency of exercise β = .198; 95% CI = .127 to .268; p < .001) and the presence of depressive symptomatology (β = .193; 95% CI = .098 to .288; p < .001) positively accounted for a significant proportion of variance of exercise performance in the presence of physical harm or injury (18.30%). Results from the second of the models tested indicated that being male (β = -.200; 95% CI = -.284 to -.117; p < .001) and perceived health status (β = -.115; 95% 95% CI = -.208 to -.021; p = .016) negatively accounted for a significant proportion of variance in depressive symptomatology, whereas being at risk for an ED (β = .281; 95% CI = .192 to .371; p < .001) and exercising in the presence of physical harm or injury (β = .186; 95% CI = .111 to .261; p < .001) positively accounted for a significant proportion of variance in this dependent variable. Specifically, the variance accounted for in this second model was 18.80%.

Discussion

The aim of this study was to analyse the relationship between depressive symptomatology and problematic patterns of physical exercise. The evidence provided indicates that the results previously reported considering such patterns as behavioural addiction (Alcaraz-Ibáñez et al., 2022a) are largely replicable if they are considered in terms of persistence in exercise practice in the presence of physical harm or injury. Specifically, the findings presented suggest that, irrespective of gender, age, BMI, or risk status in terms of risk of ED, depressive symptomatology is positively associated with exercise in situations where physical harm or injury is present.

The main difference between the results reported in the reference study (Alcaraz-Ibáñez et al., 2022a) and those presented here is that the effect sizes of the relationships of interest are slightly lower in the present study. This difference could be explained by the different natures of the manifestation of the potentially problematic exercise pattern considered in the two studies. In this respect, it should be noted that one of the inherent components of behavioural addictions is the use of the particular activity (in this case, exercise) for the purpose of mood modification and thus

as a form of coping (Griffiths, 2005). It would therefore be reasonable to some extent that the existence of the negative moods inherent in depressive processes (Derogatis, 2000) could lead to a pattern of behaviour characterised to a greater extent by using the activity in question in order to improve that mood than by persisting in the practice in the absence of harm or injury.

An analogous explanation to the above could be provided by considering depressive symptoms as a possible consequence of the problematic form of exercise examined in the present study. In this sense, one of the specific components of exercise addiction concerns the presence of conflicts arising from exercise habits (Terry et al., 2004). In addition, there is evidence pointing to this component as one of the most closely related to depressive symptoms (Sicilia et al., 2020). This suggests that the negative consequences of adopting problematic exercise patterns may be more detrimental in terms of inducing greater depressive symptoms when these patterns involve some of the components not examined in this paper. In light of this reasoning, future studies should consider examining the relationship between depressive symptomatology and problematic exercise patterns by considering not one but preferably several components in isolation. Considering the large number of such components (Sicilia et al., 2022) and, in some cases, the high degree of correlation between them (Parastatidou et al., 2014), a convenient alternative for examining the relationship of interest would be to use person-centred approaches (Bergman & Andersson, 2010). Specifically, because this type of approach would allow comparison of the levels of depressive symptomatology between groups of individuals with similar profiles according to the levels shown in the different components involved in problematic exercise patterns (Sicilia et al., 2020).

A clear implication related to the professional practice of physical education teachers can be derived from the findings. In particular, the results presented here suggest the need for teachers to be aware of a twofold possibility. First, that the adoption of exercise as a form of coping in the presence of depressive states (Baker et al., 2021) could lead people suffering from such states to exercise under circumstances in which it is not advisable (i.e., in the presence of some kind of physical harm or being injured). Secondly, that persisting with exercise in the presence of harm or injury may contribute to increased levels of depressive symptomatology. It therefore seems appropriate to advise professionals in the field of physical exercise to remain attentive to the possible presence of depressive symptoms and to persistence in the practice of physical exercise in the presence of physical harm or injury in the people under their care. A possible course of action in the latter case is to warn of the potential dangers of such behaviour (e.g., aggravation/chronification of the injury or worsening of mood).

One of the main limitations of the present study is the characteristics of the instrument used in the evaluation of physical exercise in the presence of physical harm or injury. (Lichtenstein & Jensen, 2016). In this sense, it is possible that the fact that the item used refers to two different situations (i.e., the existence of physical problems and the presence of injury) could have compromised its proper understanding (Hayes & Coutts, 2020; Kyriazos & Stalikas, 2018). It is also possible that the use of a single item would have led to an undesired increase in measurement error, which could have affected the level of precision of the results (Fuchs & Diamantopoulos, 2009). In view of this limitation, future studies should corroborate the findings presented here by using validated instruments that allow for a more comprehensive assessment of the behaviour of interest. A second limitation of the present study stems from the cross-sectional and self-reported nature of the data analysed. In light of this limitation, future studies could examine the relationship between the variables of interest over time using complementary assessments to those conducted here. Examples of the above would be clinical interviews (in the case of depressive symptomatology or risk of ED), the level of prevalence of injury (García-González et al., 2015), objective data derived from the assessment of physical condition in the case of health status, or those obtained from the use of accelerometry techniques in the case of the volume of physical exercise. A third limitation stems from the specific characteristics of the participants (i.e., university students), which makes it difficult to generalise the results. It is therefore necessary that future studies address the question raised here by considering other particularly relevant populations in this context such as, for example, individuals clinically diagnosed with some type of ED (Alcaraz-Ibáñez et al., 2020) or initially sedentary individuals who are encouraged to practice exercise in order to mitigate the presence of depressive symptomatology (Béland et al., 2020).

In conclusion, the results presented suggest that depressive symptomatology and exercise in the presence of physical harm or injury may be moderately and positively related. These findings suggest the need to further study the variables that could condition this relationship, as well as to examine the possible causal nature of this relationship.

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Current situation of Physical Activity in the Natural Environment in Physical Education in Spain

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Abstract

The aim of this study was to analyse the teachers' treatment, in Spain, of the Physical Activity in the Natural Environment content block as part of Physical Education in Secondary Education. The study developed for this research conforms to a non-experimental, sectional, descriptive and correlational design, resulting in a nationally representative study. A total of 453 teachers participated (294 male and 159 female teachers) and a questionnaire created and validated by a committee of experts for the occasion was used, which was applied at national level. The results showed a high percentage of teachers who plan activities in the natural environment (91.4%); arguments about a lack of training in the field when not planning these activities and the activities most worked on were found (orienteering, hiking, first aid and games in nature). Progress was noted in the incorporation of Physical Activities in the Natural Environment as part of the classroom programme in Physical Education in Secondary Education, but not in the content worked on in these sessions. This study leads us to know the existing deficiencies in the teaching staff in Spain and the needs required for a better implementation of the Physical Activity in the Natural Environment block as part of Physical Education.

Keywords: natural environment, physical activity, secondary school teacher.

Introduction

In 2020, the emergence of COVID-19 and social constraints had considerable impact on human lifestyles (Ocaña et al., 2022). Action protocols and limitations were imposed on people's daily lives to prevent the spread of the virus. Measures such as social distancing and house and perimeter lockdown resulted in a large part of the population suffering on a psychological level, with pathologies such as depression, stress, anxiety, among others (Ballester-Martínez et al., 2022). Lockdown led to a decrease in physical activity levels and contact with the outdoors, as demonstrated by some studies (Camacho-Cardenosa et al., 2020). In these moments, people realised how important both physical activity and the environment could be in their lives. Following the removal of these restrictions, a large part of the population took to nature to perform different types of physical activities in the natural environment (PANE) without the proper training, leading to all the serious consequences that this can have for the natural environment and for the person him/herself. It is therefore necessary to reflect on the importance of raising awareness and training people in the practice of PANE in educational centres.

Teachers have perceived an opportunity to innovate and introduce these "more fashionable" sports into their teaching programmes (Baena-Extremera et al., 2012; García-Merino & Lizandra, 2021).

Much of the interest among physical education (PE) teachers in implementing these activities as part of their programme is due to the educational potential of PANE (Dalmau-Torres et al., 2020). In addition to being part of the subject of PE in the curriculum, the different benefits they bring to student development have been demonstrated(Gibbons et al., 2018; Kyle et al., 2016).

In this sense, in order to investigate the introduction of PANE as part of PE classroom programmes, various investigations have been carried out over the years (Granero-Gallegos & Baena-Extremera, 2014; Hurtado-Barroso et al., 2019; Sáez Padilla, 2008). Thanks to these studies, the increase in recent decades regarding the inclusion of PANE in PE sessions can be observed (Sáez-Padilla et al., 2017; Sáez Padilla, 2008).

However, even though PANE is part of the PE curriculum as a block of content, there are still teachers who do not incorporate these activities into their classroom programmes (Dalmau-Torres et al., 2020; Sáez-Padilla et al., 2017). Peñarrubia Lozano et al. (2011), among others, studied the reasons that lead teachers not to carry out these activities in the natural environment, concluding that the most relevant reasons were teaching responsibility, safety, teacher training and time flexibility. In this regard, teacher training has been one of the most prominent in the research carried out in relation to PANE in schools (Dalmau-Torres et al., 2020; Hurtado-Barroso et al., 2019; Macías Sierra, 2014). However, none of the aforementioned research has studied the inclusion of PANE as a function of the socio-demographic variables of the teacher and the school, so it would be interesting to ascertain whether these variables influence the inclusion of PANE.

In addition, a clear interest was expressed in identifying the type of activities carried out in the educational centres in relation to PANE. In this respect, the literature shows that the main contents worked on are orienteering, hiking and games in nature (Granero-Gallegos et al., 2010; Peñarrubia Lozano et al., 2011; Torres et al., 2016). To justify not including other activities such as climbing or caving, among others, teachers allege, in addition to the disadvantages mentioned above, the complexity of combining the modification of the school timetable with outings to the natural environment or the lack of specific material for carrying out other activities (Hurtado-Barroso et al., 2019).

Based on the importance of these activities as educational content in physical, psychological, emotional and value development (Granero-Gallegos & Baena-Extremera, 2007) and in relation to the lack of current research at national level in this field, the aim of this work was to analyse the implementation of PANE within PE in Compulsory Secondary Education (CSE) and to update the scientific literature on this subject. The following hypotheses are thus established:

H1 A high percentage of teachers include PANE in their annual classroom programme.

H2 Those teachers who consider that they do not have adequate or sufficient training in PANE do not include these activities as part of their annual CSE PE programme.

H3 The inclusion of PANE in classroom programmes will vary according to socio-demographic variables.

H4 The contents most worked on as part of the block of contents comprising activities in the natural environment in CSE continue to be those of orienteering, hiking and games in nature.

Method

Design

The study developed for this research conforms to a non-experimental, sectional, descriptive and correlational design (Sierra, 2001). It is a non-experimental research as there is no intervention work with an experimental group pre and post. It is sectional as it is carried out with a group at a specific time. It is correlational in relation to the pattern of tests that are carried out at a precise moment in time.

Sample

The questionnaire was sent to all active secondary school PE teachers. Out of the total number of secondary school PE teachers at national level, 453 teachers (294 male and 159 female teachers) participated. This entailed obtaining a nationally representative sample, given that the data obtained on the number of people teaching secondary education in Spain in 2021 (the date on which the survey was carried out) was 16,064 teachers, of which 453 teachers from the 1st to 4th years of CSE, from all parts of Spain (North, South, East, West, Central and islands) in both rural and urban areas, took part. To this end, according to Gil (2015), a confidence level of 97% with a margin of error of 3% in the representative sample has been calculated.

Validation instrument and procedure

The construction of the ad hoc questionnaire followed the guidelines of Gutiérrez Dávila and Oña Sicilia (2005). Firstly, a literature review was carried out on questionnaires analysing the inclusion of PANE in classroom programmes. From this review, pre-existing questionnaires emerged, such as that of Granero-Gallegos and Baena-Extremera (2014) and Sáez Padilla (2008), which served as a basis for the creation of the questionnaire of the present study. This questionnaire is composed of three dimensions: teaching experience, knowledge/training in the area of PANE and educational models. In addition, a section dedicated to general socio-demographic data is also considered. The questionnaire consisted of a total of 25 items with responses collected through a Likert-type, multiple-choice and dichotomous scale.

This questionnaire was pre-validated by consulting five experts, doctors and graduates in Physical Education Sciences, with extensive experience in PANE, and experts in the design and validation of educational questionnaires. Together with the questionnaire, they were provided with an answer sheet on which they could indicate on a scale of 1-4 univocity, relevance, importance and appropriate comments. A statistical analysis with the responses of all the experts was carried out using SPSS v.26. For this purpose, the Intraclass Correlation Coefficient (ICC) was calculated, calculating the experts' agreement in terms of univocity, relevance and importance for each item. The values obtained are presented in Table 1.

Table 1
Results of the ICC among 5 experts.

	PANE Teacher Questionnaire
UNIVOCITY	.837
RELEVANCE	.633
IMPORTANCE	.55

The variation in the judges' scores was resolved using the interquartile range. Finally, those items that required it were corrected and reformulated, according to the suggestions of the experts. Subsequently, the reliability analysis was calculated with a Cronbach's alpha, obtaining a value of .831.

Procedure

The sampling procedure consisted of two steps. First, a questionnaire was designed and validated by expert judges. Subsequently, the questionnaires were sent by e-mail to all schools nationwide, with a request that they be disseminated to the school's PE teachers. In the description of the questionnaire, the objective of the study, the voluntary nature of participation and, of course, the confidential treatment of the answers were stated. At the same time, maximum honesty was requested and the anonymity of the questionnaire was communicated, following the recommendations of compliance with the rights of participants in accordance with the Declaration of Helsinki (2013).

After much reflection, taking into account the difficulty posed by the school year, it was decided that the questionnaire should be administered between the months of March and June 2021, taking advantage of the fact that teachers would be more free in terms of COVID protocols and would have the time and inclination to dedicate the necessary time to filling in the survey.

Statistical Analysis

First, a descriptive statistical analysis was carried out using frequency analysis. Subsequently, an analysis of the relationship between variables was carried out using Fisher's test.

Results

The most significant data collected in the questionnaire are shown below, organised according to the statistical analyses carried out.

According to the results, it can be asserted that the observed profile of PE teachers is a person between 35-42 years of age, with a degree in Physical Activity and Sport Sciences (PASS) (65.1%) and Master's and/or Doctorate studies (25.8%). These teachers have been teaching for more than five years (73.1%) and are permanent staff (41.7%). The most popular outdoor activities are trekking, MTB, orienteering and sailing/surfing/kitesurfing.

Most of the participants surveyed were from public schools (73.7%) in urban areas (75.7%).

With regard to the question "Is the teaching of PANE part of your classroom programme?", of the total number of responses obtained, 91.4% of the teachers stated that they included PANE in their classroom programme, while only 8.6% stated that this type of activity was not part of their classroom programme.

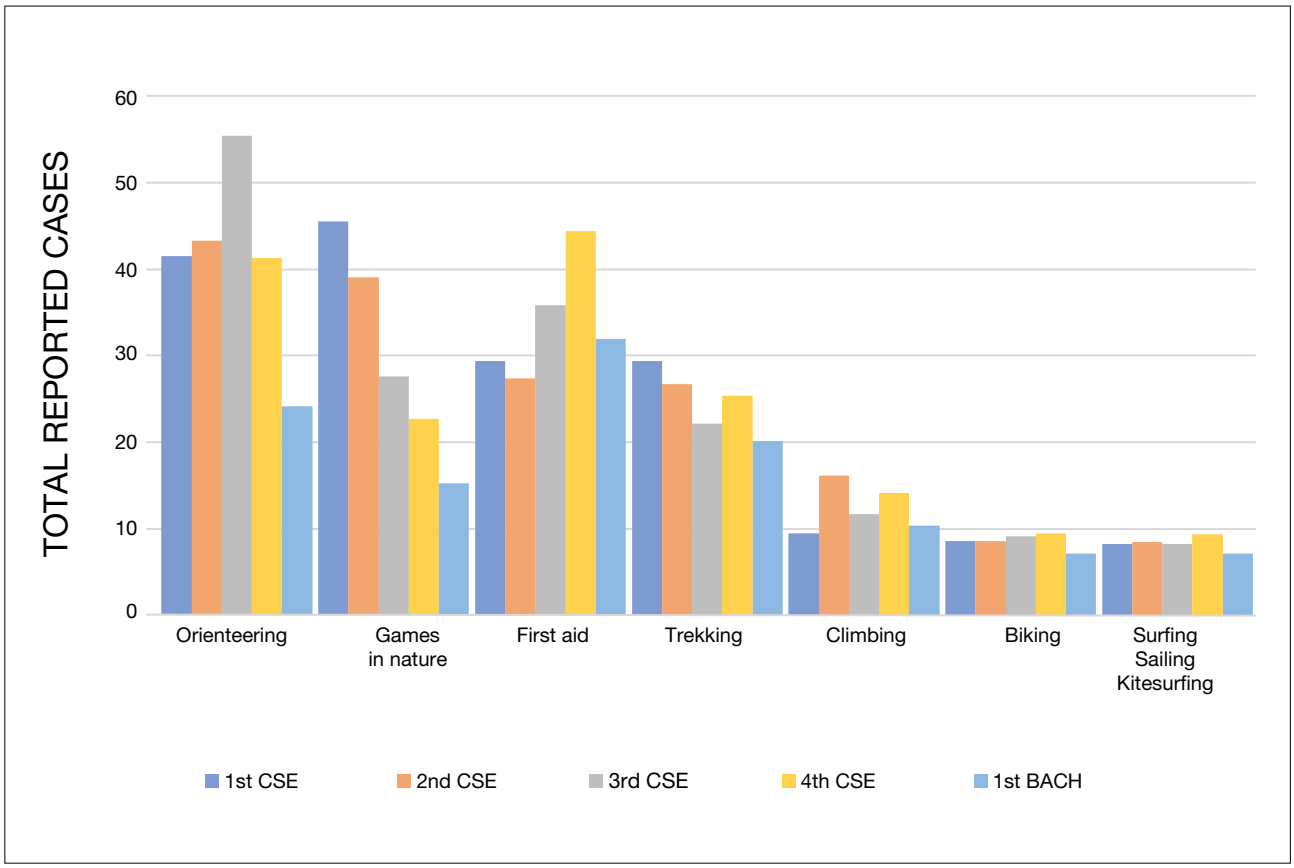
Next, those teachers who include PANE in their classroom programmes were asked about the contents included in this type of activity in the different courses of the stage in which they teach. The results are shown in table 2 below.

Table 2
Percentage of work on PANE content in CSE.

Activities	1st CSE %	2nd CSE %	3rd CSE %	4th CSE %
Orienteering	41.5	43.3	55.4	41.3
First aid	29.4	27.4	35.8	44.4
Games in nature	45.5	39.1	27.6	22.7
Trekking	29.4	26.7	22.1	25.4
Climbing	9.5	16.1	11.7	14.1
Knotting	15.7	16.6	6.4	8.6
Biking	8.6	8.6	9.1	9.5
Surfing/sailing/kitesurfing	8.2	8.4	8.2	9.3
Rucksack packing	13.7	7.3	3.5	4.4
Camping	4	4.6	5.7	8.4
Rafting/kayaking	3.5	4.2	4.4	7.3
Raids	5.5	4.9	4.9	4.2
Abseiling	2.6	3.3	4.2	6.2
Tent pitching	3.3	5.1	4	4.4
Zipline	3.5	4.9	4.2	3.8
CXM	2.2	2.2	4.2	5.1
Survival	2.2	2.2	2.6	3.1
Rope constructions	2.2	1.5	1.5	1.3
Canyoning	0.4	0.7	1.3	2.4
Via ferrata	0.4	1.1	0.9	1.8
Caving	0.9	1.1	0.2	1.3
Mountaineering	0.4	0.9	1.1	1.1

Note. This table shows the percentage of teachers who carry out each of the activities in the different CSE courses, according to the total number of responses obtained in the questionnaire.

Figure 1
Activities per school year.



As the results show, the contents most present in the PANE block are orienteering, first aid, nature games and trekking, while at the other extreme are canyoning, via ferrata, caving and mountaineering.

If the percentage of contents worked on according to year of educational stage is observed, it can be perceived that the orientation where most work is done is in 3rd year CSE where it is worked on by more than half of the teachers (55.4%); first aid stands out in 4th year CSE and games in nature in 1st year CSE. The rest of the contents, within the percentage of work, are carried out in a similar way in all courses.

The Fisher test carried out on the relationship between the inclusion of PANE content in the classroom programme and the different socio-demographic variables surveyed only yielded significant results with respect to the presence or absence of content according to the ownership of the school (table 3).

Table 3 shows that, regardless of the ownership of the school, the percentage of teachers who carry out PANE within their classroom programme is much higher than that of teachers who do not include these activities in their programme. The most notable difference is found in public schools, where 94.6% confirm PANE in their programmes, compared to 5.4% who do not implement PANE at this stage. Thus, when the Fisher test was carried out, it was found that there is a significant relationship (.000) with regard to the ownership of the centre and the inclusion of PANE in the classroom programme, such that the more the centre tends towards privatisation, the less likely it is to include this type of activity.

Table 3
Ownership of the school.

	Yes	No	Total	Exact significance (bilateral)
Public	94.6 %	5.4 %	100 %	.000
State-funded	83.2 %	16.8 %	100 %	
Private	77.8 %	22.2 %	100 %	
Total	91.4 %	8.6 %	100 %	

Table 4
Employment status.

	Yes	No	Total	Signif. exact (bilateral)
Temporary replacement	84.0 %	16.0 %	100.0 %	
	5.1 %	10.3 %	5.5 %	
Temporary with vacancy	91.9 %	8.1 %	100.0 %	
	24.6 %	23.1 %	24.5 %	
	22.5 %	2.0 %	24.5 %	
Temporary staff	100.0 %	0.0 %	100.0 %	
	2.9 %	0.0 %	2.6 %	
Permanent staff	96.3 %	3.7 %	100.0 %	.003
	44.0 %	17.9 %	41.7 %	
Indefinite (state-funded/private)	83.8 %	16.2 %	100.0 %	
	20.0 %	41.0 %	21.9 %	
Substitution (state-funded/private)	75.0 %	25.0 %	100.0 %	
	0.7 %	2.6 %	0.9 %	
Temporary employment (state-funded/private)	84.6 %	15.4 %	100.0 %	
	2.7 %	5.1 %	2.9 %	
Total	91.4 %	8.6 %	100.0 %	
	100.0 %	100.0 %	100.0 %	

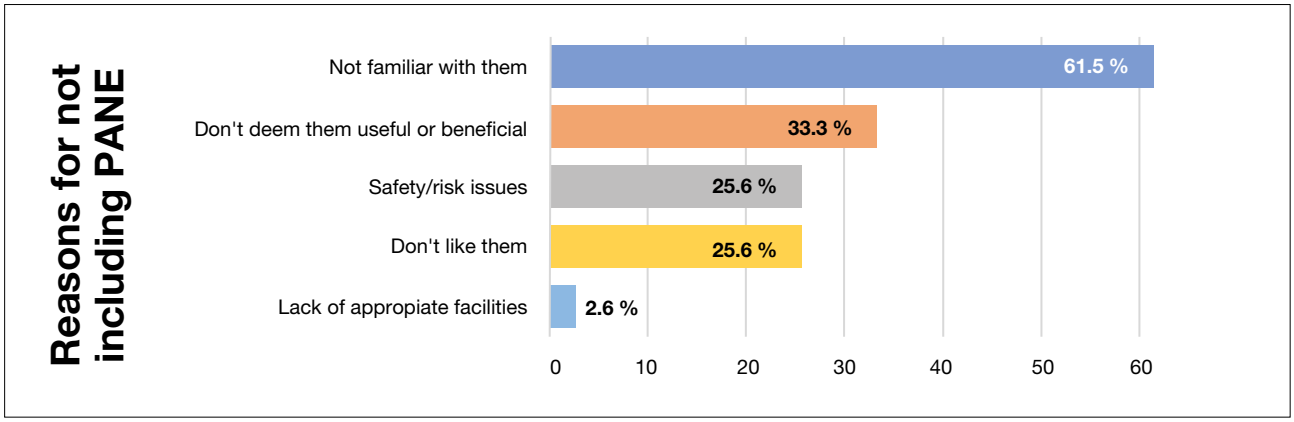
On the other hand, employment status also showed significant differences through Fisher's test (table 4).

With regard to employment status, Table 4 shows that in general there is a wide difference between teachers who carry out PANE at secondary level and those who do not. Staff with a temporary posting stand out, with 100% of the responses indicating that they include PANE in their classroom programme. Similarly, if the percentage of teachers who include PANE as part of their sessions is observed, a wide difference among permanent staff is observed, with 44%; at the other extreme are substitutes in private/state-funded schools, with 0.7% of teachers including these activities in their sessions. Fisher's test yielded significant results regarding the relationship between employment status and PANE programming, with a significance of .003, with those teachers with permanent or stable positions being those who programme these activities the most, and this decreases as their employment situation becomes more unstable.

Finally, teachers were asked about the reasons why they do not include PANE content in PE (figure 2).

As can be seen, the main reason for the exclusion of PANE is the lack of knowledge and/or training on how to carry them out (61.5%). Nonetheless, it is worth noting the response "I don't see any use or benefits", with 33.3%, as well as "I don't like them", with 25.6%.

Figure 2
Reasons for not including PANE in PE.



Discussion

The aim of this research was to analyse the implementation of PANE in secondary school PE by updating the scientific literature.

In this study, the high percentage of teachers who carry out activities in the natural environment as part of their PE sessions has been demonstrated, although a proportion of teachers who do not include them in their classroom programme continues to be seen, with their main explanation being a lack of training in these activities. Of the hypotheses put forward in relation to this point, H1 is confirmed, given that 91.1% of the teachers include PANE as part of their classroom programme, with a low percentage refusing to include these activities as part of their sessions. There are several reasons given by teachers for not carrying out activities in the natural environment in their PE sessions, among others, 61.5% of the total number of teachers who do not include PANE as part of their sessions (8.9%) state that they do not feel properly trained to be able to take responsibility for carrying out this type of activity; consequently, H2 is also partially confirmed.

The results show that the majority of PE teachers programme PANE, this result being higher than 90%. These results, at the national level, differ from those obtained by Peñarrubia Lozano et al. (2011) in the Community of Aragon, in which 77.86% reported carrying out some kind of activities in the natural environment, or those of Sáez-Padilla et al. (2017), in Andalusia, which produced results of around 70%. However, although a percentage of teachers who do not implement these activities in their PE sessions (8.6%) continues to be found, it can be observed that these data have improved considerably with respect to those reported by Peñarrubia Lozano et al. (2011) in their research, with results of 22.14% in Aragon. These results should be 100%, not least because legislation is prescriptive at national level.

With regard to the results obtained in relation to Hypothesis 2, the lack of training in PANE is the main reason why teachers do not include PANE in classroom programmes. On this point, this work coincides with the results of previous research which highlights the lack of training or knowledge, safety or risk problems, lack of installation or materials, among others (Dalmau-Torres et al., 2020; Sáez-Padilla et al., 2017). With regard to teacher training, it is worth highlighting its persistence in the studies that have been carried out on PANE, this lack of training being corroborated through the research carried out by Hurtado-Barroso et al. (2019) who, through their analysis of degrees in Physical Activity and Sport Sciences taught in Andalusian universities, concluded that only 9.9% of subjects related to PANE, a percentage that does not necessarily have to be the total number of subjects taken during the degree course, as it will depend on the choice of the student in the optional subjects, thus leaving only 3.8% of subjects taken from this block as an average in Andalusian universities. This confirms the need for broader training that balances the training of all the content blocks of PE that teachers have to teach throughout CSE.

In addition, one of the reasons given by some of the teachers for keeping PANE out of their programmes requires special attention. This is the response "I don't see any use or benefits" (33.3%), given that there is research that exposes the physical and mental benefits of contact with nature and its results at the academic level in students, therefore in recent years different research has been carried out by taking PANE to schools in search of answers to the resulting benefits. These studies have concluded benefits in terms of satisfaction (Baena-Extremera & Granero-Gallegos, 2015), learning orientation (Baena-Extremera & Granero-Gallegos, 2013), motivation (Hortigüela et al., 2017), among other variables that affect students' psychological and academic development, etc. This leads to the need for more technical training together with a bibliographical approach in the field of activities in the natural environment.

In relation to those teachers who put them into practice in their sessions, it can be seen that there are two variables that are related to greater programming of PANE on the part of the teachers. On the one hand, the ownership of the centre, as public centres have a higher rate of teachers who programme activities in the natural environment, and, on the other hand, the type of employment contract held by the teachers, with permanent staff being the ones who most incorporate these contents as part of their programme. It follows that H3 is fully confirmed. In relation to this, it has been observed that more and more teachers are incorporating these activities as part of their classroom programme. These data are consistent with those obtained by Dalmau-Torres et al. (2020), whose research confirmed that teachers in public schools were more likely to include PANE as part of their PE sessions. The reasons that may explain these results are diverse, ranging from greater ease of transferring pupils to natural areas to a greater commitment to educational law as they are dependent on the Regional Ministry of Education. In this respect, it would be interesting to carry out a study that could respond to this situation and help to ensure that this commitment is the same in all schools.

In relation to H4, it has been observed that, in spite of the progress made in the incorporation of PANE, the activities to which most sessions are devoted in this block of contents are first aid, hiking, orienteering and games in nature, data that are in line with previous research carried out by Granero-Gallegos et al. (2010), Hurtado-Barroso et al. (2019), among others. This gives an insight into how little progress has been made in this area and how much remains to be done. The reasons why these results may be produced could be due to the extensive didactic bibliography on these contents or the ease of practice within the school. However, it should be noted that in recent years there have been numerous publications in books and articles on the less frequently taught content in PANE PE, so it will be necessary to observe whether these publications have changed the trend in a few years' time. An example where teachers can be trained for free would be the www.outdoorpeactivities.com, database, where everything published on these contents in Spanish journals is collected, including the contents less addressed by teachers. For these reasons, H4 is fully confirmed.

Conclusions

By way of conclusion, the results obtained in this study analyse the current situation in Spain in secondary schools with regard to the development of activities in the natural environment as part of PE, at national level.

It is worth highlighting the increase in the number of teachers who consider PANE as part of their classroom programme, with the contents of orienteering, hiking, first aid and games in nature being the most frequently taught. Despite this, there are still a significant number of PE teachers who disregard this type of activity in their programmes. There are different reasons for this response. However, lack of training continues to be one of the main reasons why PE teachers do not include PANE in their sessions. With an educational law that incorporates a block of content dedicated to activities in the natural environment, it is time to rethink the hours of training offered within the PAASS degree, as well as the continuous training of teachers through teacher training centres, following the recommendations of Granero-Gallegos and Baena-Extremera (2014). The administrations themselves should find the best solution to help teachers feel the same confidence to carry out these activities in the natural environment as in other blocks of content. It is the responsibility of the administration and the teacher to be properly trained in order to be able to respond correctly to the requirements set out in the curriculum legislation in terms of educational content.

On the other hand, it is interesting that in the group of teachers who programme these PANE there is a significant difference according to the ownership of the school, as well as the type of contract held by the teachers. Permanent staff in public institutions are the most involved with this content.

With regard to the contents included in this block, and despite the wide range of innovative possibilities it offers, teachers are still sticking to the same range of activities: hiking, orienteering, games in nature and first aid. This leads to monotony and boredom on the part of teachers and students and, as already expressed by Granero-Gallegos and Baena-Extremera (2014), it is necessary to overcome this situation by connecting with the students' interests. It can be observed that there is still a lot of work to be done in this block of content in which, despite an increase in classroom programming, there is a lack of variety of activities.

As can be seen, despite the progress that has been made over the years, there is still much to be done within PANE. We believe that this article can be a starting point for understanding the current shortcomings of teachers in Spain and the needs for a better implementation of this block of content within PE.

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Appendix

The teaching questionnaire is attached as it was sent to the schools.
Physical activity in the natural environment (PANE) is part of the Physical Education curriculum in Secondary Education. The decree of each community refers to "Activities of adaptation to the environment and the natural environment". However, there is no information on the training and knowledge of the teachers in order to carry out the programming of this block.

SECONDARY PHYSICAL EDUCATION TEACHERS ONLY

The aim of this questionnaire is to obtain relevant information in relation to the training and knowledge of Secondary Physical Education teachers about Adventure Education (AE) programming.

Dear colleagues, we ask you to fill in the questionnaire as honestly as possible, and we guarantee the absolute anonymity of your answers.

Put an X next to the answer.

We thank you in advance for your support.
Many thanks.

We will begin with a first section on socio-demographic questions

1. What is your gender?

2. How old are you?

3. What academic qualifications do you have in Physical Education? (select all that apply)

a) Diploma
b) Degree
c) Bachelor's degree
d) Other qualifications
e) Doctorate, Master's Degree…

4. Could you tell us what activities in the natural environment you do in your free time?

	3 or more times per week	1 or 2 times a week	Less frequently	Only at weekends	Only during holidays
Camping					
Survival					
Raids / quests					
Horse riding					
Orienteering					
Mountaineering/trekking					
Mountain/trail running					
Mountain biking (MTB)					

Climbing					
Mountaineering					
Abseiling					
Caving					
Zipline					
Bungee jumping, goming					
Via ferrata					
Rope constructions (Tibetan bridges)					
Canyoning					
Rafting, kayaking					
Surfing, sailing, kitesurfing					
Others:					

Next, we include a section related to your teaching experience

5. What type of ownership does the school have?

a) Public
b) State-funded
c) Private

6. How many years have you been teaching Physical Education?

7. What is your employment status?

Public school	Temporary replacement	
	Temporary with vacancy	
	Temporary staff	
	Permanent staff	
	Indefinite	
State-funded/private school	Substitution	
	Temporary employment	
	Indefinite	

8. Where is your centre located on the peninsula? (tick all that apply)

a) Northern Spain
b) Central Spain
c) Southern Spain
d) Coastal zone
e) Mountain zone

9.Which area is your centre in?

a) Rural
b) Urban

10. Indicate what spaces and facilities you have available for the performance of activities in the natural environment, during school hours.

	None	Sometimes	Normally	Very often	Always
Indoor sports facility belonging to the school (sports hall, gymnasium...)					
Indoor sports facility not belonging to the school (sports hall, gymnasium...)					
Outdoor sports facilities belonging to the school (multi-sports courts, football pitch, etc.).					
Outdoor sports facility not belonging to the school (multi-sports courts, football pitch, etc.).					
Communal areas belonging to the centre					
Recreational open spaces outside the centre (parks, squares, gardens...)					
Classrooms or other enclosed non-sports spaces					
Peri-urban parks close to the city centre or town centre					
Natural parks near the city					
Forests or beaches					
Other (specify):					

We will continue with a section on the knowledge you have about outdoor activities and what you apply in the centres

11. Is the teaching of PANE part of your classroom programme?

a) Yes (if yes, go to question 13)
b) No

12. What are the reasons why you do not work on these contents in Physical Education? (only answer in the negative case in question 11) (Please tick those that apply, max. 3)

a) I don't like them
b) I don't know them well
c) I see no use or benefits
d) I do not have adequate materials and facilities, nor any nearby
e) Due to safety and risk concerns
f) I consider other content more important
g) Other reasons (specify)

13. How are activities in the natural environment valued in the Physical Education department?

	Strongly disagreed with	Slightly agreed with	Agreed with	Strongly agreed with	Totally agreed with
They are part of the JEP					
The same as the rest of the content blocks					
They are used as a complement to programmes, without assessment					
Working in complementary and extracurricular activities is interesting					
Occasionally as novel content to round out the term					
Other (specify):					

14. How important is it to you to carry out PANE within the school?

Not at all	
A little	
Quite	
Very	

15. How do you organise PANE within your programme? (tick all that apply)

I don't include them		
They are present in the Anual General Programme and in the Centre's Educational Project to be worked on in a transversal way in the school and especially in PE.		
Organisation	Through my own initiative	
	Jointly with the whole department	
	Jointly with other departments	
Educational planning	Through didactic units (DU)	
	In centre activities, as a complementary activity	
	In school activities, such as extracurricular activities	
	Others (specify):	

16. What PANE content do you currently include in your programme? (tick all that apply)

	1st CSE	2nd CSE	3rd CSE	4th CSE	1st BACH
Knotting					
Rucksack packing					
Tent pitching					
First aid					
Camping					
Survival					
Games in nature					
Raids					
Orienteering					
Mountaineering/trekking					
Mountain/trail running					
MTB					
Climbing					
Mountaineering					
Abseiling					
Caving					
Zipline					
Bungee jumping, goming					
Via ferrata					
Rope constructions					
Canyoning					
Rafting/kayaking					
Surfing, sailing, kite surfing					
Others					

17. Including all the levels you teach, how many PANE teaching units do you carry out in your PE programme? (Indicate the number of didactic units (DU))

	DU
Knotting	
Rucksack packing	
Tent pitching	
First aid	
Camping	
Survival	
Games in nature	
Raids/quests Horse riding routes	
Orienteering	
Mountaineering/trekking	
Mountain/trail running	
MTB	
Climbing	
Mountaineering	
Abseiling	
Caving	
Zipline	
Bungee jumping	
Via ferrata	
Rope constructions	
Canyoning	
Rafting/kayaking	
Surfing, sailing, kitesurfing	
Others (specify)	

18. If you include theoretical content in your PANE sessions, how do you do it?

Separate theory and practical elements	
Theory integrated into practical elements	
Work in small groups, with theoretical and practical presentation by the students	
Small projects to be carried out over the course of a term, supervised by the teacher	
Service Learning	
Shared use of ICT	
Nature classrooms	
Project-based learning	
Others (specify):	

19. Where did you learn this content in order to work on it in the classroom? (tick the appropriate ones)

During university studies	
Sport technicians training courses	
In Teacher and Resource Centre activities	
At other courses, conferences and congresses	
With associations and friends	
On your own account	
Others (specify)	

20. Which professionals deliver PANE during the PE sessions in your school? (please tick all that apply)

Adventure company monitor	
Specialised sports technician/guide	
PE teacher	
Corresponding Federation	
Associations or clubs	
Others (specify):	

21. What kind of adventure sport facilities do you have in or around the centre that you can use freely?

Climbing wall	
Zipline	
Rope constructions (bridges...)	
Cycle paths	
Bikes parks	
Permanent, signposted orienteering circuits	
Others (specify)	

22. Do you have at school and/or do you use any kind of material for PANE in PE, how many? (tick all that apply)

	School equipment	Own material
Tent		
Sleeping bag and insulation mattress		
Mountain equipment (rucksack, boots...)		
Climbing equipment (harness, rope, carabiners, climbing shoes...)		
Mountain/road bicycle		
Caving equipment		
Head torch		
Static ropes		
Coordinates		
Others (specify):		

Finally, a section of five questions to explore the educational models you are familiar with.

23. How did you learn and how do you teach during your PE sessions? (tick all that apply)

		Training	Teaching
Traditional approaches	Direct involvement		
	Assigning tasks		
Individualised approaches	Group work		
	Individual work		
Participatory approaches	Reciprocal teaching		
	Small groups		
	Microteaching		
Cognitive approaches	Guided discovery		
	Problem solving		
Creative approaches			
Socialisation approaches			

24. What models of adventure and education programmes are you familiar with, and do you apply any of them? (tick all that apply)

	I know	I apply
Experiential learning		
Adventure learning		
Adventure education		
Outdoor education		
Outdoor learning		
High ropes courses		
Others (specify)		
I don't know any		

25. How did you learn about these adventure and education programme models?

Research and education papers	
Training through the Teachers' and Resources Centre	
University training	
Others (specify)	
I don't know any	

26. Are you willing to train in adventure and education programme models?

☐ **Yes** ☐ **No**

If yes, what would be the ideal format?

University Expert Course on activities in the natural environment	
Master's Degree in activities in the natural environment	
Course organised by the Teachers Centre with a sufficient number of hours to guarantee adequate training.	
Intensive weekend courses	
Other (specify):	

27. Are you familiar with Baena's (2011) adventure teaching model for working with an Adventure Education programme?

https://www.researchgate.net/publication/277275059_Programas_didacticos_para_Educacion_Fisica_a_traves_de_la_educacion_de_aventura

Yes, I know it, but I have not applied it	
Yes, I know it and I have applied it	
I don't know it	

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PHYSICAL EDUCATION

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Assessment Aspects of Student's Motor Skills and Assessment Tools in Physical Education

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Abstract

Educational developments call for a change in the way in which aspects related to students' motor skills are assessed in the field of physical education, moving towards a global assessment that goes beyond assessment centred on physical performance. This research aims: (i) to analyse the most and least valued variables in relation to the assessment aspects of student motor skills and the type of assessment tools used by PE teachers; (ii) to assess whether there are statistically significant differences in these aspects among Primary and Secondary school teachers, according to teaching experience, according to the highest academic degree obtained and the type of school in which they teach; and (iii) to assess the relationship between the assessment tools used and the aspects that are assessed in relation to student motor skills. Quantitative, comparative, correlational and cross-sectional research was carried out. A total of 455 physical education teachers from all over Spain took part. The data was collected through the *Questionnaire on Assessment Processes in Physical Education #AssessPE*. The results demonstrated that among the assessment aspects of students' motor skills, teachers reported giving greater importance to whether students know and respect health and hygiene habits and motor problem solving. In terms of assessment tools, teachers indicate that those most frequently used are contextualised game situations and observation sheets, with tests being the least frequently used. There are some differences in these aspects depending on the variables studied, although they are not constant. Finally, there is no clear relationship between most of the assessment tools studied and the motor skill assessment aspects.

Keywords: assessment, motor skills, physical education, teachers, tools.

Introduction

Traditionally, assessment in physical education (PE) has been associated with the measurement of students' physical fitness and performance (Secchi et al., 2016) with a view to ranking students (López-Pastor et al., 2013). As a result, the use of examinations and tests of physical fitness or perceptual-motor skills as assessment tools for assessing student performance has prevailed (López-Pastor et al., 2013; Secchi et al., 2016). However, changes in educational paradigms, in the way of understanding PE and assessment, have increased the importance of assessing aspects other than physical performance (Cañadas et al., 2019; James et al., 2005), such as the improvement and progress of students from their starting point (Chng & Lund, 2018; Chróinín & Cosgrave, 2013; Hortigüela-Alcalá & Pérez-Pueyo, 2016). Among these aspects, aspects such as attitudes, creativity, understanding of how to apply sporting tactics or certain techniques in the natural environment are beginning to be considered (Fisette & Franck, 2013; Sicilia et al., 2006). Furthermore, the current curriculum (Royal Decree 157/2022; Royal Decree 217/2022) establishes that the field of PE should contribute to the all-round development of students. In this way, varied learning situations should be offered which allow students to develop all their abilities, and in which their progress in all areas can be assessed (Holfelder & Schott, 2014; Organic Law 3/2022;). To this end, an increasing number of assessment tools are emerging to assess students' competences and skills (Herrán et al., 2019; Otero & González, 2016; Pérez-Pueyo et al., 2019).

In recent decades there has been a growing academic interest in alternative assessment processes in PE, however, when analysing the assessment practices developed by PE teachers in their classes, this change is not apparent (MacPhail & Murphy, 2017; Moura et al., 2021). For this reason, it is essential to find out how teachers carry out their assessment process and to analyse what and how they assess. Along these lines, Cañadas & Santos-Pastor (2021) find that PE teachers consider that procedural, attitudinal and conceptual aspects should be assessed. At primary level, the latter two do not play a major role in assessment, whereas at secondary level, conceptual learning seems to be assessed more systematically. Furthermore, they demonstrate that observation sheets tend to be one of the most commonly used tools in both Primary and Secondary Education for the procedural domain, and informal procedures are used for the rest. The study by Rodríguez-Negro & Zulaika (2016) shows that, while theoretical tests are rarely used in Primary Education, they are used more frequently by Secondary Education teachers. These aspects may be influenced by many factors such as the level of education, teaching experience and teacher training. In the study conducted by Chaverra (2014), the participating teachers associate reflections on their assessment practices and years of experience with the development of formative assessment practices. All of them report having used assessment tools to measure the physical fitness of students, especially in their first years as teachers. However, experience has prompted them to reflect on their lack of formative content and to use other, more qualitative tools to collect data on the different dimensions of learning. Along these lines, teachers report that they attach particular importance to the assessment of attitudes in their PE lessons.

For this reason, and with the aim of exploring this subject in greater depth, the objectives of this research are as follows: (i) to analyse the most and least valued variables in relation to the assessment aspects of student motor skills and the type of assessment tools used by PE teachers; (ii) to assess whether there are statistically significant differences in these aspects among Primary and Secondary school teachers, according to teaching experience, according to the highest academic degree obtained and the type of school in which they teach; and (iii) to assess the relationship between the assessment tools used and the aspects that are assessed in relation to student motor skills.

Method

Quantitative, comparative, correlational and cross-sectional research was carried out.

Participants

455 Spanish PE teachers of Primary Education (51.9%) and Secondary Education (48.1%), with a mean age of 41.6 years (SD ± 9.43), participated in this research. Participants were selected by random, incidental, non-probabilistic sampling. Full information on the participants can be found in Table 1.

Table 1
Characteristics of the participating sample.

Variables		%
Sex	Female	36.7
	Male	63.6
Teaching experience	0-10 years	36.0
	11-20 years	34.5
	21-40 years	29.5
Level of education taught	Primary	51.9
	Secondary	48.1
School ownership	Public	75.8
	Fully private	21.5
	State-funded private	2.6
Highest Academic Degree Obtained	Degree	28.8
	Bachelor's degree	8.1
	Diploma	11.4
	Master's Degree	27.0
	Doctorate	3.3
	PAC	19.8
	Postgraduate	1.5

Instrument

The *Questionnaire on Assessment Processes in Physical Education #AssessPE* (Zubillaga-Olague & Cañadas, 2021) was used to collect data. It is a questionnaire designed *ad hoc*, consisting of 81 items divided into 13 Likert-type closed-responses with 6 response levels ranging from 1 (never/strongly disagree) to 6 (always/strongly agree). The scale had an internal consistency of $\alpha = .95$. Of all the items included in the questionnaire for this research, those corresponding to the dimensions of the aspects related to motor skill assessment and the assessment tools used by the teachers were taken into account. Table 2 lists the items used in this research.

Procedure

The e-mail addresses of all Spanish schools and institutes that provide this information freely and openly on their websites were collected. After designing and validating the questionnaire, it was transcribed into the Google Forms platform and sent by email to the schools. In the e-mail, PE teachers were asked to participate in filling in the questionnaire. In accordance with the ethical principles of research (American Psychological Association, 2010), an information sheet and an informed consent form were attached to the email. The research was approved by the Ethics Committee of the Autonomous University of Madrid on 24 April 2020.

Table 2
Items related to the assessment aspects of students' motor skills and the assessment tools used.

Assessment aspects of students' motor skills
I assess the correct technical execution (gestures, forms specific to each sport modality) of sport skills
I assess the use of tactical elements (individual or collective / cooperative and oppositional) in game situations
I assess the application of the rules (knowledge, applications, use, etc.) in game situations
I assess the physical fitness of the student
I assess motor problem solving (basic, specific, sporting, etc. motor skills and abilities)
I assess students' ability to make artistic and expressive creations
I assess the execution of dance techniques and/or dances
I assess students' ability to carry out activities in the natural environment
I assess whether students know and respect health and hygiene habits in the practice of physical activity
Assessment tools used
Observation sheet
Rubrics
Exam
Motor tests
Psychomotor skills test
Contextualised game situations
Physical fitness test

Statistical Analysis

The Kolmogorov-Smirnov test was used to analyse the normality of the data. As the distribution was not normal, non-parametric analyses were carried out. In response to the first objective, the descriptive data on the sample for the variables studied are presented (Table 2). For the second objective, to test for differences between primary and secondary school teachers according to the highest academic degree obtained and the ownership of the school in which they teach, the Mann-Whitney U test was used, and to test for differences according to teaching experience, the Kruskal-Wallis H test was used. In order to carry out the analysis according to school ownership, teachers working in fully private and state-funded private schools were grouped together in the same variable and, in order to analyse according to the highest academic degree, those with a bachelor's degree (undergraduate, graduate, diploma) and postgraduate level (master's degree, doctorate, PAC and other postgraduate degrees) were grouped together. Finally, Spearman's correlation was used to assess the relationship between the assessment tools used and the assessment aspects of students' motor skills. Analyses were performed with SPSS v. 27. statistical software and the significance level was set at $p < .05$.

Results

Table 3 shows the descriptions of the assessment aspects of students' motor skills and of the assessment tools used, and the differences according to the level of education at which teaching is carried out (primary vs. secondary).

Table 3
Differences in the assessment aspects of students' motor skills and the assessment tools used, and according to the level of education at which teaching is carried out.

	Total	Primary Education	Secondary Education	
	M ± SD	M ± SD	M ± SD	
n,	455	236	219	*p*
Assessment aspects of motor skills				
I assess the correct technical execution (gestures, forms specific to each sport modality) of sport skills	4.13 ± 1.33	3.91 ± 1.30	4.37 ± 1.32	**.000****
I assess the use of tactical elements (individual or collective/cooperative and oppositional) in game situations	4.50 ± 1.18	4.43 ± 1.21	4.58 ± 1.14	.280
I assess the application of the rules (knowledge, applications, use, etc.) in game situations	4.38 ± 1.22	4.32 ± 1.22	4.44 ± 1.22	.249
I assess the physical fitness of the student	3.75 ± 1.44	3.50 ± 1.33	4.01 ± 1.51	**.000****
I assess motor problem solving (basic, specific, sporting, etc. motor skills and abilities)	5.00 ± 1.05	5.01 ± 1.12	5.00 ± 0.97	.467
I assess students' ability to make artistic and expressive creations	4.96 ± 1.08	4.86 ± 1.11	5.07 ± 1.05	**.015***
I assess the execution of dance techniques and/or dances	4.23 ± 1.32	4.14 ± 1.27	4.33 ± 1.37	.093
I assess students' ability to carry out activities in the natural environment	4.32 ± 1.31	4.28 ± 1.33	4.37 ± 1.29	.559
I assess whether students know and respect health and hygiene habits in the practice of physical activity	5.18 ± 1.09	5.21 ± 1.12	5.15 ± 1.06	.317

Note. Statistically significant differences are in **bold:** *$p < .05$ **$p < .001$.

Table 3 (Continuation)
Differences in the assessment aspects of students' motor skills and the assessment tools used, and according to the level of education at which teaching is carried out.

	Total	Primary Education	Secondary Education	
	M ± SD	M ± SD	M ± SD	
n,	455	236	219	*p*
Assessment tools				
Observation sheet	4.76 ± 1.14	4.75 ± 1.16	4.76 ± 1.12	.933
Rubrics	4.45 ± 1.52	4.36 ± 1.54	4.55 ± 1.49	.159
Exam	2.84 ± 1.59	2.16 ± 1.33	3.58 ± 1.51	**.000****
Motor tests	2.67 ± 1.63	2.54 ± 1.53	2.81 ± 1.72	.135
Psychomotor skills test	2.50 ± 1.59	2.60 ± 1.58	2.38 ± 1.60	.091
Contextualised game situations	4.85 ± 1.17	4.78 ± 1.21	4.94 ± 1.12	.176
Physical fitness test	3.04 ± 1.63	2.41 ± 1.38	3.72 ± 1.61	**.000****

Note. Statistically significant differences are in **bold:** *$p < .05$ **$p < .001$.

Results show that the items that show a higher degree of consensus on the part of the teachers are: (i) I assess whether the students know and respect health and hygiene habits in the practice of physical activity (5.18 ± 1.09) and (ii) I assess motor problem solving (5.00 ± 1.05). The item that shows the lowest degree of consensus is the assessment of the physical fitness of the students (3.75 ± 1.44). On the other hand, the tools most frequently used by teachers on average are contextualised play situations (4.85 ± 1.17) and the least frequently used are motor tests (2.67 ± 1.63) and psychomotor tests (2.50 ± 1.59), which are below the average level of response on the scale. The differences in the assessment aspects of students' motor skills among teachers who teach at different educational levels appear in 3 of the 9 items studied. Specifically in: (i) I assess the correct technical execution of sport skills ($p < .001$; 3.91 ± 1.30 vs. 4.37 ± 1.32); (ii) I assess the physical fitness of the students ($p < .001$; 3.50 ± 1.33 vs. 4.01 ± 1.51) and I assess students' ability to make artistic and expressive creations ($p = .015$; 4.86 ± 1.11 vs. 5.07 ± 1.05), showing higher mean values for secondary education teachers in all cases. In the assessment tools, statistically significant differences appear according to the level of education at which teaching is provided in 2 of the 7 items studied ($p < .001$): (i) Exam (2.16 ± 1.33 vs. 3.58 ± 1.51); and (ii) physical fitness test (2.41 ± 1.38 vs. 3.72 ± 1.61), with Secondary Education teachers in both cases obtaining higher average usage values.

The differences in the assessment aspects of students' motor skills according to teaching experience are presented in Table 4. Of the 9 items studied, 7 show statistically significant differences among the groups, with the group with the least teaching experience showing the highest mean values. These are: (i) I assess the use of tactical elements in game situations ($p < .001$; 4.66 ± 1.13 vs. 4.55 ± 1.26 vs. 4.24 ± 1.11); (ii) I assess the application of the rules in game situations ($p < .001$; 4.61 ± 1.13 vs. 4.47 ± 1.24; 3.99 ± 1.20); (iii) I assess motor problem solving ($p = .030$; 5.19 ± 0.88 vs. 4.88 ± 1.23 vs. 4.93 ± 0.99); (iv) I assess students' ability to make artistic and expressive creations ($p = .012$; 5.15 ± 0.95 vs. 4.87 ± 1.23 vs. 4.83 ± 1.03); and (v) I assess students' ability to carry out activities in the natural environment ($p = .012$; 4.48 ± 1.32 vs. 4.34 ± 1.32 vs. 4.10 ± 1.26). In the case of the items I assess the physical fitness of the students ($p = .043$; 3.58 ± 1.34 vs. 3.95 ± 1.55 vs. 3.71 ± 1.40) and I assess the technical execution of dances ($p = .026$; 4.23 ± 1.26 vs. 4.38 ± 1.41 vs. 4.06 ± 1.27), teachers with 11-20 years of experience show the highest mean values. Table 4 also shows the difference in the tools used by PE teachers according to teaching experience. Statistically significant differences are found in 3 of the 7 items studied: (i) rubrics ($p < .001$; 4.88 ± 1.44 vs. 4.56 ± 1.35 vs. 3.80 ± 1.59) and (ii) contextualised game situations ($p = .013$; 4.97 ± 1.09 vs. 4.93 ± 1.19 vs. 4.63 ± 1.21), teachers with less teaching experience report using these most frequently, and teachers with more experience use these the least. On the other hand, statistically significant differences appear in the use of exams ($p = .043$; 2.73 ± 1.49 vs. 2.72 ± 1.66 vs. 3.12 ± 1.59), with more experienced teachers claiming to use these more often.

Table 4
Differences in the assessment aspects of students' motor skills and the assessment tools used according to teaching experience.

	0-10 years	11-20 years	21-40 years	
	M ± SD	M ± SD	M ± SD	
n,	168	158	143	*p*
Assessment aspects of motor skills				
I assess the correct technical execution (gestures, forms specific to each sport modality) of sport skills	4.26 ± 1.24	4.05 ± 1.44	4.06 ± 1.29	.354
I assess the use of tactical elements (individual or collective/cooperative and oppositional) in game situations	4.66 ± 1.13	4.55 ± 1.26	4.24 ± 1.11	**.000****
I assess the application of the rules (knowledge, applications, use, etc.) in game situations	4.61 ± 1.13	4.47 ± 1.24	3.99 ± 1.20	**.000****
I assess the physical fitness of the student	3.58 ± 1.34	3.95 ± 1.55	3.71 ± 1.40	**.043***
I assess motor problem solving (basic, specific, sporting, etc. motor skills and abilities)	5.19 ± 0.88	4.88 ± 1.23	4.93 ± 0.99	**.030***
I assess students' ability to make artistic and expressive creations	5.15 ± 0.95	4.87 ± 1.23	4.83 ± 1.03	**.012***
I assess the execution of dance techniques and/or dances	4.23 ± 1.26	4.38 ± 1.41	4.06 ± 1.27	**.026***
I assess students' ability to carry out activities in the natural environment	4.48 ± 1.32	4.34 ± 1.32	4.10 ± 1.26	**.012***
I assess whether students know and respect health and hygiene habits in the practice of physical activity	5.28 ± 0.97	5.14 ± 1.26	5.10 ± 0.99	.126
Assessment tools				
Observation sheet	4.77 ± 1.18	4.85 ± 1.06	4.63 ± 1.18	.316
Rubrics	4.88 ± 1.44	4.56 ± 1.35	3.80 ± 1.59	**.000****
Exam	2.73 ± 1.49	2.72 ± 1.66	3.12 ± 1.59	**.043***
Motor tests	2.60 ± 1.54	2.83 ± 1.77	2.57 ± 1.56	.527
Psychomotor skills test	2.37 ± 1.49	2.66 ± 1.74	2.47 ± 1.51	.496
Contextualised game situations	4.97±1.09	4.93 ± 1.19	4.63 ± 1.21	**.013***
Physical fitness test	2.84±1.59	3.14 ± 1.74	3.17 ± 1.54	.138

Note. Statistically significant differences are in **bold:** *$p < .05$ **$p < .001$.

Table 5 shows the differences in the assessment aspects of students' motor skills and in the use of the assessment tools according to school ownership. With regard to the assessment aspects of students' motor skills, only 4 of the 9 items studied show statistically significant differences according to school ownership. In 3 of these, it is public school teachers who show the highest average values. Specifically in: (i) I assess students' ability to make artistic and expressive creations ($p = .003$; 5.02 ± 1.10 vs. 4.47 ± 1.02); (ii) I assess students' ability to carry out activities in the natural environment ($p = .004$; 4.41 ± 1.27 vs. 4.03 ± 1.38); and (iii) I assess whether students know and respect health and hygiene habits in the practice of physical activity ($p = .018$; 5.25 ± 1.05 vs. 4.96 ± 1.19). Finally, in

the item I assess the correct technical execution of sport skills, private school teachers give greater importance to this aspect when assessing students' motor skills, obtaining higher mean values (p = .002; 4.03 ± 1.24 vs. 4.45 ± .25). With regard to differences in the frequency of use of the tools by public and private school teachers, statistically significant differences were found in 4 of the 7 items analysed. In three of these, private school teachers show higher mean values: (i) motor test (p = .004; 2.54 ± 1.57 vs. 3.08 ± 1.75), psychomotor skills test (p < .001; 2.34 ± 1.53 vs. 2.97 ± 1.68) and physical fitness test (p = .004; 2.91 ± 1.57 vs. 3.45 ± 1.75), with private schools teachers being the most frequent users in all cases. Statistically significant differences also appear in the use of rubrics (p = .009; 4.58 ± 1.42 vs. 4.05 ± 1.73) with public school teachers reporting using them to a greater extent.

Table 5
Differences in the assessment aspects of students' motor skills and the assessment tools used according to school ownership.

	Public	Fully private	
	M ± SD	M ± SD	
n,	345	110	*p*
Assessment aspects of motor skills			
I assess the correct technical execution (gestures, forms specific to each sport modality) of sport skills	4.03 ± 1.24	4.45 ± 1.25	**.002***
I assess the use of tactical elements (individual or collective/cooperative and oppositional) in game situations	4.53 ± 1.18	4.41 ± 1.17	.256
I assess the application of the rules (knowledge, applications, use, etc.) in game situations	4.35 ± 1.24	4.46 ± 1.14	.612
I assess the physical fitness of the student	3.69 ± 1.41	3.93 ± 1.52	.058
I assess motor problem solving (basic, specific, sporting, etc. motor skills and abilities)	5.01 ± 1.06	4.97 ± 1.02	.552
I assess students' ability to make artistic and expressive creations	5.02 ± 1.10	4.47 ± 1.02	**.003***
I assess the execution of dance techniques and/or dances	4.23 ± 1.32	4.25 ± 1.32	.969
I assess students' ability to carry out activities in the natural environment	4.41 ± 1.27	4.03 ± 1.38	**.004***
I assess whether students know and respect health and hygiene habits in the practice of physical activity	5.25 ± 1.05	4.96 ± 1.19	**.018***
Assessment tools			
Observation sheet	4.81 ± 1.10	4.57 ± 1.25	.092
Rubrics	4.58 ± 1.42	4.05 ± 1.73	**.009***
Exam	2.80 ± 1.53	2.97 ± 1.76	.532
Motor tests	2.54 ± 1.57	3.08 ± 1.75	**.004***
Psychomotor skills test	2.34 ± 1.53	2.97 ± 1.68	**.000****
Contextualised game situations	4.79 ± 1.23	5.05 ± 0.94	.149
Physical fitness test	2.91 ± 1.57	3.45 ± 1.75	**.004***

Note. Statistically significant differences are in **bold:** *p < .05 **p < .001.

Table 6 shows the differences according to the highest academic degree obtained. With regard to the assessment aspects of students' motor skills, only the item assessing the students' ability to make artistic and expressive creations shows statistically significant differences between teachers with undergraduate and postgraduate training, the latter presenting the highest mean values (p = .002; 4.82 ± 1.12 vs. 5.09 ± 1.04). In relation to the use of assessment tools according to the highest academic degree of the teachers, statistically significant differences appear in 4 of the 7 items analysed. Teachers with postgraduate studies exhibit higher mean values in the use of: (i) rubrics (p = .003; 4.25 ± 1.55 vs. 4.64 ± 1.46); (ii) exams (p < .001; 2.51 ± 1.52 vs. 3.15 ± 1.59); and (iii) physical fitness tests (p < .001; 2.74 ± 1.56 vs. 3.33 ± 1.65). Regarding motor skills tests, it is the teachers with undergraduate studies who exhibit the highest mean values (p = .043; 2.66 ± 1.64 vs. 2.34 ± 1.53).

Table 6
Differences in the assessment aspects of students' motor skills and the assessment tools used according to the highest academic grade obtained.

	Degree	Postgraduate	
	M ± SD	M ± SD	
n,	220	235	*p*
Assessment aspects of motor skills			
I assess the correct technical execution (gestures, forms specific to each sport modality) of sport skills	4.01 ± 1.38	4.24 ± 1-27	.094
I assess the use of tactical elements (individual or collective/cooperative and oppositional) in game situations	4.40 ± 1.20	4.60 ± 1.15	.106
I assess the application of the rules (knowledge, applications, use, etc.) in game situations	4.34 ± 1.16	4.41 ± 1.27	.291
I assess the physical fitness of the student	3.71 ± 1.39	3.77 ± 1.50	.616
I assess motor problem solving (basic, specific, sporting, etc. motor skills and abilities)	4.99 ± 1.09	5.02 ± 1.01	.988
I assess students' ability to make artistic and expressive creations	4.82 ± 1.12	5.09 ± 1.04	**.002***
I assess the execution of dance techniques and/or dances	4.20 ± 1.31	4.27 ± 1.33	.541
I assess students' ability to carry out activities in the natural environment	4.28 ± 1.31	4.36 ± 1.31	.444
I assess whether students know and respect health and hygiene habits in the practice of physical activity	5.12 ± 1.15	5.23 ± 1.02	.464
Assessment tools			
Observation sheet	4.77 ± 1.12	4.74 ± 1.17	.942
Rubrics	4.25 ± 1.55	4.64 ± 1.46	**.003***
Exam	2.51 ± 1.52	3.15 ± 1.59	**.000****
Motor tests	2.64 ± 1.62	2.70 ± 1.64	.674
Psychomotor skills test	2.66 ± 1.64	2.34 ± 1.53	**.043***
Contextualised game situations	4.77 ± 1.23	4.93 ± 1.11	.213
Physical fitness test	2.74 ± 1.56	3.33 ± 1.65	**.000****

Note. Statistically significant differences are in **bold:** *p < .05 **p < .001.

Table 7
Relationship between the assessment aspects of students' motor skills and the assessment tools used.

	Observation Sheet	Rubrics	Exam	Motor Tests	Psychomotor Tests	Contextualised game situations	Physical Fitness Test
I assess the correct technical execution (gestures, forms specific to each sport modality) of sport skills	-.007	**.122***	**.306****	**.190****	**.150***	**.108***	**.285****
I assess the use of tactical elements (individual or collective/cooperative and oppositional) in game situations	**.130***	**.195****	.086	**.137***	.088	**.219****	**.156***
I assess the application of the rules (knowledge, applications, use, etc.) in game situations	**.147***	**.203****	**.154***	**.134***	.070	**.224****	**.140***
I assess the physical fitness of the student	**.101***	.035	**.255****	**.343****	**.300****	**.159***	**.519****
I assess motor problem solving (basic, specific, sporting, etc. motor skills and abilities)	**.131***	**.170****	.028	**.091***	**.108***	**.192****	.023
I assess students' ability to make artistic and expressive creations	**.113***	**.296****	.068	.061	.022	.080	.068
I assess the execution of dance techniques and/or dances	.065	.054	**.170***	**.193***	**.159***	.054	**.215****
I assess students' ability to carry out activities in the natural environment	**.124***	**.201****	.062	.082	.049	.004	.075
I assess whether students know and respect health and hygiene habits in the practice of physical activity	**.162****	**.256****	-.046	.051	.013	.052	-.011

Note. Statistically significant differences are in **bold:** *$p < .05$ **$p < .001$.

Table 7 shows the relationship between the assessment tools used and the assessment aspects of students' motor skills. Although there are quite a few relationships between the items investigated, they are weak ($r < .200$). Those with the highest values among the items studied are highlighted here. In the case of rubrics, the relationship when assessing the students' ability to make artistic and expressive creations stands out ($r = .296$; $p < .001$). Exams are positively related to assessing the correct technical execution of sport skills ($r = .306$; $p < .001$) and motor and psychomotor tests are positively related to assessing students' physical fitness ($r = .343$ and $r = .300$, respectively; $p < .001$). Contextualised game situations are related to assessing the use of tactical elements in game situations ($r = 219$; $p < .001$) and assessing the application of rules in game situations ($r = .224$; $p < .001$). Finally, physical fitness tests have a strong and positive relationship with assessing students' physical fitness ($r = .519$; $p < .001$).

Discussion

This research aims: (i) to analyse the most and least valued variables in relation to the assessment aspects of students' motor skills and the type of assessment tools used by PE teachers; (ii) to assess whether there are statistically significant differences in these aspects among Primary and Secondary school teachers, according to teaching experience, according to the highest academic degree obtained and the type of school in which they teach; and (iii) to assess the relationship between the assessment tools

used and the aspects that are assessed in relation to student motor skills. With regard to the first objective, the results of this research show that the elements with the highest average values in the assessment aspects of students' motor skills are "to assess whether students know and respect health and hygiene habits in the practice of physical activity and motor problem solving" and the least valued "to assess the state of students' physical fitness". This shows a change in perspective with respect to what has traditionally been considered the most important value in the area. This is consistent with the study by Cañadas & Santos-Pastor (2021) and Chaverra-Fernández & Hernández-Álvarez (2019a), where it is evident that teachers are giving less and less importance to the measurement of physical fitness. In relation to the use of assessment tools, those reported as the most used are contextualised game situations and observation sheets, and the least used are psychomotor tests, thereby abandoning traditional physical fitness tests, and giving way to new assessment tools to assess students' motor skills and learning, as has been shown in previous studies (Chaverra & Hernández-Álvarez, 2019b).

In relation to the second objective, in the assessment aspects of students' motor skills, it can be seen that work on sports technique, physical fitness and artistic creations are assessed more frequently in Secondary Education. This is in line with the type of knowledge that should be developed at this stage of education and which is given much less importance in Primary Education within the curriculum (Royal Decree 157/2022; Royal Decree 217/2022). On the other hand, less experienced teachers tend to assess aspects related to sport tactics, rules, motor problem solving, the creation of expressive activities and carrying out activities in the natural environment more frequently. This may be because they have received different initial training, focused on the practical rationality of PE, and which places more importance on working on all curricular content, and therefore on its assessment (Hortigüela-Alcalá & Pérez-Pueyo, 2016; López-Pastor & Gea-Fernández, 2010). In the case of school ownership, public school teachers most frequently assess the production of artistic creations, carrying out activities in the natural environment and respecting and maintaining health and physical activity habits. In private schools, physical fitness, motor and psychomotor tests are used to a greater extent. As Flores et al. (2008) point out, this may be linked to the fact that in private schools education is more elitist in nature, placing greater importance on performance and the assessment of students' effectiveness in the proposed tasks.

On the other hand, with regard to assessment tools, physical fitness tests and examinations are most frequently used in secondary education. This higher incidence of use of assessment tools related to measurement may indicate an academicist view and a performance perspective associated with increasing demands in PE as one progresses through the grades and levels of education (Holfelder & Schott, 2014; Fisette & Franck, 2013; Sicilia et al., 2006). However, at both levels of education, the results highlight the importance of the assessment of procedural and attitudinal content. For the assessment of these, the most commonly used tools include observation sheets and rubrics. These results are in line with those produced in research carried out by Sicilia et al. (2006), which highlights the use of observation to assess attitudinal and procedural learning as the tool most commonly used by PE teachers. Similarly, Chaverra (2014; 2019a) highlights that teachers use qualitative assessment tools such as rubrics, observation sheets, field diaries, etc., to keep a record of the activities that take place in their classes, highlighting the need to prioritise attitudes as a means of comprehensive training and not to overvalue the technical elements of the field.

Less experienced teachers make more use of rubrics and contextualised game situations, while more experienced teachers make more use of tests. As López-Pastor and Pérez-Pueyo (2017) conclude, this may be due to the influence of the summative tradition of assessment, automatism and the reproduction of assessment practices experienced during the student stage. However, Chaverra (2014) finds that as teachers become more experienced and reflect more on their assessment practice, they are more inclined to use formative tools. Thus, he concludes that professional experience and reflection on one's own assessment practice are determining factors in the paradigm shift towards formative assessment.

Finally, with regard to the third objective, there is no clear relationship between the tools used and assessment aspects in PE. Physical fitness tests have a strong and positive relationship with the assessment of students' physical fitness, and it is clear that, although there has been progress in the assessment tools used, in the case of physical fitness assessment it continues to be one of

the most widely used resources. On the other hand, the relationship between the use of rubrics and assessment of students' ability to produce artistic and expressive creations stands out, and this tool is becoming an increasingly used resource, especially for those contents that are more difficult to assess (Pérez-Pueyo et al., 2019). Contextualised game situations are related to assessing the use of tactical elements as well as assessing the application of the rules in game situations, showing the coherence for teachers to assess in the same way as this content has been previously worked on.

Conclusions

This study has shown that, among the assessment aspects of students' motor skills, teachers report giving greater importance to assessing whether studentsknow and respect health and hygiene habits in the practice of physical activity and motor problem solving, the least valued aspect being the assessment of students' physical fitness. In terms of assessment tools, teachers indicate that the most frequently used are contextualised game situations and observation sheets, with tests being the least frequently used. There are some differences in these aspects depending on the educational level, teaching experience, academic degree and ownership of the school, although they are not constant and in many cases coincide with the logic of training that students should receive at each educational level or having received more up-to-date training. Finally, there is no clear relationship between most of the assessment tools studied and the motor skill assessment aspects; however, the use of tests to assess physical fitness and contextualised game situations for the assessment of tactics and sporting rules do stand out.

Among the strengths of this research is the large sample of Spanish PE teachers, as well as the innovation of the research itself, investigating aspects that have not previously been researched in depth. On the other hand, it has certain limitations, such as those inherent to quantitative research, since it cannot analyse the reasons for certain situations or the fact that it does not include the conceptual and attitudinal aspects that also form part of student assessment. In future lines of research, it is necessary to broaden research on this subject, extending the sample within the Spanish context and to other international contexts. In addition, it is necessary to analyse the reasons that lead teachers to assess certain aspects or to use certain types of tools.

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Benefits of Gamified Learning in Physical Education Students: A Systematic Review

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Abstract

The application of gamification in Education is becoming increasingly popular. However, empirical studies on gamification and physical education are very heterogeneous. What do we know about the impact of gamification in PE so far? The purpose was to provide a current overview on the benefits of gamification in PE belonging to the different educational levels. Additionally, this review aims to analyse the features that these interventions have in common. Studies were identified in seven databases: Dialnet, ERIC, Redalyc, EBSCOhost, ProQuest: ERIC, SCOPUS and Web of Science. Twenty-two studies were included: seven qualitative, seven quantitative and eight of mixed method, enrolling 2,095 students and 12 teachers. The analysis carried out showed significant increase in intrinsic motivation, and the satisfaction of all basic psychological needs and, consequently, commitment to the physical education subject, improving in learning and academic performance. Benefits were also highlighted regarding promotion of cooperative work and a positive atmosphere within physical education class.

Keywords: active methodologies, BPNs, compromise, educational innovation, engagement, gamification, motivation.

Introduction

The subject of Physical Education (PE) taught at school should be based on a curriculum adapted to the needs of the youngest and in accordance with social transformations. For example, PE aims to help pupils to optimally develop the motor, cognitive, social and emotional skills they need to lead a physically active life (McLennan & Thompson, 2015). To achieve this, unlike other subjects, PE already makes an extensive use of game as a didactic resource, being the cornerstone of this discipline (Normand & Burji, 2019).

Games have traditionally been considered as a form of entertainment (Yıldırım & Şen, 2019). In recent years, however, they have been at the heart of a growing trend in more formal environments such as industry and education (Dichev & Dicheva, 2017). The adoption of some mechanics, dynamics and components proper to games (Hanus & Fox, 2015; Werbach & Hunter, 2012) across a range of environments and/or contexts makes more formal, tedious and/or boring tasks more attractive. The inclusion of these new elements in the education system has brought about a relatively recent concept: gamification.

Gamification can be understood as the application of elements of game and video game principles and design to a learning environment so as to raise students' compromise, engagement and motivation levels (Buckley & Doyle, 2016; Dichev & Dicheva, 2017; Dicheva et al., 2015). In terms of its definition, gamification should not be confused with other similar terms, such as *serious games* or *game-based learning* (Sailer & Homner, 2020; Yıldırım & Şen, 2019). For example, *serious games* have serious aims about education before fun. Specifically, gamification transfers the mechanics and dynamics of games or video games to different contexts, such as the educational field, intended to augment or alter an existing learning process to create a version that users experience as game-like (Landers et al., 2018). While dynamics refer to restrictions, progression structure and narration technique, mechanics can be cooperation, challenge and competition. Generally, components (or aesthetics) within game design can be listed as point, badge, level, experience point, and leaderboards (Yıldırım & Şen, 2019).

Gamification or *gamified learning* (Armstrong & Landers, 2017) is becoming increasingly popular in educational contexts and its use has become more extensive across all subjects and levels. Nevertheless, a notable body of research has produced a variety of results and there is thus insufficient support to make substantiated claims about the effectiveness of gamification in education (Dichev & Dicheva, 2017). In line with this, empirical studies on gamification in PE are limited (Fernandez-Rio et al., 2020) varying greatly in their methodology (sample size, educational stage, intervention duration, quantitative or qualitative results, etc.).

Some systematic reviews and meta-analyses on gamification in the educational context currently exist (Dichev & Dicheva, 2017; Kim & Castelli, 2021; Mora et al., 2017; Prieto-Andreu, 2020; Sailer & Homner, 2020; Yıldırım & Şen, 2019), but no review has specifically addressed the effects of gamified didactics on PE. In this regard, collecting the results of the experimental research carried out on the effects of gamified PE has relevance to the evolution of the subject and the future design of the gamified proposals in PE. In this context, the present review aims to answer the following research questions:

(1) What benefits do PE students gain from a gamified learning?

(2) What main features should gamified learning have to achieve these benefits in PE?

Method

This study was conducted in accordance with the PRISMA declaration, which includes a series of evidence-based criteria to report on systematic and meta-analysis reviews (Page et al., 2021).

Selection Criteria and/or Eligibility

Regarding the selection criteria, only articles written in English or Spanish were included, and no publication date restrictions were applied. To establish the rest of the inclusion criteria, we considered the PICOS acronym (Participants, Interventions, Comparisons, Outcomes, Study Design). Firstly, the study participants were students of any age, belonging to any educational stage. Secondly, studies directly related to a PE gamified teaching-learning technique were selected, since gamification should not be confused with *game-based learning* or *serious games* or *exergames*, despite some common characteristics. Studies on hybrid methodologies in gamification (e.g., Valero-Valenzuela et al., 2020), thesis and books' chapters were excluded. Thirdly, both the single-group studies and the ones with dual comparison groups were included. Fourthly, studies that demonstrated the advantages of gamification whether quantitatively or qualitatively, were considered. Finally, regarding the study design, pre-experimental, quasi-experimental, non-experimental (descriptive) and qualitative (narrative and research-action) studies were selected while studies understood to be reflections, proposals and didactical applications and/or educational experiences with no evaluation of processes or results were excluded.

Sources of Information and Search Strategy

The search was performed during the months of May and June 2022 in the following databases: open access databases (Dialnet, ERIC and Redalyc) and databases with restricted access (EBSCOhost, ProQuest: ERIC, SCOPUS and Web of Science). The keywords used in both languages (English and Spanish) were: *gamification*, *gamified* and *physical education*. These descriptors were deemed the most pertinent. Finally, two search strategies were selected, composed of the above terms, compound concepts (""), truncators (*) and Boolean operators (AND/OR): *gamifi** AND "*physical education*"; gamifica* AND "Educacion Fisica".

Data Extraction and Quality Assessment Process

After having sorted the studies included in the review by means of the *RefWorks* bibliographic manager, the following data were extracted: design type, participants and characteristics, variables, measuring instruments and results obtained (Table 1, 2 and 3).

Results

Study Selection Process

The search in all databases produced a total of 646 documents. After having verified and discarded 569 duplicates, 77 were left. The full text of the remaining 76 documents underwent a more detailed analysis (authors read the title and abstract, and discussed it to agree on the characteristics of the papers to be included in the review). A total of 54 studies did not meet the inclusion criteria described above. Finally, a total of 22 studies ultimately met the inclusion criteria and were included in the review: seven articles were based on a qualitative methodology, seven were quantitative studies and eight were mixed methods (Figure 1).

Characteristics of the Studies

We describe the characteristics of the qualitative (Table 1), quantitative (Table 2), and mixed methods studies (Table 3) included in this review, following the PICOS acronym.

Figure 1
Prisma study selection flow chart.

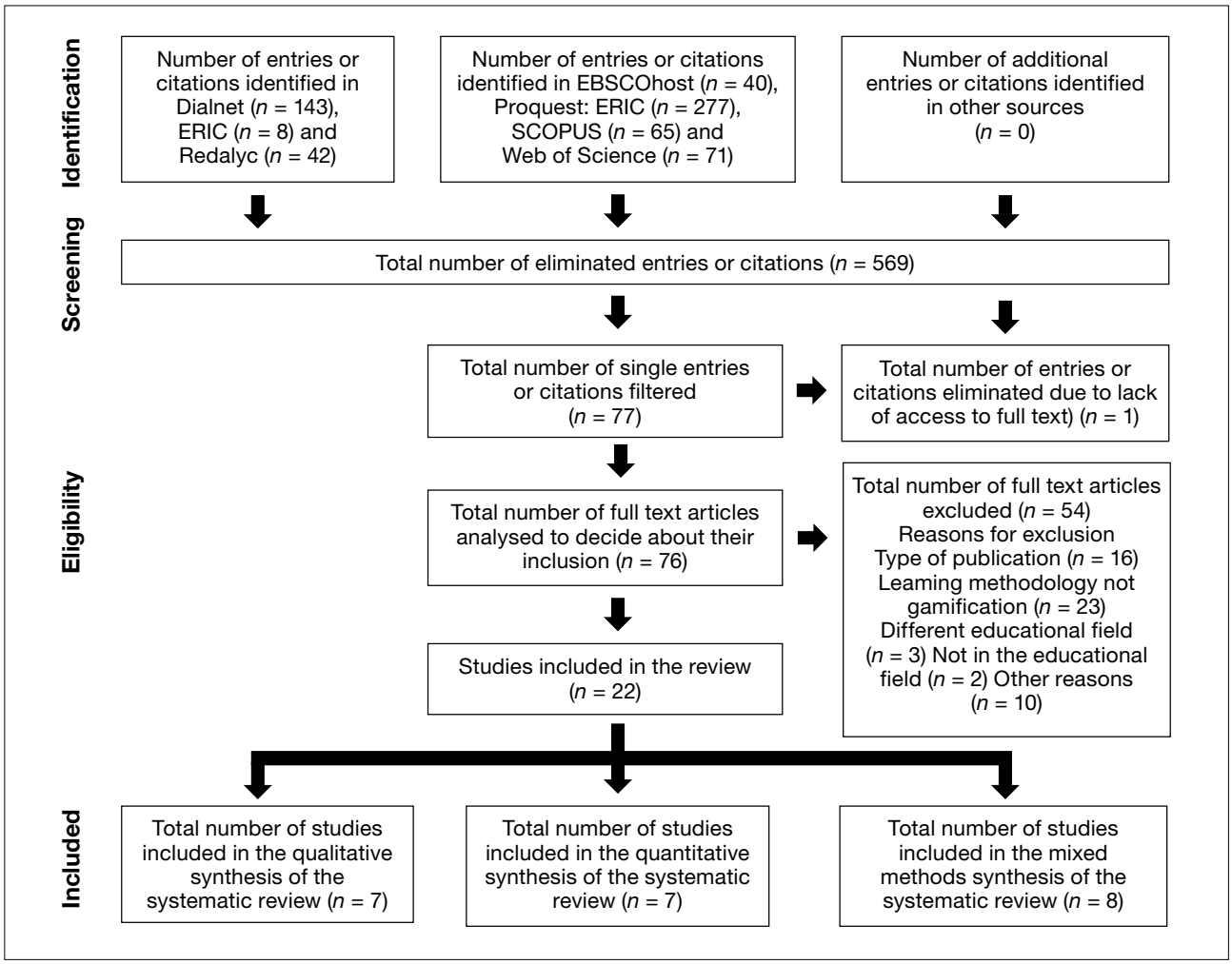

Table 1
Characteristics of qualitative studies included.

Reference	Research design	Sample	Sample characteristics	Variables	Instruments	Game-fiction (Length)
Arufe-Giráldez (2019)	Action-research	N_S = 47	Physical Education Teacher Education	Satisfaction, values formation, motivation, cooperative working, gamified experience	Open-ended and closed-ended questionnaire	*Fornite PE* (~1 hour)
Monguillot-Hernando et al. (2015)	Action-research	N_S = 99 N_T = 2	Secondary (2nd)	Healthy heart rate, motivation, gamified experience	Open-ended and closed-ended questionnaire, Systematic monitoring, Focus group (teachers)	*Play the game* (~12 hours)
Pérez-López & Rivera (2017)	Narrative-Evaluative	N_S = 69	College students from sports sciences	Learning, classroom environment, methodology and assessment, gamified experience	Form	*The prophecy of the chosen ones* (~60 h)
Pérez-López et al. (2017)	Narrative-Evaluative	N_S = 69	College students from sports sciences	Learning, classroom environment, methodology and assessment, gamified experience	Form	*The Threat of the Sedentaris* (~60 h)
Pérez-López et al. (2019)	Narrative-Evaluative	N_S = 59	College students from sports sciences (N_f = 16; N_m = 43)	Feelings, gamified experience	Open-ended questionnaire	*Game of Thrones: the wrath of dragons* (~60 h)
Rutberg & Lindqvist (2018)	Action-research	N_S = 32 N_T = 2	*Primary* (N_f = 15; N_m = 17)	School transport active, motivation, learning, gamified experience	Focus group, Interview	Active School Transportation (four weeks)
Rouissi et al. (2020)	Action-research	N_S = *102*	*Secondary (3rd- 4th) and Bachelor (1st)* (N_f = 53; N_m = 49)	Satisfaction, (dis)advantages of gamified experience and gender	Interview	*Orienteering (~2 hours)*

N_S = Students sample; N_T = Teacher sample; N_f = Female sample; N_m = Male sample

Table 2
Characteristics and results of quantitative studies non-randomised included.

Reference	Research design (*N*)	Sample	Sample characteristics	Variables	Instruments	Game-fiction (Length)
Castañeda-Vázquez et al. (2019)	Pre-experimental single-group	N_S = 64	Physical Education Teacher Education (N_f = 40; N_m = 24)	Intrinsic motivation, extrinsic motivation and gamified experience	Questionnaire CEAM II	*Actijuegos Pentathlon* (~60 h)
Ferriz-Valero et al. (2020)	Quasi-experimental non-equivalent group	N_{EG} = 62 N_{CG} = 65	Physical Education Teacher Education (N_f = 54; N_m = 73)	Intrinsic motivation, extrinsic motivation, academic performance and gamified experience	Motivational Questionnaire CMEF	*ClassCraft* (~30 h)
Fernández-Río et al. (2022)	Quasi-experimental non-equivalent group	N_{EG} = 27 N_{CG} = 27	*Secondary (3rd)* (N_f = 26; N_m = 28)	Intrinsic motivation, autonomy satisfaction, competence satisfaction, relatedness satisfaction, and intention to be physically active	Three motivational questionnaires: PLOC, Basic Psychological Needs and Intentions.	*Dragon Ball Z* (~14 h)
Martín-Moya et al. (2018)	Pre-experimental longitudinal single-group	N_S = 30	*Bachelor (2nd)* (N_f = 15; N_m = 15)	Motivation, self-perceived and comparative motor competence, commitment to learning, anxiety and fear to failure, gamified experience	MLPE Questionnaire Sociodemographic questionnaire	*DiverHealth* (~10 h)
Serrano-Durá et al. (2021)	Quasi-experimental non-equivalent group	N_{GE} = 17 N_{GC} = 19	*Secondary (1st)* (N_f = 19; N_m = 17)	Health and back care knowledge, mood state, perception of effort, gender, resistance of flexor and extensor muscles of the trunk.	Two theoretical questionnaires (COSACUES and COSACUES-AEF-), Feeling scale, OMNI scale, Three physical tests (Side bridge, Biering-Sørensen and Forearm plank)	Back health (~6 h)
Sotos-Martínez et al. (2022)	Quasi-experimental non-equivalent group	N_{EG} = 133 N_{CG} = 142	*Secondary* (N_f = 127; N_m = 148)	Basic Psychological Needs and motivation	Satisfaction for basic psychological needs (BPNES) and motivation (SMS-II spanish version)	*ClassCraft* (~10 h)
Real-Pérez et al. (2021)	Quasi-experimental non-equivalent group	N_{EG} = *49* N_{CG} = *49*	*Secondary (3rd and 4th)* (N_f = 58; N_m = 40)	Support and satisfaction for basic psychological needs, motivation and motivational climate	Support (CANPB) and satisfaction for basic psychological needs (BPNES), motivation (CMEF) and motivational climate (PEPS; SSI-EF)	African dance (~10 h)

N_S = Students sample; N_T = Teacher sample; N_f = Female sample; N_m = Male sample; N_{EG} = Experimental group sample; N_{CG} = Control group sample; EG = Experimental group; CG = Control group

Table 3
Characteristics and results of the mixed method studies included.

Reference	Research design	Sample	Sample characteristics	Variables	Instruments	Game-fiction (Length)
Carrasco-Ramírez et al. (2019)	Pre-experimental static single-group action-research	N_{EG} = 50 N_{CG} = 40 N_T = 2	*Bachelor*	Academic performance, perception, motivation, teacher perception and gamified experience	Questionnaire, Exam, Evaluation report, Interview, Anecdotal register, Focus group	Basic physical qualities (~10 h)
Dólera-Montoya et al. (2021)	Quasi-experimental non-equivalent group action-research	N_{EG} = 26 N_{CG} = 19 N_T = 2	*Primary (5th)* (N_f = 18; N_m = 27)	Perception, motivation, responsibility, violence, psychological needs, and emotional and social functioning	Questionnaires (BREQ-2; PSRQ; CUVECO; PNSE and EQ-i:YV), Interview, Student's diary	*Problem on the Island* (~4 h)
Fernández-Río et al. (2020)	Pre-experimental longitudinal single-group action-research	N_S = 290 N_T = 4	*Primary and Secondary (only 1st and 2nd)* (N_f = 138; N_m = 152)	Intrinsic motivation, gamified experience	Questionnaire Motivation Drawing, Focus group, Teacher diary	*MarvEF* (~25 h)
Flores-Aguilar et al. (2021)	Pre-experimental longitudinal single-group action-research	N_S = 76	College students from sports sciences	Motivation, engagement, academic performance, learning, gamified elements, ICT, cooperative learning and formative assessment.	Self-Questionnaire (11 items) and three open-ended questions.	Super Mario Bros (~60 h)
Ortega & Chacón (2022)	Pre-experimental longitudinal single-group action-research	N_A = 111	*Secondary (1st)* (N_f = 60; N_m = 51)	Final grades, students' attitudes, motivation and work done	Class notebook, Rubric and Teacher's notebook	Harry Potter (~10 h)
Pérez-López et al. (2017)	Pre-experimental static single-group action-research	N_{EG} = 73 N_{CG} = 75	College students from sports sciences	Healthy lifestyles and gamified experience	Questionnaire Green Survey, Overall assessment (only EG)	*The prophecy of the chosen ones* (~60 h)
Quintero-González et al. (2018)	Pre-experimental single-group action-research	N_S = 29	*Secondary (2nd)* (N_f = 11; N_m = 18)	Motivation, learning, prosocial attitudes, collaboration-cooperation, transfer of learning, gender and gamified experience	Questionnaire: Diana, Two open-ended questions	*ExpandEF* (~20 h)
Rodríguez-Martín et al. (2022)	Pre-experimental longitudinal single-group action-research	N_S = *143 (Only girls)*	*Primary (5th and 6th)*	Anxiety about failure	Spanish AMPET questionnaire Four open-ending question	*The trip to Healthy Land* (~20 h)

N_S = Students sample; N_T = Teacher sample; N_f = Female sample; N_m = Male sample; N_{EG} = Experimental group sample; N_{CG} = Control group sample

Participants

The total sample consisted of 2,123 participants (2,095 students and 12 teachers) divided into: 481 participants (477 students and four teachers) from selected qualitative studies; 686 students from selected quantitative studies and 940 participants (938 students and eight teachers) from selected mixed methods studies. They included university students enrolled in the Teacher Education degree with a specialisation in PE (n = 240) and in the Physical Activity and Sport Sciences Degree (n = 421), high school students (n = 1,031), and Primary Education students (n = 403).

Interventions

Just one investigation was conducted in Sweden (Rutberg & Lindqvist, 2018). The remaining studies were conducted in different parts of Spain (A Coruña, Alicante, Barcelona, Ceuta, Granada, Madrid, Murcia, Seville and Tenerife).

The educational objectives of the included interventions were varied:

- to teach sport and recreation (Arufe-Giráldez, 2019; Castañeda-Vázquez et al., 2019; Ferriz-Valero et al., 2020; Quintero-González et al., 2018; Rouissi et al., 2020) or coexistence (Dólera-Montoya et al., 2021).
- to develop healthy behaviors (Monguillot-Hernando et al., 2015; Pérez-López et al., 2017b; Rutberg & Lindqvist, 2018).
- to develop competencies that help students become better teachers (Carrasco-Ramírez et al., 2019; Flores-Aguilar et al., 2021; Pérez-López et al. 2017a; Pérez-López & Rivera-García, 2017).
- to assess the feelings or motivation of students (Fernandez-Rio et al., 2020, 2022; Ferriz-Valero et al., 2020; Martín-Moya et al., 2018; Ortega-Jiménez & Chacón-Borrego, 2021; Pérez-López et al., 2019; Real-Pérez et al., 2021; Rodríguez-Martín et al., 2022; Sotos-Martínez et al., 2022).

Regarding the length of intervention, the average of all interventions is ~26.7 hours. Within the range of the selected studies, there are studies with interventions of only one or two hours (Arufe-Giráldez, 2019) and another of ~60 h (Castañeda-Vázquez et al., 2019; Pérez-López & Rivera-García, 2017). In total, five studies applied < 10 hours, 11 studies between 10-30 hours and six studies ~60 hours.

The design of a gamified experience can be applied from a superficial approach of Points, Badges and Leaderboards (PBL) or, instead, develop it through a deeper and complex model of mechanics, dynamics and components of the game (MDA). Of all the studies included in this review, only four studies use the PBL model (Carrasco-Ramírez et al., 2019; Martín-Moya et al., 2018; Rouissi et al., 2020; Rutberg & Lindqvist, 2018). The rest of the studies, except Serrano-Durá et al. (2021) which is not determined, offer indications in their methodology to conclude that they follow an MDA model.

The learning content of PE worked with the student in the selected articles relate to physical condition and health (n = 12), sports and recreation (n = 8), outdoor and sustainability (n = 8), body expression (n = 3), and coexistence (n = 1). Some of these studies work several of these blocks in the same intervention (Pérez-López et al., 2019; Sotos-Martínez et al., 2022).

Finally, most studies implement gamification without technological resources, except Monguillot-Hernando et al. (2015), that use Google Sites as a virtual classroom, and Ferriz-Valero et al. (2020) and Sotos-Martínez et al. (2022), that carried out gamification with Classcraft®. Although other studies are considered not to use technological resources to implement gamification, some of them use them as a complement to teach (social networks, blogs, videos, QR codes, Kahoot, etc.).

Comparison

Firstly, the qualitative studies included did not compare gamification with any other intervention and/or methodology. Secondly, Castañeda-Vázquez et al. (2019) and Martín-Moya et al. (2018) were the only quantitative studies included that did not compare gamification to a traditional methodology. Finally, other investigations (Carrasco-Ramírez et al., 2019; Dólera-Montoya et al., 2021; Pérez-López et al., 2017a) were the only mixed methods studies that have compared gamified and traditional methodologies.

Outcomes

The most relevant results are summarized below. The variables evaluated were diverse.

(1) Motivation (15 studies). All studies, after gamified intervention, claim to find an increase in student motivation except one (Carrasco-Ramírez et al., 2019), which claimed that teachers felt that motivation depends on the teacher and not the type of methodology used. Specifically, the studies that address motivation from the SDT framework observe positive aspects such as an increase in intrinsic motivation (Castañeda-Vázquez et al., 2019; Fernandez-Rio et al., 2020, 2022; Sotos-Martínez et al., 2022) or a decrease in amotivation (Dólera-Montoya et al., 2021; Sotos-Martínez et al., 2022). Other investigations (Castañeda-Vázquez et al., 2019; Ferriz-Valero et al., 2020) also observed an increase in extrinsic motivation. Although the study of

Ortega-Jiménez & Chacón-Borrego (2021) describes that a motivational questionnaire is used, no results or references of the instrument used are provided.

(2) Learning and academic performance (10 studies). Most studies reveal greater learning after gamified intervention. Some authors (Monguillot-Hernando et al., 2015; Pérez-López et al., 2017a) revealed that students positively appreciated the use of gamification as a strategy to learn ICT skills and healthy behaviors, especially in boys (Serrano-Durá et al., 2021). Others (Pérez-López et al., 2019; Pérez-López et al., 2017b; Pérez-López & Rivera-García, 2017) concluded that students were satisfied with learning and they highlighted students' acquisition of competences in terms of knowledge, know-how, life skills and attitudes. Castañeda-Vázquez et al. (2019) noted that 87.9% of students passed the subject in the first examination. Fernandez-Rio et al. (2020) noted that some students claimed to have learned during the experience. Finally, only two investigations (Carrasco-Ramírez et al., 2019; Ferriz-Valero et al., 2020) demonstrated a higher academic performance in gamified group.

(3) Engagement (Nine studies). This variable is almost always accompanied by the term motivation. In fact, just a quantitative study (Martín-Moya et al., 2018) measures it specifically through a validated instrument such as the MLPE questionnaire, observing this improvement only in boys. All of them conclude that students' engagement improves with the gamified proposal. Specifically their commitment to physical activity (Arufe-Giráldez, 2019; Monguillot-Hernando et al., 2015) or to learning (Flores-Aguilar et al., 2021; Martín-Moya et al., 2018; Pérez-López et al., 2019; Quintero-González et al., 2018; Rodríguez-Martín et al., 2022; Rutberg & Lindqvist, 2018).

(4) Teamwork component (seven studies). Arufe-Giráldez (2019) study concluded gamification was regarded as an effective tool for cooperation work. Rutberg and Lindqvist (2018) showed that links were created between the students after the gamified proposal. Rouissi et al. (2020) showed that student satisfaction appeared with the teamwork component (higher in girls). Dólera-Montoya et al. (2021) observed that students emphasized the interest in challenges and group work in the student's diary. Fernandez-Rio et al. (2020) highlighted that some students claimed to have worked as a team. Flores-Aguilar et al. (2021), Quintero-González et al. (2018) and Rodríguez-Martín et al. (2022) identified benefits regarding cooperative work following the implementation of the gamified treatment.

(5) Class climate (five studies). All studies report improvements in class climate except one (Real-Pérez et al., 2021). Arufe-Giráldez (2019) study concluded that Fortnite PE was highly instrumental in preventing violent behaviors in the classroom despite the violent nature of the original game. In addition, the experience was regarded as an effective tool for cohesion among classmates. Dólera-Montoya et al. (2021) observed another very remarkable aspect which is that both treatment groups decreased the violence suffered. Pérez-López and Rivera-García (2017) concluded that the students progressed in their life skills competences as individuals and social beings. Pérez-López et al. (2017a) pointed to the achievement of a remarkably positive classroom atmosphere.

(6) Basic Psychological Needs (Four studies). Fernández-Río et al. (2022) and Sotos-Martínez et al. (2022) found improvement in all BPNs (autonomy, competence and relation). Instead, Dólera-Montoya et al. (2021) and Real-Pérez et al. (2021) did not observe any statistically significant differences in the BPNs' support and satisfaction although the authors argue a higher improvement in the gamified group.

(7) Other variables. In the study of Martín-Moya et al. (2018), the experimental group showed significant improvements in self-perceived motor competence (especially girls) and comparative motor competence (especially boys). Pérez-López et al. (2019) found that the implemented gamified learning methodology generated differences in feelings according to sex. Girls showed greater disappointment, enjoyment, emotion, stress, frustration, illusion, nervousness, satisfaction, and surprise. Instead, boys showed greater happiness, anxiety, confidence, and uncertainty. These differences remained constant throughout each stage of the experience and/or proposal (presentation, initial phase, mid-term phase, and final phase) except for an increase in enjoyment and satisfaction at the initial stage and a decline in satisfaction at the final stage. Rutberg and Lindqvist (2018) showed a change in family attitudes towards active school transport. Rouissi et al. (2020) and Fernandez-Rio et al. (2020) highlighted that most of students claimed to have a good time (enjoyment). Most students did not report any negative aspects of the gamification experience, only a few of them reported finding some difficulties in the tasks or lack of time to complete them. In this line, teachers claimed that gamification requires greater workload. In addition, they considered the narrative the most important factor and portfolio as a key element in the implementation of a gamified experience.

Design

Firstly, among the qualitative studies, four were designed based on an action-research tradition and/or methodology; three employed a narrative-evaluative methodology (Table 1). Secondly, all quantitative studies were based on a pre-experimental or quasi-experimental design. Five were cross-sectional in nature, and six were longitudinal (Table 2). Thirdly, according to mixed methods studies, as far as the quantitative component is concerned, all the studies were based on a pre-experimental and quasi-experimental design. Three were cross-sectional and five were longitudinal. As for the qualitative component, an action-research tradition and/or methodology was followed in all works (Table 3).

Discussion

Summary of the Evidence

We adopt Landers (2014) *theory of gamified learning* to lead the guiding thread of this discussion, unifying theory with practice. This theory explains that gamification can affect learning through one of two processes: a more direct mediating process or a less direct moderating process. For instance, many studies included in this review (Dólera-Montoya et al., 2021; Fernandez-Rio et al., 2020, 2022; Flores-Aguilar et al., 2021; Pérez-López et al., 2019; Pérez-López et al., 2017a; Pérez-López et al., 2017b; Pérez-López & Rivera-García, 2017; Quintero-González et al., 2018; Sotos-Martínez et al., 2022) using narrative as a game-fiction component. Although there is not enough information to determine exactly whether the narrative used serves to increase motivation (via moderation) or to increase learning of contents (via mediation) as well, all studies conclude that motivation is improved except one (Dólera-Montoya et al., 2021). Of the remaining research that does not use narrative as a gamified component, all works report an improvement in the student motivation (Arufe-Giráldez, 2019; Castañeda-Vázquez et al., 2019; Martín-Moya et al., 2018; Monguillot-Hernando et al., 2015; Rouissi et al., 2020; Rutberg & Lindqvist, 2018) except one (Carrasco-Ramírez et al., 2019) that relates to increased motivation to the novelty of the pedagogical approach (González-Cutre & Sicilia, 2019). Even though some authors believe the narrative is the highest conceptual level and the most significant feature of gamification (Dichev & Dicheva, 2017; Hanus & Fox, 2015; Werbach & Hunter, 2012), the results seem to indicate that the use of a narrative is not a moderating factor in applying gamified didactic in PE according to other meta-analysis studies performed with closely serious games (Wouters et al., 2013).

Gamification applications can be very varied, and there are many different game design elements that can result in different affordances for learners, modes of social interactions, and learning arrangements (Sailer et al., 2017). Another example of this is the different models used (PBL vs MDA). In most cases, MDA includes the characteristics of PBL. Although the PBL model could respond to those teachers who are concerned that the application of gamified teaching requires excessive workload (Fernandez-Rio et al., 2020), being a simpler and easier model, most authors use the MDA model. According to this, some studies have claimed that the PBL model could generate excessive competitiveness, increased external regulation or even a decrease in interest (Blázquez-Sánchez & Flores-Aguilar, 2021; Ferriz-Valero et al., 2020; Werbach & Hunter, 2012). At this point of the gamification research in PE, it would be very speculative to reflect on which model is best in PE, since both show positive results of gamification. For instance, Rutberg and Lindqvist (2018) point out that the stickers (points and badges for achieving challenges) enhanced the motivation and engagement for the children, and many children wanted to bike to school even if the weather was bad. Although the age of the students could be a significant independent variable in this assertion, when students voluntarily proposed to participate in a gamified environment, one aspect that repeated in many studies, with examples from primary to college students, was the student engagement to challenges (Arufe-Giráldez, 2019; Carrasco-Ramírez et al., 2019; Castañeda-Vázquez et al., 2019; Dólera-Montoya et al., 2021; Fernandez-Rio et al., 2020; Monguillot-Hernando et al., 2015; Pérez-López et al., 2019; Pérez-López et al., 2017a; Pérez-López et al., 2017b; Pérez-López & Rivera-García, 2017; Quintero-González et al., 2018; Rouissi et al., 2020; Rutberg & Lindqvist, 2018) and, consequently, a greater self-perceived motor competence (Martín-Moya et al., 2018). In fact, in the Pérez-López et al. (2017b) study, a college student stated that: "The truth is that I recognize that my self-esteem has been reinforced, because I never thought I would be able to improve some lifestyles, and more importantly, to be able to help my girlfriend improve hers" (p. 947).

According to the previous paragraph, there is a key mechanic element (Werbach & Hunter, 2012) that we consider important to discuss: the feedback that students receive about their progress in gamified experience. Points, badges, levels, etc., help this goal through a portfolio (Fernandez-Rio et al., 2020), progress bar (Castañeda-Vázquez et al., 2019; Rutberg & Lindqvist, 2018; Serrano-Durá et al., 2021), tracking card or leaderboards (Arufe-Giráldez, 2019; Martín-Moya et al., 2018; Monguillot-Hernando et al., 2015; Pérez-López et al., 2019; Pérez-López et al., 2017a; Pérez-López et al., 2017b; Pérez-López & Rivera-García, 2017; Quintero-González et al., 2018; Rouissi et al., 2020) and, finally, using mobile apps (Ferriz-Valero et al., 2020).

These resources used to encourage student feedback are usually set up to direct players' actions towards concrete or desirable actions, and are closely linked to levels, and a specific number of points are required to move from level to level. As for the leaderboards, each participant can follow their progress in terms of performance level according to the goals presented in the activity. This means that the individuals involved are motivated to progress in their performance and increase competitiveness among them, as it also allows to observe how the others advance. At this last point, it is important to note that public exposure of leaderboards o scoreboards could cause discomfort in students, as there are aspects that have not been achieved and a non-constructive comparison between classmates could be favoured, avoiding another gamification benefit as a relaxed classroom atmosphere (Arufe-Giráldez, 2019; Dólera-Montoya et al., 2021; Pérez-López et al., 2017a; Pérez-López & Rivera-García, 2017) and/or teamwork.

A promising gamification design feature is collaboration work. All the studies mentioned in this review have included cooperative work in their PE gamified proposal, except two where this is not specifically indicated (Carrasco-Ramírez et al., 2019; Serrano-Durá et al., 2021). Collaboration can be manifested in many ways in gamified environments, but the important thing is that the interaction among students in a learning activity appears to have a durable effect on student learning outcomes (Sung et al., 2017) across educational settings (Huang et al., 2020). A common benefit in most of these research studies that include collaborative work is the increase in motivation of the student. A less investigated common benefit is improved commitment to physical activity (Arufe-Giráldez, 2019; Monguillot-Hernando et al., 2015), commitment to learning (Flores-Aguilar et al., 2021; Martín-Moya et al., 2018; Pérez-López et al., 2019; Quintero-González et al., 2018; Rodríguez-Martín et al., 2022; Rutberg & Lindqvist, 2018), the class climate (Arufe-Giráldez, 2019; Dólera-Montoya et al., 2021; Pérez-López et al., 2017a; Pérez-López & Rivera-García, 2017) and Basic Psychological Needs (Fernández-Río et al., 2022; Sotos-Martínez et al., 2022).

Besides that, positive results were also found in relation to the learning outcomes of content in PE (Carrasco-Ramírez et al., 2019; Fernandez-Rio et al., 2020; Ferriz-Valero et al., 2020; Monguillot-Hernando et al., 2015; PPérez-López et al., 2017b; Pérez-López & Rivera-García, 2017; Rutberg & Lindqvist, 2018; Serrano-Durá et al., 2021). Fitness and health is the block of instructional content which is common to all previous studies, except for Ferriz-Valero et al. (2020), where it was outdoor sports. However, according to the *theory of gamified learning*, instructional content could hide the success of gamification intervention. If the instructional content does not already help students learn, gamification of that content cannot itself cause learning (Landers, 2014). Consequently, in order to implement effective gamification, the student must participate voluntarily and, therefore, feel a minimum pleasure towards the instructional content that they are going to learn.

Regarding the studies included in this review that compared gamified and traditional learning methodologies, differences were notably found with respect to the benefits for students. Firstly, the participants who performed their activity based on a gamified experience significantly improved their intrinsic motivation compared to those who did not (Fernandez-Rio et al., 2022; Sotos-Martínez et al., 2022). In contrast to these findings, studies such as that of Ferriz-Valero et al. (2020) on the effects of gamification in the context of PE teacher training showed a significant increase in extrinsic motivation. Apostol et al. (2013) argue that gamification allows both extrinsic and intrinsic motivation to be encouraged whenever it contains challenges to overcome, awakens the student's curiosity, allows the ability to control, and contains fantasy elements. In this way, according to the contributions of Hanus and Fox (2015), many studies recommend that caution be taken when seeking to increase students' intrinsic motivation, since the use of rewards, badges, etc., have been found to be counterproductive and diminish the intrinsic motivation of the most motivated and interested students (Deci et al., 2001; Deci & Ryan, 1985; Hanus & Fox, 2015). However, if properly implemented, it can contribute to the development of various positive effects in the educational context, such as a greater ability to concentrate on the task or higher levels of learning engagement (Aelterman et al., 2012; Ferriz-Valero et al., 2020; Hagger et al., 2003). On the other hand, the study of Carrasco-Ramírez et al. (2019) found no significant motivation differences between the control and experimental groups, although the latter presented greater engagement. Secondly, in relation to healthy lifestyle habits, the students participating in the gamification experience obtained a significant improvement compared to those who did not (Pérez-López & Rivera-García, 2017). In line with these results, the program on gamification and prevention of childhood obesity conducted by González et al. (2016) demonstrated its effectiveness relating to the adoption of healthy habits, significant differences in diet quality rates having been observed between the control and the experimental groups. Finally, differences, albeit not significant ones, were also encountered in terms of academic performance. Students who participated in the intervention achieved better results (Carrasco-Ramírez et al., 2019; Ferriz-Valero et al., 2020).

Limitations of the studies, the results and the review

Firstly, the methodological quality of the qualitative, quantitative, and mixed methods studies varied widely. Secondly, none of the quantitative and mixed methods studies included in the review guaranteed sample representativeness. The bias due to the non-response of some participants in the quantitative and mixed studies constituted an additional notable drawback. Regarding the mixed methods studies, the lack of integration of the qualitative and quantitative component in the vast majority of the studies generated a risk of result interpretation bias, which prevented attaining the robustness of the combination of both methods. Furthermore, the differences in quality between each study's qualitative and quantitative component led us to consider them of low quality. Finally, the quality of some criteria (complete results data and confounders) could not be adequately assessed due to lack of information in some studies.

The main limitation of the present work as a review article was the scarce number of publications on the use of gamification in PE in countries other than Spain, perhaps due to the novel nature and complex execution of such gamification. This does not mean that the topic is not relevant, since many articles are published in the most impact scientific journals in PE (Fernandez-Rio et al., 2020, 2022; Sotos-Martínez et al., 2022) and this is not happening in other gamification reviews in other subjects than PE (Yıldırım & Şen, 2019). Meta-analysis techniques were not used either. Finally, it is necessary to highlight that only four studies have shown differentiated results based on sex.

Conclusions/ Future Lines of Research

Regarding the benefits of gamification, the review showed that it was considered as a very useful tool to foster positive attitudes and behaviors in PE students (whenever the student participates voluntarily and is grateful for the instructional content) and, consequently, learning outcomes. In line with the findings of other authors, gamification is presented in the scientific literature as a pedagogical innovation capable of increasing students' engagement and motivation, autonomy (through continuous feedback), teamwork, as well as improving their learning.

On the one hand, the results analysed in this review point to the fact that the narrative is not a moderator element within the gamified design in PE. On the other hand, motivation, engagement, "pointification" (Huang et al., 2020) and feedback do seem to be mediators of gamified learning. However, gamification in education should not be understood as a concept formed by juxtaposed features, but as a complex and global concept formed by elements interacting synergically within a continuous process. Consequently, gamification with all moderating/mediating elements may not be effective. Instead, a gamified design with all well-designed factors will find the best results. Therefore, more studies are suggested to analyse the interaction between these elements to establish stronger conclusions.

Most studies focusing on analysing the effects of gamification present very diverse methodological approaches; that is why the conclusions must be interpreted with caution. Despite having identified various studies with empirical evidence on the effectiveness of gamification in PE (significant increases in intrinsic motivation, benefits regarding academic performance, notable improvements in healthy lifestyle habits, etc.), many studies show low methodological rigor.

Further relevant empirical research is thus needed to examine other variables that may be affected by the methodology (i.e., sex differences, relationship between moderating/mediating factors, use of technology) in the benefits of PE gamification and to ultimately confirm the effectiveness of this active learning methodology in PE. We hope this review has reflected the potential of gamification to continue to advance in our knowledge of quality education for our PE area and all future students.

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Evidence-Based Classification in Wheelchair Sports: A Systematic Review

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Two surfers practicing freestyle kitesurfing. Adobestock ©MandicJovan. Mediteraneo

Abstract

The purpose of this study is to answer the following questions: What kind of evidence-based classification test is being discussed for wheelchair Paralympic sports? What kind of tool does the research use to quantify these evidence-based classification tests? A systematic review was carried out in the databases of PubMed and ScienceDirect. The main parameters studies described were muscle strength of upper limbs and trunk, and measures of mobility performance, especially speed. The main tests these studies carried out were isometric strength tests, tilt tests, sprints, and acceleration tests. The instruments most commonly used in the studies were load cells and dynamometers, video systems, laser devices, force platforms, and inertial sensors. Biomechanics tools are important allies for evidence-based classification. Classification tests with equipment and sensors that provide objective measurements of parameters allow validating simple field tests and obtaining reliable values concerning such parameters during athletes' classification.

Keywords: evidence-based classification, measurement, Paralympic sports, technologies in sport, wheelchair sports.

Introduction

Eleven out of twenty-two Paralympics summer sports are wheelchair modalities: wheelchair rugby, wheelchair basketball, World Para Athletics, wheelchair tennis, table tennis, para badminton, wheelchair fencing, paratriathlon, para shooting, para archery, and boccia (International Paralympic Committee, 2020). Wheelchair sports athletes are typically classified with the following eligible impairments: impaired muscle power (e.g. spinal cord injury, muscular dystrophy, post-polio syndrome, and spina bifida), impaired passive range of movement (e.g. arthrogryposis and contracture resulting from chronic joint immobilization or trauma affecting a joint), limb deficiency (e.g. amputation, and dysmelia), leg length difference, hypertonia (e.g. cerebral palsy, traumatic brain injury and stroke), ataxia (e.g. cerebral palsy, traumatic brain injury, stroke, and multiple sclerosis), and athetosis (e.g. cerebral palsy, traumatic brain injury and stroke) (International Paralympic Committee, 2017).

Over the years, since the development of adapted modalities, there has been some sort of classification. Initially, the classification of athletes was based on the individual's medical diagnosis, comprising distinct classes for people with spinal cord injury (ISMWSF), amputations and others (ISOD), blindness and visual impairment (IBSA), cerebral palsy (CPISRA), as well as such as hearing impairment (ICSD) and intellectual disability (Special Olympics and INAS) (Reina et al., n.d.). With the maturing of the Paralympic movement and the popularization of the modalities, some inconsistencies appeared in the classification system: people with the same diagnosis could present different functionalities and so the system was updated and is now based on the athletes' functionality (Reina et al., n.d.; Tweedy & Vanlandewijck, 2014).

In addition, thinking in terms of functionality, there is a taxonomic relationship between the International Classification of Functioning, Disabilty and Health (ICF) of the World Health Organization and the Paralympic Functional Classification, in which it is possible to apply the language and structure of the ICF to the context of Paralympic sport (Tweedy, 2002). Thus, the Functional Classification system is based on the definitions and language of the ICF (Tweedy & Vanlandewijck, 2014). Therefore, the classification ceased to consider the injury itself and started to take into account the impact of the injury on performing tasks, that is, on its functionality, and the classification code was updated until it reached the form we know today.

For fair play matters, sports federations must evaluate and classify an athlete's impairment (Vanlandewijck et al., 2011). The federations of each sport, regulated by the International Paralympic Committee (IPC), have their own classification rules. According to the definition of the IPC, athletes are grouped into classes according to how much their permanent disability affects the fundamental activities of each sport (*IPC Athlete Classification Code, 2015*). Sport classification may be partly a subjective-quantitative process (Vanlandewijck et al., 2011). The classification rules for each wheelchair Paralympic sport have similar principles, but each sport has its assessment characteristics and classes.

Classification has a significant impact on successful performance in Paralympics (Tachibana et al., 2019). Classification systems sometimes are based on the judgment of experienced classifiers and these evaluations may lead to questionable classifications, allocating athletes to classes that can give them advantages or disadvantages over their competitors (Tweedy & Vanlandewijck, 2014; Van der Slikke et al., 2018). In this sense, the evidence-based classification (EBC) has been gaining popularity throughout the last years. An EBC system aims to provide more objective classifications according to empirical evidence based on quantitative methods.

In this sense, an evidence-based system requires that scientific research be developed, in order to answer questions relevant to the athletes' classification process. So, Tweedy et al. (2016) developed a scheme that aims to resolve doubts about the process of developing evidence-based classification systems. This process is sequential and consists of six steps:

- Step 1 Identify the target sport and the types of disability to be classified. In this step the type of disability is selected based on the 10 types of disability that are eligible for Paralympic sport (impaired muscle power, impaired passive range of movement, limb disability, leg length difference, hypertonia, ataxia, athetosis, short Stature, vision impairment and intellectual impairment) and within these types, the eligible disabilities for each sport are chosen.
- Step 2 Develop the theoretical model of the determinants of sports performance. In this step, the researcher determines how general sports performance is evaluated and identifies the factors that determine overall performance in this sport, such as muscle strength, range of motion, among others.

- Step 3a Develop valid measures of impairment(s). This step identifies ways to directly measure one of the ten types of eligible impairments, that is, methods to infer impairment based on knowledge of intact bodily structures and functions.
- Step 3b develop standardized, sports-specific measure(s) of performance. This step develops standardized, sport-specific measures that quantify performance individually or collectively. Thus, test selection needs to take into account whether the outcome is predictive of performance, whether the outcome measure is sensitive to differences in impairment measures, and whether factors that are not rated have minimal influence.
- Step 4 Assess the relative strength of association between valid measures of impairment and sport-specific measure(s) of sport performance. In this step the relative strength of association between measures of disability and sport-specific measures of performance in athletes with disabilities is assessed. Tests that have strong and statistically significant associations can be incorporated into rating systems, helping to guide practitioners in decision-making during the rating process.
- Step 5 Use outcomes from Step 4 to determine minimum impairment criteria, number of classes, and methods for allocating classes. In this step, the minimum disability criteria are defined, that is, it is determined that the disability is severe enough to adversely affect performance in that sport. In addition to determining the number of classes according to the degrees of commitment in each sport, statistical methods to achieve these results are used.

The quest to make the classification evidence-based requires a lot of studies, going through each of these steps, in order to make the assessments as close as possible to the ideal, increasing confidence in the processes and allowing the Paralympic vision to be realized (Tweedy et al., 2016, 2018).

This topic raises at least two questions: What type of EBC tests are under discussion for wheelchair Paralympic sports? What type of tools does research use to quantify such EBC tests? Therefore, the objective of this systematic review was discussing what type of quantitative tests, based on movement analysis techniques (e.g., inertial measurements, videophotogrammetry, etc.), literature has been applying for the EBC concerning wheelchair Paralympic sports.

Materials and methods

Preliminary settings

The present study is in agreement with Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement. It was registered in the International Prospective Register of Systematic Review (PROSPERO; https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42020166767) on 28/04/2020 (registration number CRD42020166767) (Booth et al., 2012). The inquiries of this study fit PICO's strategy as follows: (1) Participants: wheelchair athletes; (2) Intervention: Research on evidence-based classification; (3) Comparison: descriptive data on evidence-based classification; and (4) Outcomes: main tests and instruments that make the classification of Paralympic sports more objective.

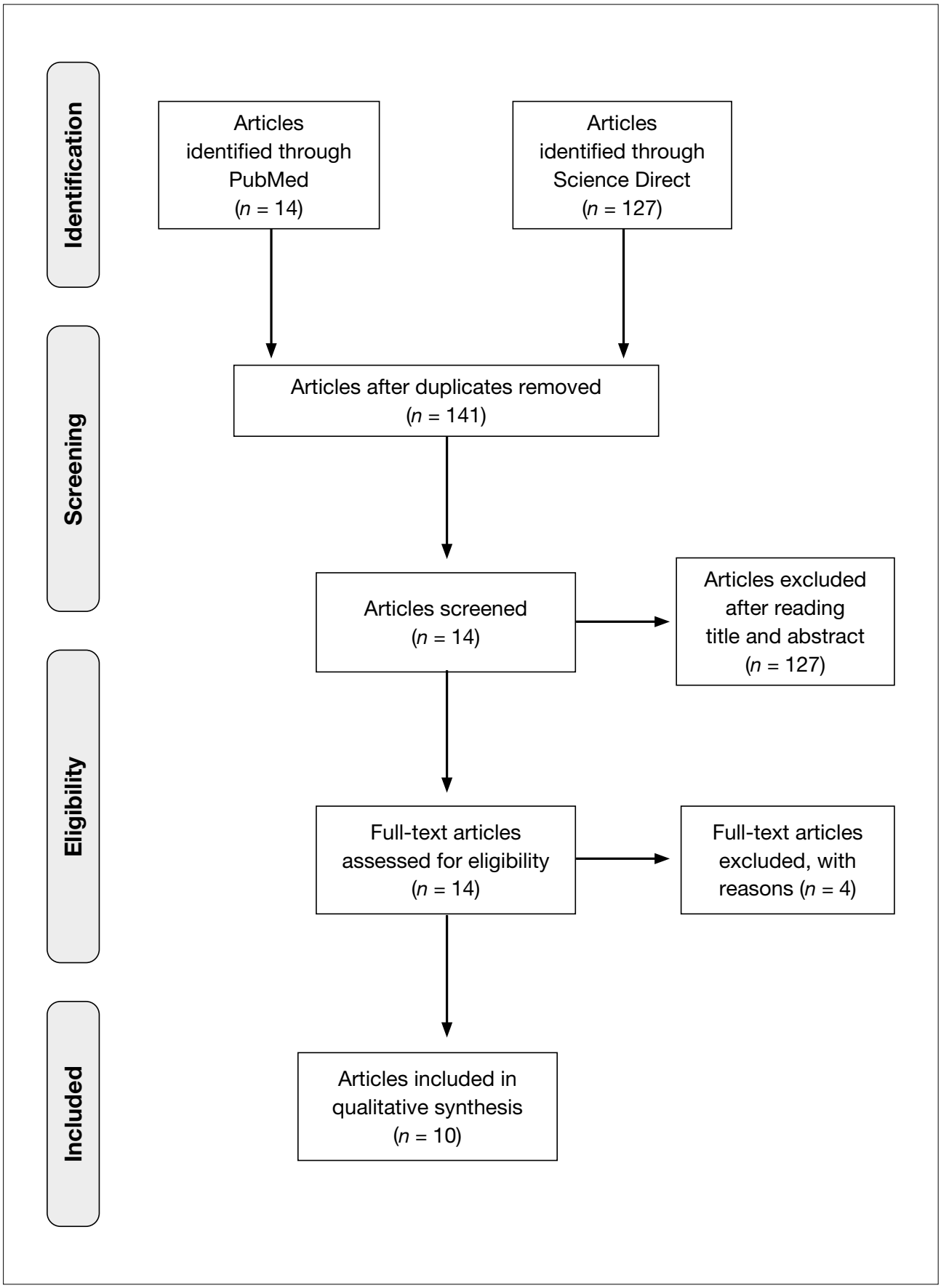
Eligibility criteria

To be considered, manuscripts had to: (1) be cross-sectional studies written in English; (2) present methodologies for the quantification of the performance of wheelchair sports; (3) present quantitative data of evidence-based classification in wheelchair sports; and (4) involve movement analysis in Paralympics athletes. This research excluded studies that were: (1) introduction of conference proceedings; (2) duplicate studies; (3) studies applying evidence-based classification of Paralympic sports without a wheelchair.

Search strategy

Systematic searches were conducted in the following databases with English language restriction and without date restriction: PubMed/Medline and ScienceDirect. The search terms used were: "evidence-based classification" AND "wheelchair sports". After searching, two researchers selected articles independently, excluding duplicated papers. Decision-making was based on the titles and abstracts of the articles and the inclusion criteria previously described (Figure 1). A third researcher solved occasional disagreements.

Figure 1
Flow diagram.



Data extraction

Data extraction was performed independently by two researchers and when inconsistencies were presented, a third researcher solved them. The following features were extracted from selected studies: author's name, year, purpose, sport, sample, evaluated parameter, tests, sensors and equipment, and main results.

Quality assessment

The studies were evaluated through the Appraisal tool for Cross-Sectional Studies (AXIS tool) (Downes et al., 2016). This tool consists of twenty questions that evaluate the quality and risk of bias of cross-sectional studies.

Results

Included studies

This study identified a total of 141 articles in the databases and selected 14 articles by reading the title and abstract. Afterward, the articles were fully read and the inclusion criteria mentioned above were applied. Only four studies did not meet the inclusion criteria: one study was a systematic review (Morriën et al., 2017); a book section (Ungerer, 2018); one study did not focus on classification aspects (Van der Slikke et al., 2015); and one study focused in people without physical impairments (Vanlandewijck et al., 2011). Finally, 10 articles remained for this review (Figure 1). Taking into account the chronology of these studies, the first was published in 2014 (Borren et al., 2014), and the two most recent in 2020 (Mason et al., 2019; Van der Slikke et al., 2020), until the submission of this review.

Quality assessment

The selected studies had the quality assessment and methodological rigor evaluated by the AXIS tool. We identified that for the 20 questions present in the AXIS tool, none of the articles reported items 7, 9 (methods), and 14 (results). In addition, items 3 (methods), 13 (results), and 19 (others) were negative for all articles. In general, all articles have good methodological quality, which makes their results reliable (see supplementary material 1). This assessment did not influence the selection of studies.

Studies Summary

We found that wheelchair rugby was the most studied sport (N = 8) (Altmann et al., 2016, 2017; Borren et al., 2014; Hyde et al., 2016; Mason et al., 2019; Santos et al., 2017; Squair et al., 2017; Van der Slikke et al., 2020), followed by wheelchair basketball (N = 4) (Altmann et al., 2016; Borren et al., 2014; Hyde et al., 2016; Van der Slikke et al., 2020), World Para Athletics (N = 2) (Connick et al., 2017; Hyde et al., 2016), and wheelchair tennis (N = 1) (Van der Slikke et al., 2020). Some of the articles evaluated over one sport (Altmann et al., 2017; Hyde et al., 2016; Van der Slikke et al., 2020). Regarding the EBC, the main instruments researchers used to carry out their evaluations were: load cells and dynamometer (N = 3) (Altmann et al., 2017; Connick et al., 2017; Mason et al., 2019); video systems (N = 3) (Borren et al., 2014; Connick et al., 2017; Hyde et al., 2016); laser device (N = 2) (Altmann et al., 2016; Connick et al., 2017); inertial sensors (N = 2) (Van der Slikke et al., 2018, 2020); and force platform (N = 1) (Santos et al., 2017). The most widespread tests were: isometric strength tests (N = 4) (Altmann et al., 2017; Connick et al., 2017; Hyde et al., 2016; Mason et al., 2019); tilt tests (N = 2) (Altmann et al., 2016, 2017); sprints (N = 2) (Altmann et al., 2016; Connick et al., 2017); acceleration (N = 2) (Altmann et al., 2016, 2017); match and field tests (N = 2) (Van der Slikke et al., 2018, 2020); pass tests (N = 1) (Borren et al., 2014); throwing test (N = 1) (Hyde et al., 2016); and trunk inclination to the sides (N = 1) (Santos et al., 2017). Some of the computed variables were: strength (N = 4) (Altmann et al., 2017; Connick et al., 2017; Hyde et al., 2016; Mason et al., 2019); speed and acceleration values (N = 2) (Van der Slikke et al., 2018, 2020); tilt height (N = 2) (Altmann et al., 2016, 2017); and Seated limits of stability (LoS) (N = 1) (Santos et al., 2017). For more information see table 1.

EBC aims to make classification in Paralympic sports more precise by using tests and measures. To do so, it is important to 1) select the most relevant parameters to be assessed and the conditions for the assessment; 2) choose adequate instruments and tests to assess such parameters; 3) provide objective values to assist decision-making concerning an athlete's class choice.

Table 1
Data extracted from the eligible studies regarding evidence-based classification in wheelchair sports.

Study	Purpose	Para Sport /Sample	Evaluation of the Test	Quantification Tools	Quantified Variables	Main results for classification
(Borren et al., 2014)	Analyze wheelchair rugby athletes while performing different passing techniques and compare athletes from different classes.	Wheelchair Rugby / 15 athletes	Chest pass. Impact pass. Overarm pass. Sidearm pass.	Kinematic Analysis.	Throw force, power, and speed for each one of the passing techniques.	The group without triceps function had an average pitch of 3.5 m and the group with triceps function had an average pitch of 8 m. In this way, athletes with higher classes had better results than athletes with low legs. In addition, the study showed that the current classification had a good correlation with what was found in the study.
(Hyde et al., 2016)	Investigate the influence of the assistive pole, seat configuration, and upper-body and trunk strength during sitting throws in athletes with spinal cord injury (SCI).	Wheelchair Rugby, Wheelchair basketball and World Para Athletics / 10 athletes	Seated throwing and strength tests.	kinematic analysis; Grip Strength; Dynamometer.	3D kinematic data were collected (150 Hz) for both conditions using standardized and self-selected seat configurations. Dominant and nondominant grip strength were measured using a dynamometer, and upper-body and trunk strength was measured using isometric contractions against a load cell.	The athletes performed better when they used an assistive pole. The seat configuration had no influence on performance. Grip strength measures were significantly correlated with the speed of the throw. These results contribute to the investigation of the evidence-based classification.
(Altmann et al., 2016)	Assess the impact of trunk impairment, using the Trunk Impairment Classification (TIC) on performance.	Wheelchair rugby / 55 athletes: - 21 with TIC score 0. -13 with TIC score 0.5. - 11 with TIC score 1.0. -10 with TIC score 1.5.	10 m sprint test, Turn test. Tilt test. Maximal initial acceleration test. Hitting test.	Infrared sensors; A sensor (AMR Sports).	10 m sprint test: time to perform the test [s]. Turn test: time to cover the 10 m distance [s]. Tilt test: tilt height [mm]. Maximal initial acceleration test [m/s^2]. Hitting test: Distance [m] needed to reach a difference of 81 cm between athletes per TIC score; and, sprint momentum [kg*m/s].	The study demonstrated that trunk impairment has an impact on acceleration in the first 2 meters, so we can infer that athletes with limited trunk impairment are more proficient in wheelchair rugby than athletes with severe trunk impairment.

Caption: this table presents the main information of the articles that were selected for this review.

Table 1 (Continuation)
Data extracted from the eligible studies regarding evidence-based classification in wheelchair sports.

Study	Purpose	Para Sport /Sample	Evaluation of the Test	Quantification Tools	Quantified Variables	Main results for classification
(Santos et al., 2017)	They evaluated the influence of the classification of rugby in a wheelchair (WR) and the competitive level in the function of the trunk using seated stability limits (LoS).	Wheelchair rugby / 28 athletes divided into three groups according to national or international competition following IWRF categories: a low-point group, comprising 0.5–1.5-point players, *N* = 8; a mid-point group, with 2.0–2.5-point players, N = 14; and a high-point group, with 3.0–3.5-point players, N = 6.	Participants had to sit down on a wooden block, leaning and stretching their bodies as widely as possible towards eight pre-defined directions. Research arranged all eight directions in a diamond shape, separating them by 45-dregree intervals.	Force platform.	Seated limits of stability (LoS) were computed as the area of ellipse adjusted to maximal CoP excursion achieved in each one of the eight directions.	High point players had a higher limit of seated stability (LoS) when compared to low point players. LoS can be a valid form of assessment for trunk impairment, which contributes to evidence-based classification.
(Connick et al., 2017)	Validate isometric strength tests and analyze whether strength measures can be used to classify athletes.	Wheelchair-Racing / 32 athletes	Maximum Isometric strength tests: arm extension (right and left), combined arm extension + trunk flexion, isolated trunk flexion combined forearm pronation with grip strength (right and left). Wheelchair racing performance	S-type load cell; Musclelab unit; Video camera; Dartfish Prosuite; T-dynamometer; Laser devices.	Isometric strength tests: peak force Racing performance: maximum speed (0–15 m) (m/s), maximum speed (absolute) (m/s).	All six strength tests correlated with performance (r = 0.54-0.88). Through cluster analysis, 4 classes were identified and for 6 athletes the allocation differed from their current class, classes T53 and T54 had no significant differences in any of the performance results. This demonstrates that perhaps the class system adopted for this sport needs to be revised. These results contribute to the classification based on evidence of wheelchair racing.

Caption: this table presents the main information of the articles that were selected for this review.

Tabla 1 (Continuation)
Data extracted from the eligible studies regarding evidence-based classification in wheelchair sports.

Study	Purpose	Para Sport /Sample	Evaluation of the Test	Quantification Tools	Quantified Variables	Main results for classification
(Squair et al., 2017)	Establish an ideal autonomic test protocol to predict cardiovascular capacity during wheelchair rugby competition.	Wheelchair Rugby / 26 athletes.	Neurological level and completeness of injury. Autonomic completeness of injury. Resting hemodynamic. Orthostatic challenge test. Cold-pressor test. In-competition exercise performance.	International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI); Sympathetic skin responses (SSRs) electrodes one-lead electrocardiography; Automated BP cuff.	Motor scores for upper and lower limbs (on a scale of 0-5). Sympathetic skin responses (on a scale of 0-2). Measure SSRs of median nerve stimulation. Resting hemodynamic (HR, SBP). Orthostatic intolerance. Cold-pressor test = changes in BP and HR with temperature change. Peak HR during competition	Changes in PAS during the orthostatic challenge test and foot and hand TCP correlated significantly with cardiovascular response in competition. The results demonstrate the importance of incorporating cardiovascular capacity assessments in the classification to ensure more equitable competitions.
(Altmann et al., 2017)	Evaluate the relationship between impaired trunk strength and performance in Wheelchair Rugby through the concept of "natural classes".	Wheelchair Rugby and wheelchair basketball / 27 athletes	Maximum isometric trunk muscle strength test (three directions: forward, to the left and to the right). Activity limitation: tilt test (lifting the non Fixed wheel from the floor by using their legs), and trunk acceleration test (perform maximum acceleration, maintaining speed for 3 to 5 m and then decelerate)	Load cell; Cheetah LMT.	Maximum isometric trunk muscle strength test: mean isometric force (N). Tilt test: The height of the tilt (difference between H1 and H0 [mm]). Acceleration test: Displacement of the wheelchair (m) and time (s).	The inclination height had significant correlations with the left force, right force, frontal force and acceleration. The cluster analysis demonstrated that at least one cutoff point in performance, supporting the concept of "natural classes". The Strength of the trunk plays a fundamental role in the classification of this sport.

Caption: this table presents the main information of the articles that were selected for this review.

Tabla 1 (Continuation)
Data extracted from the eligible studies regarding evidence-based classification in wheelchair sports.

Study	Purpose	Para Sport /Sample	Evaluation of the Test	Quantification Tools	Quantified Variables	Main results for classification
(Van der Slikke et al., 2018)	Evaluating whether measurements with inertial sensors could offer an alternative point of view for classification.	Wheelchair Basketball / 76 athletes	First group: match. Second group: standardized field test.	Inertial sensors.	Six key outcomes of wheelchair performance: Average speed (m/s). Average best speed (m/s). Average acceleration (m/s^2). Average rotational speed (m/s^2). Average best rotational speed (°/s). Average rotational acceleration (°/s)	Low class athletes showed lower performance results when compared to middle class athletes, however there were no differences between middle class athletes and high class athletes. The Two Step Statistical Method revealed two clusters, one of low class and another of middle / high class, the most important predictors of the model being the results of the forward movement. These results demonstrate the possibility of revising the basketball classes.
(Mason et al., 2020)	Validate and test the reliability of a battery of uniarticular isometric strength tests, for the evidence-based classification in wheelchair rugby (WR).	Wheelchair Rugby / 20 athletes (WR) and 30 healthy participants able-bodied (AB)	Seated participants performed a battery of isometric strength tests: shoulder flexion and extension and elbow flexion and extension	S-type load cell; MuscleLab.	Peak isometric force (N)	The battery of tests revealed that there is an increase in flexural strength around the shoulder and elbow. In addition, the test battery achieved good reliability. Thus, the results suggest that the battery of tests can be used to safely infer the impairment of strength in WR athletes. Supporting an evidence-based classification system.
(Van der Slikke et al., 2020)	Apply the Wheelchair Mobility Performance Monitor (WMP) to athletes to identify factors and results that have an impact on classification and performance.	Wheelchair basketball (WB), Wheelchair tennis (WT) and Wheelchair rugby (WR) / 29 WB athletes; 32 WR athletes; 15 WT athletes	The athletes were evaluated during competitive matches in each para sport	Inertial sensors.	Average speed (m/s) Average best speed (m/s) Average acceleration in the first 2 m from standstill (m/s^2) Average rotational speed during a curve (m/s) Average best rotational speed during a turn on the spot (m/s) Average rotational acceleration (m/s^2).	The WB achieved better performance results in the VMP, followed by the WT and finally the WR. In all sports, a substantial amount of time, ~ 10% was spent at reverse speed. Through the results found in this work it was possible to identify that intensity is an important factor for WB training programs, as well as maneuverability for WT and level of disability for WR.

Caption: this table presents the main information of the articles that were selected for this review.

Discussion

Our findings provide information, as follows: 1) most studies mention muscle strength of upper limbs and trunk and mobility performance measures (mainly speed) as main parameters; 2) most studies carry out the following tests: isometric strength tests; tilt tests; sprints; and acceleration; 3) most studies use the following instruments: load cells and dynamometer; video systems; laser device; force platform; and inertial sensors.

Overview of wheelchair sports and the classification system

The para sport evolved in the articles were wheelchair basketball, wheelchair rugby, World Para Athletics and wheelchair tennis. Although these para sports have quite different features, they have similar characteristics within their classification aspects. In general, the classification system of wheelchair sports assesses athletes' trunk, and upper and lower limbs. Wheelchair rugby, wheelchair basketball, and wheelchair tennis evaluate one's lower limb functions as an eligibility criterion: athletes eligible for competition have at least one impairment in their lower limbs that prevents them from playing in stand up position (*IWBF Official Player Classification Manual, 2021; WWR Classification Rules, 2022*). Since there are multiple categories of competition within World Para Athletics, the function of an athlete's lower limbs determines his/her classification. In this sport, athletes do not have to have mandatory lower limb impairment, as in some track competitions athletes with upper limb impairment compete. (*WPA Classification Rules and Regulations, 2018*). Van der Slikke et al. demonstrated in their manuscript a clear relation between functional classification and performance (Van der Slikke et al., 2018). The higher the athlete's class, the better is the performance in tests that assess skill and in match tests. In this sense, the use of these tests during classification process could assist classifiers in decision-making.

Classifications concerning all four abovementioned sports are based on athletes' trunk and upper limbs function. The current classification system of wheelchair rugby—which is practiced by athletes with quadriplegia or those with equivalent physical impairment—consists of seven classes ranging from 0.5 to 3.5 (*WWR Classification Rules, 2022*). The classification system of wheelchair basketball—practiced by athletes with motor or physical impairment—has classes ranging from 1.0 to 4.5 (*IWBF Official Player Classification Manual, 2021*). In World Para Athletics, there are two competition categories: track and field events. Athletes with alterations of their motor coordination may fit into classes of T32-T34 (tracking) and F31-F34 (throwing). Athletes with limb deficiency or changes in their muscle power, may fit into classes T51 -T54 (tracking) and F51-F57 (throwing) (*WPA Classification Rules and Regulations, 2018*). To be eligible for wheelchair tennis, athletes need to have limited mobility. There are two wheelchair tennis classes: Open and Quad (*Wheelchair Tennis Classification Rules, 2019*).

In general, when evaluating the minimum commitment criteria for these sports, we follow the premise that the eligible disability affects the athlete's functions to perform specific tasks and activities fundamental to the sport. Thus, the difference lies in the eligible disabilities determined in each of these sports. In the case of wheelchair basketball, we have impaired muscle power, impaired passive range of movement, limb disability, leg length difference, hypertonia, ataxia, and athetosis. In wheelchair rugby, leg length difference is not considered an eligible disability and the same is true for wheelchair tennis that does not consider leg length difference and limb disability as eligible. In the World Para Athletics, for classes that compete in the wheelchair, we have classes T51-T54: limb disability, impaired passive range of movement, impaired muscle power, and leg length difference; for classes T32-T34 we have hypertonia, athetosis, and ataxia; for classes F31-F34: hypertonia, athetosis, and ataxia, and finally, for classes F51 F57: limb disability, impaired passive range of movement, impaired muscle power, and leg length difference.

A classification system is not simply about verifying who is eligible for competition. It provides a structure that controls and/or mitigates the impact of an athlete's physical impairment on the final results of a competition by establishing adequate classes concerning each sport (Tweedy & Vanlandewijck, 2014).

Evaluated parameters and tests

Several parameters can make classification more precise by enabling evidence-based classification: strength, speed, acceleration, distance covered and angulations—all described in the studies listed above. Tests are necessary to offer objective and reliable measures concerning such parameters.

Studies focused on strength analysis showed that muscle strength (upper limb and trunk) is strongly related to sports performance (Altmann et al., 2016, 2017; Borren et al., 2014; Hyde et al., 2016; Mason et al., 2019). Therefore, it is recommended to assess the existing strength that each individual has and thus infer how much strength has been impaired (Beckman et al., 2017). Thus, both multiarticular isometric tests in joint angles that facilitate maximum strength production (Altmann et al., 2017; Beckman et al., 2017; Mason et al., 2019) and pitch tests (Borren et al., 2014; Hyde et al., 2016) seem appropriate to assess muscle strength. In addition, trunk strength relates to one's ability of performing lateral inclinations and trunk flexion/extension, directly linked to sports classes. Santos et al. (2017) demonstrated how force platforms objectively assess trunk by using data from center of pressure (CoP) and seated limits of stability (LoS) collected through trunk inclination tests in eight different directions. Roldan et al. assessed trunk control in boccia athletes through the BISFEed trunk scale and a posturographic test battery consisting of two static and the dynamic tasks. BISFed TFS was not able to discriminate sports classes; however, posturographic tasks were able to discriminate classes ($p = 0.004$). They concluded that it is necessary to develop new field tests to assess trunk stabilization (Roldan et al., 2020).

In the same way, speed (variation of position in space in relation to time) is closely linked to acceleration (rate of change of an object's speed over time) and both relate to good performance in sports that require wheelchair moving maintaining maximum speed and ability to respond with acceleration quickly after braking (Goosey-Tolfrey et al., 2012). Tests such as Illinois Agility Test (Rietveld et al., 2019; Usma-Alvarez et al., 2010), 20-meter speed test (De Groot et al., 2012; Rietveld et al., 2019), spider test, and butterfly-sprint test (Rietveld et al., 2019) aim to analyse these variables by measuring an athlete's ability to deliver a task in the shortest time possible (high speed and high acceleration). Squair et al. (2017) proposed cardiovascular capacity tests would be an interesting tool concerning wheelchair rugby. The study observed that a change in systolic blood pressure (SBP) during an orthostatic challenge test was correlated with peak HR in competition. Such finding is truly relevant: cardiovascular functions may be a limiting factor in an aerobically demanding sport such as wheelchair rugby. Including cardiovascular assessments when classifying these athletes may help ensuring a level playing field, avoiding advantages or disadvantages related to poor cardiovascular control. However, despite the importance of this measure, its applicability remains a challenge for EBC because it is difficult to discriminate between cardiovascular capacity and lack of training, and for this reason the use of this measures for EBC deserve further investigation. This parameter is not included in the current classification process of this para sport.

Instruments

It is necessary to emphasize the importance of using equipment that provides reliable measures to target evaluations. This review noted that the main equipment used in wheelchair rugby was force analysis equipment, inertial measurement units, infrared sensors, video systems and force platforms. In wheelchair basketball, it was video systems, inertial measurement units and force analysis equipment. In the World Para Athletics, video analysis and strength analysis equipment and inertial measurement units in wheelchair tennis.

Researchers use video-based systems (both in 2D or 3D) for biomechanical analysis. Image resolution, temporal resolution, and frame rate per second are characteristics a researchers needs to consider when analysing video. Frame rates ≥ 120 Hz, for example, provide images that are rich in details and enable carrying out motion analysis (Souza, 2016). In wheelchair sports, Borren et al. (2014) used video to analyse throwing techniques and trajectories. The authors identified that athletes with lower sport class obtained lower results of speed and throwing distance when compared with higher sport class. These results indicate that throwing speed and distance are related to an athletes' functionality. Hyde et al. (2016) also used video to analyse throwing. The researchers used a video system to quantify the influence of both seat configuration and the use of an auxiliary pole. Through video analysis, the authors assessed throwing speed and identified that shooting with an auxiliary pole resulted in significantly higher hand speed than shooting without a pole and that there was no significant difference in hand speed in release between standard and self-selected seat configurations during seated throwing with or without an auxiliary pole. Throwing speed is linked to sports performance and impairment, quantifying such parameter as an evaluation measure may help classification

decision-making. The study also used video as auxiliary equipment for positioning an athlete's trunk and receiving real-time feedback (Connick et al., 2017). Video-based systems carry out not only pitch analysis, but also analysis of speed, acceleration, and distance a wheelchair covers. Corroborating such scope, Connick et al. (2017) used laser to measure wheelchair speed.

Research uses equipment such as load cells (devices that measure force by converting the charge acting on it into a measurable electrical output) and dynamometers (a device that measures the force through the deformation of a spring that suffers due to the action of a force applied to it, so the intensity is indicated in the graduation existing in the structure) to assess muscle strength. The cells are tension gauges that capture force electronically, amplifying and recording it in newtons. Such devices are sensible for assessing trunk and upper limbs strength in isometric strength tests (Stark et al., 2011; Steeves et al., 2019). Isokinetic dynamometers are computerized machines which are considered the gold standard in muscle strength evaluation, including peak strength, endurance, power, maximum force angle. However, they are not accessible equipment given their high price and difficult mobility. The digital manual dynamometer rises as an alternative. A hand dynamometer suffers from the force of the handgrip, measuring the intensity of this force digitally in newtons and hand grip strength is linked to the total strength of an individual. It is used to measure isometric torque and has a good correlation with the reference method (Stark et al., 2011).

The inertial measurement unit (IMU) is a device in which the signals from an accelerometer, a gyroscope and, in some cases, a magnetometer, are fused and used in movement analyses (Kianifar et al., 2019; Toft Nielsen et al., 2018). Van der Slikke et al. (2018) evaluated whether inertial sensors could offer alternative measures for classification in wheelchair basketball. By using wheelchair speed and acceleration measures, the study verified that athletes with high sport class (class 4.0-4.5) delivered better performance results when compared with athletes with lower sport class (class 1.0-1.5). In addition, authors identified that athletes with middle sport class (class 2.0-3.0) delivered similar performance results if compared with high-level athletes. This indicates that athletes with middle sport class could be incorporated into upper classes, suggesting that some wheelchair basketball classes that currently exist would cease if the classification process were based on deeper efficient studies. Van der Slikke et al. (2020) also used inertial sensors to investigate which are the most important aspects concerning wheelchair mobility performance (WMP) for each sport. These authors identified that wheelchair basketball is the sport that requires the highest performance intensity, whereas in wheelchair tennis manoeuvrability is a key performance factor. In rugby, researchers have identified that WMP is related to the athlete's level of physical/motor impairment. Such results could be used directly incorporated in classification and training guidelines, bringing more emphasis on intensity matters for wheelchair basketball, focussing on manoeuvrability for wheelchair tennis, and impairment-level based training programs for wheelchair rugby. In addition, the authors emphasized the importance of using these sensors in future classifications. Through measures such as acceleration, speed, and trunk oscillation, one can obtain evaluation parameters that can be incorporated into the classification system.

Research also uses force platforms to obtain objective measures of balance. Such measures are based on the displacement of one's pressure center, that is, the point of application of vertical forces acting on a support base (Harro & Garascia, 2019). Santos et al. (2017) evaluated whether wheelchair rugby classification and competitive level influence the trunk function of athletes with physical impairment, concerning seated limits-of-stability (LoS) through center of pressure (CoP), which the study analysed through tilt test of trunk in 8 different directions. The research identified that LoS were greater in athletes with high sport class (3.0-3.5) compared with athletes with low sport class (0.5-1.5). Thus, LoS may be a valid assessment of trunk impairment, potentially contributing to the development of an evidence-based classification for wheelchair rugby.

The instruments described above provide measurements that are useful for generating patterns of movement and allow analyses to have a reduced risk of error. Machine learning may assist such process by reporting movement patterns and generating prediction equations based on such patterns (Heo et al., 2019). However, the first step to be taken in this direction is properly collecting data and correctly interpreting them within biomechanics and movement analysis to extract important parameters for

each para sport. The challenge is making classification increasingly technological, what requires resources and professional training so that classifiers can efficiently use assessment equipment.

Challenges to implement an evidence-based classification system

The path to make a more technological classification comes up against many factors, such as financial investment and professional training. The implementation of instruments during the classification process or even for carrying out surveys would entail a lot of expense due to the purchase of such equipment, the professional training of classification officers and, in addition, all of this would take time. However, the significant value of these changes would justify the expense and there are alternatives, such as partnering with universities and research centers (as the IPC is already doing, basing its code updates on research carried out at large universities).

As future recommendations, this study provides a vision of a future in which it will be possible to use technological instruments throughout the classification process and tests that can provide reliable and objective measures, such as those presented here above, can be used.

EBC: Isolated tests or during match play?

As we have seen throughout the study, the classification of wheelchair sports moves towards the use of empirical evidence to support the choice of athletes' classes. This evidence directs us to the use of tests, whether isolated or field tests (skill or performance tests that are given on the court or the field, such as the Illinois Test and the 20-meter speed test) and match tests (tests that simulate competitive matches), in addition to the possibility of using technology to help in the decision. In this perspective, when we analyze isolated tests such as manual strength tests and range of motion assessments, they evaluate specific (isolated) domains that, when united, will form a set of information that guides the classifier in its decision-making. This feature is interesting for assessing eligibility for the sport and perhaps as a differentiating criterion when there are doubts. Skills tests and match tests, on the other hand, provide us with information regarding the athlete's performance, which we have already seen is closely linked to the functional class. These tests would be interesting to classify athletes; however, there are points to be considered. Athletes with more practice time compared to athletes with less time but who are in the same class could present different performances, which would confuse at the time of classification. Therefore, the combination of isolated tests and tests of skills and match tests seems to be an appropriate way forward. In addition, portable technologies are of great help during these tests.

Perspectives

This topic is relevant and current and this systematic review presents and discusses several tests and instruments that can be used in the evidence-based classification of wheelchair sports. In this sense, this study presents a path for the practical application of these resources—and possible barriers to their implementation—. It can be used by researchers to generate new studies and also by professionals who deal more closely with the classification of athletes in different sports.

Conclusion

This study shows the important role technology has within the classification process based on evidence. Using instruments, we can access objective measures of the parameters evaluated in the classification process and validate simple tests that can be applied in classification guidelines. In addition, studies indicate that a technological approach has been increasing in wheelchair sports classification. The measurements collected with the aforementioned instruments can guide and assist research during the classification process, mitigating human error. Training classifiers is also essential to bring reliable outcomes to the process. Over time, the inclusion of adequate technology within the classification process will take sports competitions to a new level. The delimitation of clear parameters, with a lower risk of errors, will bring greater clarity to athletes and will benefit them to develop better in their respective classes.

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Optimising Motor Coordination in Physical Education, an Observational Study

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Abstract

One of the challenges of Physical Education during compulsory education in primary and secondary school is guaranteeing students' motor development, and coordination is a fundamental element. The aim of the research was to identify the improvement of motor coordination patterns in a selection of students finishing primary education, following a programme of stimulation and progressive intervention based on pedagogical strategies over 41 sessions of Physical Education. This intervention was implemented during three terms of the school year with 25 participants aged 12 (± 1) from one school. The systematic observational study with a Mixed Methods convergent design approach integrated: the exhaustive observations of the motor behaviours of the whole group-class from the 41 sessions, and the timely administration of the 3JS test to assess the coordinative development of each of the participants. A motor coordination observation system (COS) was constructed and validated to detect the temporal patterns (T-patterns) of coordinative behaviours recorded using the free LINCE PLUS software and analysed with Theme software. The 3JS test was administered at the beginning and at the end of the didactic intervention. The results reveal differences between the T-patterns before and after the pedagogical intervention, the latter being richer and more diverse, as the coordinative motor elements appeared more frequently and at a higher coordinative level, coinciding with the results of the 3JS test.

Keywords: coordination skills, educational research, Mixed Methods convergent design, motor development, observational methodology.

Introduction

Physical Education requires the integration of diversified, organised and programmed motor experiences, through which the neuronal development of the brain is stimulated (Bássoli et al., 2021). It also facilitates the whole learning process and the attainment of other skills or knowledge from any other area or subject that may extend beyond the subject of Physical Education itself (Padial et al., 2022). At the same time, as indicated by the WHO (2020), physical inactivity is associated with low levels of motor competence (Jarani et al., 2016; Valero-Valenzuela et al., 2020), thereby creating a negative feedback cycle in which low motor competence predisposes to even lower levels of physical activity (Henrique et al., 2020; Sentalin et al., 2019). Thus, education in movement and by movement promotes a change in this context of sedentary lifestyles, unhealthy diets and the tendency for constant stress that generate imbalances in the ontogenetic development of individuals (Engel et al., 2018), as indicated by Castañer and Camerino (2022) in the Dynamic and Integrated Approach to Motricity (EDIM). All habits that result in children and adolescents becoming overweight and obese are modifiable and can be changed (Romeo, 2018; Kari et al., 2016). In this context, therefore, Physical Education must become a curricular space where students can integrate and internalise cognitively stimulating physical activity habits, the fundamental axis being movement.

The development of motor coordination is a key content in Physical Education interventions that seek to promote the integral development of students in the developmental stages (Bravo et al., 2017; Lopes et al., 2012), as well as to guarantee adherence and motor autonomy in adulthood (Puigarnau et al., 2016). The development of this capacity is fundamental in the process of physical, motor and cognitive maturation at pubertal ages (Coetze 2016; Walhain et al., 2016).

Although it is difficult to find a single definition for the concept of motor coordination (Angulo et al., 2011), it can be understood as "the ability to regulate the intervention of one's own body in the execution of any motor skill in a precise and effective manner" (Castañer & Camerino, 2022, p. 81). Thus, coordination enables the integration of all sensory and sensorial motor elements in order to facilitate the organisation and regulation of the motor actions necessary to perform a motor task with precision, economy, harmony and efficiency (Castañer & Camerino, 2022), as part of a process of interaction between the person and the environment (Lladó, 2017). According to Rosa et al. (2020), motor coordination is the set of perceptual-kinetic abilities that enable the organisation, regulation and execution of motor and sensory processes associated with certain motor actions with a specific objective. Delignières et al. (2009) define coordination as the spatio-temporal relationships that exist between different body parts during the performance of a task.

Complementarily, the concepts of learning and coordination are closely linked, since when a learner is confronted for the first time with a new motor situation they will have to activate their coordination skills in order to respond to that task or problem (Herlitz et al., 2020). It is through this spontaneous set of motor tasks which must be mastered that their motor coordination is built up.

Coordination can also be understood as the capacity that "allows the body to detect the position and movement of its structures, especially those that make up the musculoskeletal apparatus" (García et al., 2011, pp. 42-43). In this case, the concept of coordination is related to the concept of proprioception, which comes from the Latin root *propius* (own) and the Latin word *perceptio* (ability to capture or perceive). In fact, according to Sánchez-Lastra et al. (2019), proprioception training is found to be effective in improving coordination level.

During the periods prior to puberty, students are in a phase in which coordination work is especially important for conditioning and positively influencing motor development (Chacón-Cuberos, 2020; Castañer et al., 2018; Hirtz & Starosta, 2002). Therefore, it is of interest to take advantage of this developmental stage of students in order to provide them with diverse motor experiences with the aim of ensuring a development that allows them to acquire a range of motor execution and, consequently, to develop their coordination (Sánchez-Lastra et al., 2019).

The aim of the research was to identify the improvement of motor coordination patterns of students finishing primary education following a progressive intervention based on pedagogical strategies over 41 sessions of Physical Education in a school.

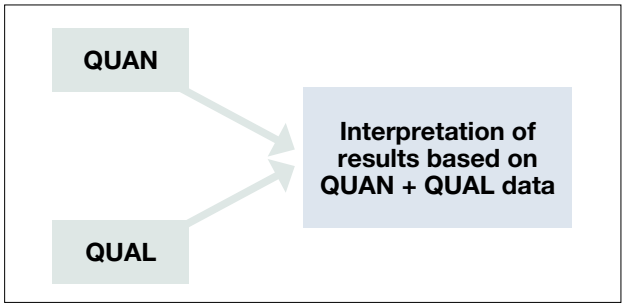
Methodology

The Systematic Observational Methodology (Anguera et al., 2017) was applied, as it is the most appropriate methodology for analysing behavioural and interactive development during the implementation of intervention programmes. This methodology enables spontaneous behaviour to be captured in the natural context of the session by means of an observation instrument (Anguera et al., 2011; 2012) that has been validated and constructed ad hoc and which enables a systematic record to be kept throughout the temporal continuity of the intervention programme (Amatria et al., 2019; Castañer et al., 2011; 2016; 2020; Fernández-Hermógenes et al., 2017; Flores & Anguera, 2018).

Design

The present research was carried out using a Mixed Methods convergent design (fig. 1) (Anguera et al., 2012; Camerino et al., 2012) in order to strengthen the interpretation of the results obtained, as it combines: a) the qualitative data from the temporal patterns (T-patterns) obtained from the systematic observation throughout the intervention, and b) the quantitative data from the application of the motor test (3JS), which assessed motor coordination before and after the intervention.

Figure 1
Mixed Methods convergent design (Anguera et al., 2012; Camerino et al., 2012).



Participants

In order to ensure that intensiveness prevailed over the extensiveness (Anguera & Hernández, 2015) that the systematic observational methodology offers, it was decided to observe in detail all the motor actions that the participants carried out throughout all the sessions of the intervention (41 sessions observed). The sample consisted of 21 participants, 11 females and 10 males, aged 12 (± 1) and, in accordance with Decree 119/2015, of 23 June, on the organisation of primary education, they were in the 5th year of Primary Education in a state-funded school in the district of the city of Barcelona. Permission was obtained from the school and the families at the educational centre along with informed consent for participation in the study, and a certificate from the Clinical Research Ethics Committee of the sports administration of Catalonia (020/CEICGC/2021).

Resources

Observation instrument

The observation instrument, the Coordination Observation System (COS), was designed and validated by three experts in methodology and motor skills, and is applicable to the real and natural context of Physical Education (Anguera & Hernández-Mendo, 2015). It is a system based on the Observational System of Motor Skills (OSMOS) (Castañer et al., 2020) and on the OSMOSTI (Observational System of Motor Skills, Space, Time and Interaction) (Castañer et al., 2020) for motor skills and the use of space and time (Castañer et al., 2020). As shown in Table 1, the COS is made up of five broad criteria (motor skill, motor coordination, height level of the space, location in space and pause of inactivity), displaying a total of 12 categories. The motor skill criterion provides four categories depending on the type of movement being performed; the coordination criterion allows identification of how the motor skill of the previous criterion is being performed; the level of space criterion refers to the place where the motor skill is performed from a vertical perspective; the location in space criterion allows identification of the point on the court or pitch where the motor skill is performed (horizontal perspective); and finally, the inactivity pause criterion refers to the lack of performance of a given motor skill.

Table 1
Motor Coordination System (COS).

Criterion	Category systems	Description
Motor skill	Motor locomotion (LOC).	Motor skills that allow the body to move from one point in space to another.
	Motor stability (STA).	Motor skills that allow the body to maintain balance without motor locomotion.
	Motor manipulation (MAN).	Motor skills that allow for receiving, throwing, striking or driving/holding an object or body.
	Combination (COM).	Combination of the above motor skills.
Coordination	Precision (PRE).	Correct calculation of distance and space.
	Efficiency (EFF).	The end result/motor objective is achieved.
	Synergies (SYN).	Only the required muscular energy is expended and no unnecessary movements are made.
Height level of the space	Aerial (AER).	The motor skill is done in the air, without the body being supported.
	Terrestrial (TER).	The motor skill is done on the ground.
Location in space	Central (CEN).	The task is performed in the central area of the space where the core of the tactical action of the activity takes place.
	Peripheral (PER).	The task is performed in the distal part of the centre of the court.
Inactivity pause	Pause (PAU).	Moment of inactivity as a result of a voluntary stoppage, which is not related to the dynamics or operation of the activity.

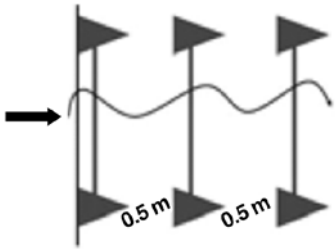
3JS motor test

In order to quantify the participants' coordination level, the 3JS test (Cenizo et al., 2016; 2017) was used, which is aimed at assessing the participants' motor coordination level based on the performance of 7 tasks. It is apparently a qualitative test, as its design provides a series of tasks that can be graded according to the level of performance. The assessment criteria for each test are qualitative, since in each test there is a gradation of four possible performance levels; however, the result obtained from the test is quantitative, since scores are obtained.

Figure 2
3JS tests (Cenizo et al., 2017).

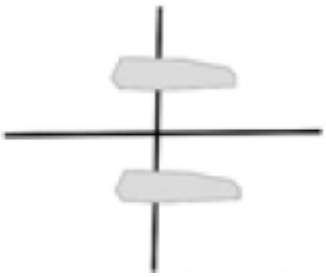
Test 1.-Jump with both feet together on the poles positioned at a height

- 1 point. Do not push off with both legs simultaneously. Do not flex the torso.
- 2 points. Flex the torso and push off with both legs. Do not land on both feet simultaneously.
- 3 points. Push off and fall with both feet but do not coordinate simultaneous extension of arms and legs.
- 4 points. Push off and land with both feet simultaneously, coordinating arms and legs.



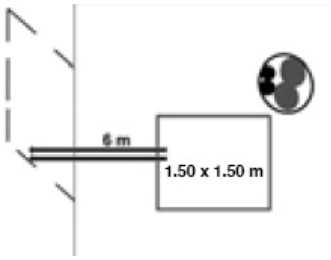
Test 2.-Turn

- 1 point. Turn between 1 and 90º
- 2 points. Turn between 91 and 180º
- 3 points. Turn between 181 and 270º
- 4 points. Turn between 271 and 360º



Test 3.-Throw two balls at a goalpost from a distance, without leaving the box.

- 1 point. The torso does not rotate laterally at the shoulder and the throwing arm is not brought backwards.
- 2 points. There is little elbow movement and there is external rotation of the shoulder joint.
- 3 points. Arm raised and the object is brought to the back of the head.
- 4 points. Coordinate a fluid movement of the legs and torso to the wrist of the opposite arm to the forward leg.



Test 4.-Hit two balls at a goalpost from a distance, without leaving the box.

- 1 point. Do not place the supporting leg next to the ball. There is no flexion and extension of the knee of the striking leg.
- 2 points. Do not place the supporting leg next to the ball and strike with a leg and foot movement.
- 3 points. Balance on the supporting leg by placing it next to the ball. Swing the striking leg with a sequence of hip, leg and foot movements.
- 4 points. Balance on the supporting leg and swing the leg in one stroke, following a sequence of movement from the torso to the hip, thigh and foot.

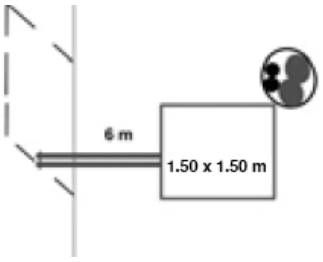
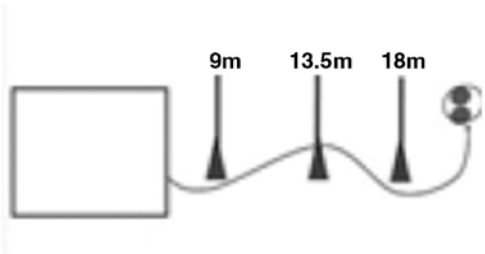


Figure 2 (Continued)
3JS tests (Cenizo et al., 2017).

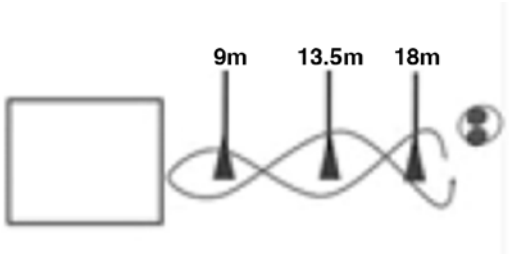
Test 5.-Cone drills

- 1 point. The legs are stiff and the gait is uneven. Very reduced aerial phase.
- 2 points. Shock and swing phases are distinguished, but with limited swing movement (no elbow flexion).
- 3 points. Brachiation and elbow flexion. The arm movements do not facilitate the fluidity of movement around the brackets (the frequency of braking is not the same as that of the brackets).
- 4 points. Coordinate arms and legs while running and adapt to the set course by changing direction correctly.



Test 6.-Bounce a basketball back and forth over a simple cone and change direction around a pike/pivot.

- 1 point. Need ball grip to give continuity to the bounce.
- 2 points. There is no homogeneity in the height of the bounce or the ball is hit (no accompanying contact with the ball).
- 3 points. Flexion and extension of the elbow and wrist are used to execute the bounce. Uses only hand/arm.
- 4 points. Correctly co-ordinate the bounce using the most appropriate hand/arm for cone displacement. Properly uses both hands/arms.



Test 7.-Driving a ball back and forth with the foot over a simple cone.

- 1 point. Need to catch the ball with the hand to give continuity to the drive.
- 2 points. There is no homogeneity in the power of the strike. Differences are observed in the distance the ball travels after each strike.
- 3 points. Uses one leg to constantly controls the ball, using the most appropriate contact surface and adjusting the power of the strikes.
- 4 points. Consistently controls the ball, using the most appropriate leg and the most opportune surface. Adjusts the power of shots and keeps eyes on the course (not on the ball).

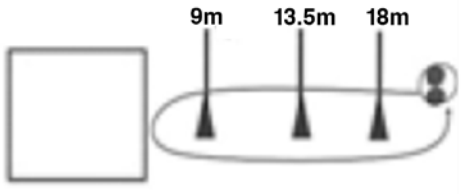
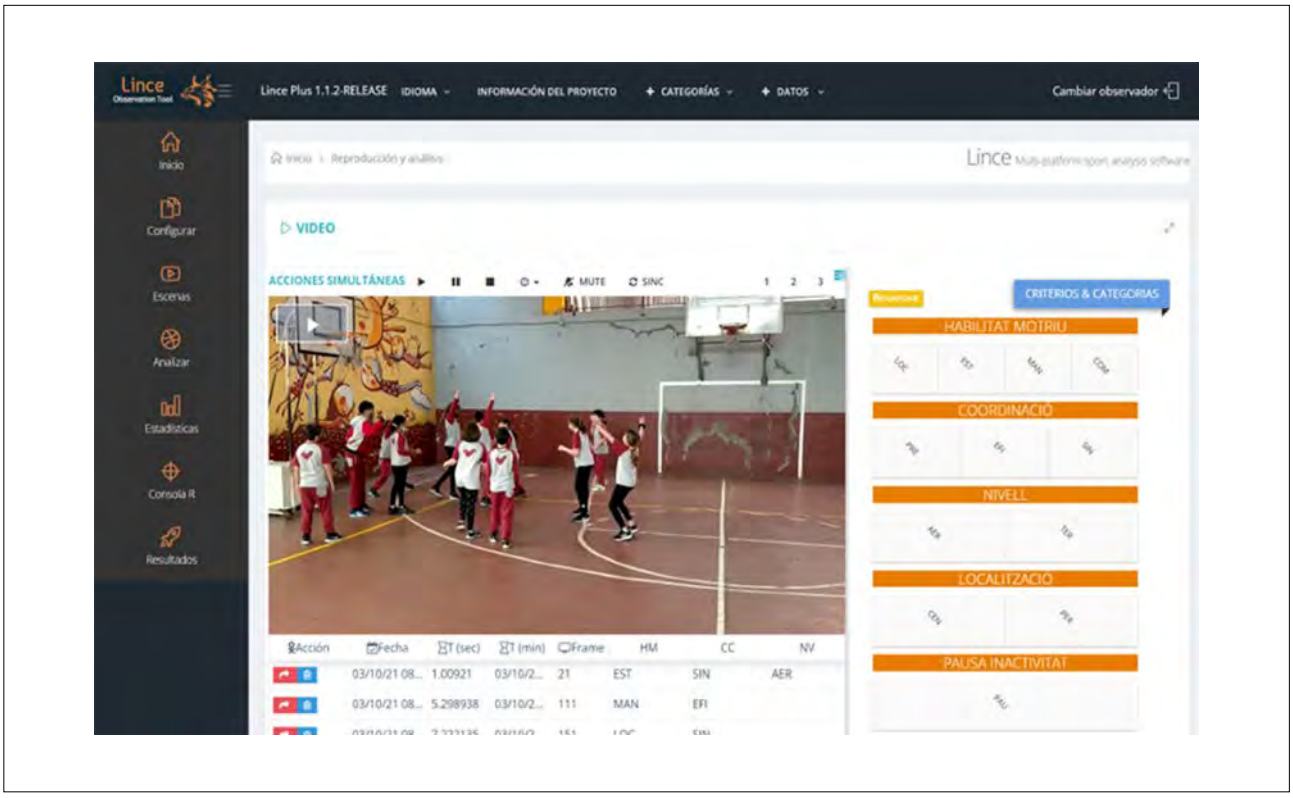


Figure 3
Free LINCE PLUS software (Soto et al., 2022).



Recording instrument

The motor behaviours to be observed within the PE sessions were recorded and coded using the free LINCE PLUS software (fig. 3) (Soto et al., 2022), which facilitates the display of the recorded images from the sessions in order to code them and obtain the data quality by calculating the concordance through intra- and inter-observer reliability.

Procedure

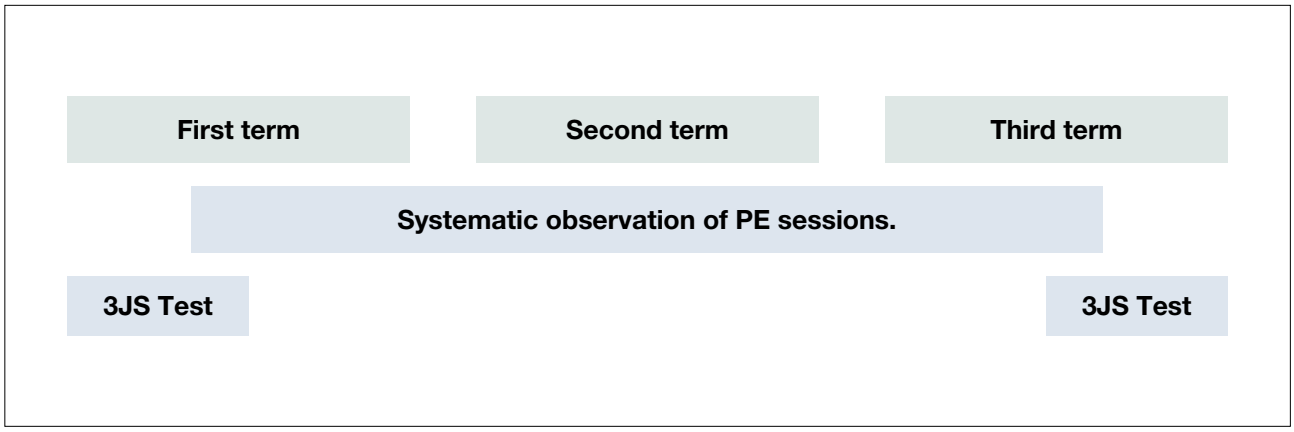
After obtaining the certificate from the Ethics Committee and the informed consent, the didactic intervention was carried out, consisting of 41 Physical Education sessions in different contexts, with a recreational, playful or competitive focus depending on the nature of the session. The programme consisted of a total of 6 didactic units that introduced didactic approaches to locomotor and manipulative skills. It began with a unit in which several traditional games from Catalonia and pre-sports games (Monguillot et al., 2015) were worked on in order to diversify the motor situations and experiences posed by modifying rules, spaces, structures, equipment and materials.

The second unit focused on the area of corporal expression, practising popular and traditional dances and introducing increasingly complex expressive activities with a greater simultaneity of motor actions. The third unit focused on developing basic motor skills using a sporting discipline capable of encompassing them as a whole: athletics. The fourth unit focused on developing the basic motor skills associated with team sports played with equipment: hockey. At the motor level, the importance of introducing this sport into the subject was precisely the fact that it is played with equipment —a stick—. The activities that were introduced were very diverse, both in terms of game dynamics and material, and many tasks were decontextualised, distancing them from the real sport form and, moreover, worked on through play.

As for the fifth didactic unit, this dealt with laterality, body schema and general coordination, ensuring that students worked with body ambidextricism throughout the sessions, regardless of their dominance or preference. The aim, therefore, was not to modify their motor dominance with respect to the transversal axis, but to stimulate the students cognitively.

Finally, the last and sixth didactic unit focused, once again, on a sport: basketball. The sporting activity itself was greatly distorted in order to focus on the development of hand-eye coordination and motor manipulation by introducing balls other than basketballs in order to experience various sensations (bouncing, for example), modifying rules and spaces when planning activities played or reducing sensory capacity in some activities (covering an eye, tying a hand, going on one leg...).

Figure 4
Temporalisation of the research.



The systematic observation was made from the video recording of a specific activity from the session, rather than the entire session, in order to code it with TRONCO using the free LINCE PLUS software (Soto et al., 2022), with which the Cohen's kappa coefficient (K) for intraobserver reliability was also analysed and a value of .91 was obtained.

The 3JS test was administered in a timely manner at the beginning and end of the course, coinciding with the beginning and end of the intervention. On both occasions, the material for each of the 7 tests was prepared and the participants took each of them one by one in the order indicated by the test authors. Figure 4 shows the time distribution of the instruments.

Statistical Analysis

The participants' behaviour during Physical Education sessions throughout the school year was analysed, as well as their development according to the detection of temporary motor patterns. The motor behaviours from the COS categories were recorded using the free LINCE PLUS software (Soto et al., 2022) and analysed using Theme (Magnusson et al., 2016). The 3JS test data were analysed by comparing the results obtained before and after the intervention. Only the data for the first and third term are presented here in order to capture the substantial changes in motor responses. The results of the test at the beginning and end of the intervention were entered into Excel, which facilitated this comparison of the results of the first and third term.

Results

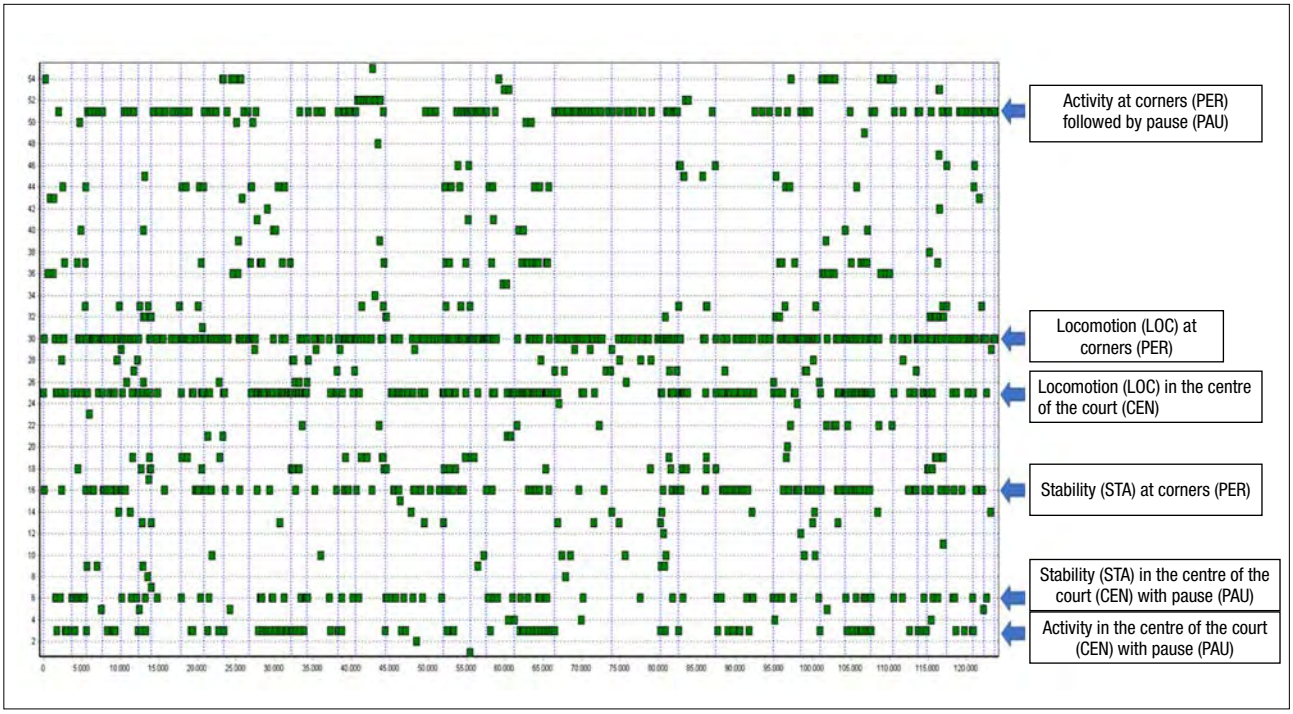
Results of systematic observation

The results of the systematic observation which enable the demonstration of the motor patterns in the first and third term are presented in two types of figures: a) plots (figures 5 and 7), where each point illustrates the dynamics of the coordinative motor behaviours within the time frame of each term and whose significance is indicated in a box next to the figure; b) T-patterns obtained, which figures 6 and 8 illustrate in the form of dendrograms or tree graphs, which indicate the most relevant motor patterns throughout the didactic intervention.

First term results.

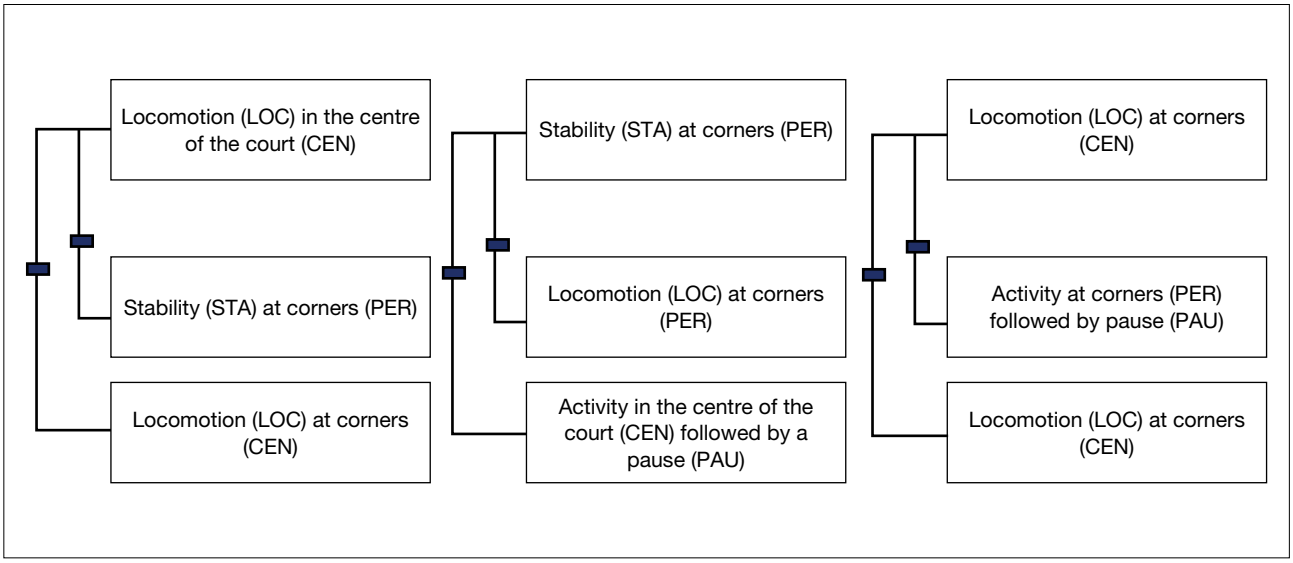
In the plot corresponding to the first two teaching units of the first term (fig. 5), the temporal distribution of the motor-coordination behaviours can be observed. The most relevant of these are set out below, with the codes for each behaviour indicated in brackets, as well as their frequency. Thus, the following was detected: (i) in row number 3, a high concentration of coordinative behaviours corresponding to motor activity in the centre of the court (cen) with a pause (pau) (80); (ii) in row 6, the same frequency of stability (sta) behaviours is also detected in the centre of the court (cen) followed by a pause (pau) (80); iii) in row 16, a considerable number (106) of stability (sta) actions are observed around the periphery of the court (per); v) in rows 25 and 30, a lot of locomotion (loc) can be seen both in the centre (cen) (175) and in the periphery of the court (per), at a very high frequency (243); v) and finally, in row 51 a lot of activity (113) in the periphery (per) can be observed but followed by a pause (pau).

Figure 5
First term Even Time Plots.



These results are reaffirmed by the 3 T-patterns in figure 6 from the first term, where it can be seen that there is a direct relationship between the two motor skills: locomotion and stability (fig. 6). The first demonstrates how a locomotion in the centre of the court produced a stability in the periphery that, in most cases, continued with a new motor locomotion. The second demonstrates how, from a stability in the periphery, a motor locomotion was produced at the same point of the court, sometimes involving a motor pause in the centre. Thus, once again, a new relationship was established between locomotion ability and stability. Finally, the third T-pattern demonstrates how a motor locomotion in the centre was followed by a pause in the periphery, sometimes followed by a new locomotion in the periphery. In the latter case, it is the pause that separated two locomotions, and not stability or equilibrium.

Figure 6
First term T-patterns.



Final term results

In all of the third term sessions, it was observed that there was a high concentration of coordination behaviours corresponding to a wider combination of motor skills, which appeared more frequently as the didactic intervention progressed. These results are reaffirmed by the plot (fig. 7), in which a temporal distribution of the following coordinative motor actions can be observed with the following distribution: (a) in row number 14 it is possible to see combinations (com) of efficient (eff) and synergistic (syn) behaviours; (26); (b) in row 20 there appear a large number of stability (sta) behaviours that are efficient (eff) in the centre (cen) and in the periphery of the court (per) (85); (c) in row 35 the efficient (eff) locomotions (loc) in the centre (cen) and in the periphery of the court (per) can be seen (90); (d) in row 42 the above locomotions (loc) appear at the same location in the centre (cen) and at the periphery of the court (per) (57) but synergistically (syn); (e) in rows 47 and 50 there appear efficient (eff) manipulations (man), some on the ground in the periphery (per) and in the centre (cen) (55), others only in the periphery (per) and in the centre (cen) (30) and the last ones synergistically (syn) and in the centre of the court (cen) (38).

The T-patterns observed in the third term were more complex. Thus, figure 8 shows how an effective manipulation in the centre of the court was followed by an equally effective stability in the court centre, which sometimes ended with an equally effective manipulation in the same space of the court. A second T-pattern detected, which was relevant because of this repeatability and linkage between the different elements that comprise it, initiated the action through an effective manipulation in the centre of the court that was followed by a combination of varied and effective motor skills in the court centre and that, on occasions, ended with a new effective manipulation in the centre of the court.

Figure 7
Plots for the third term.

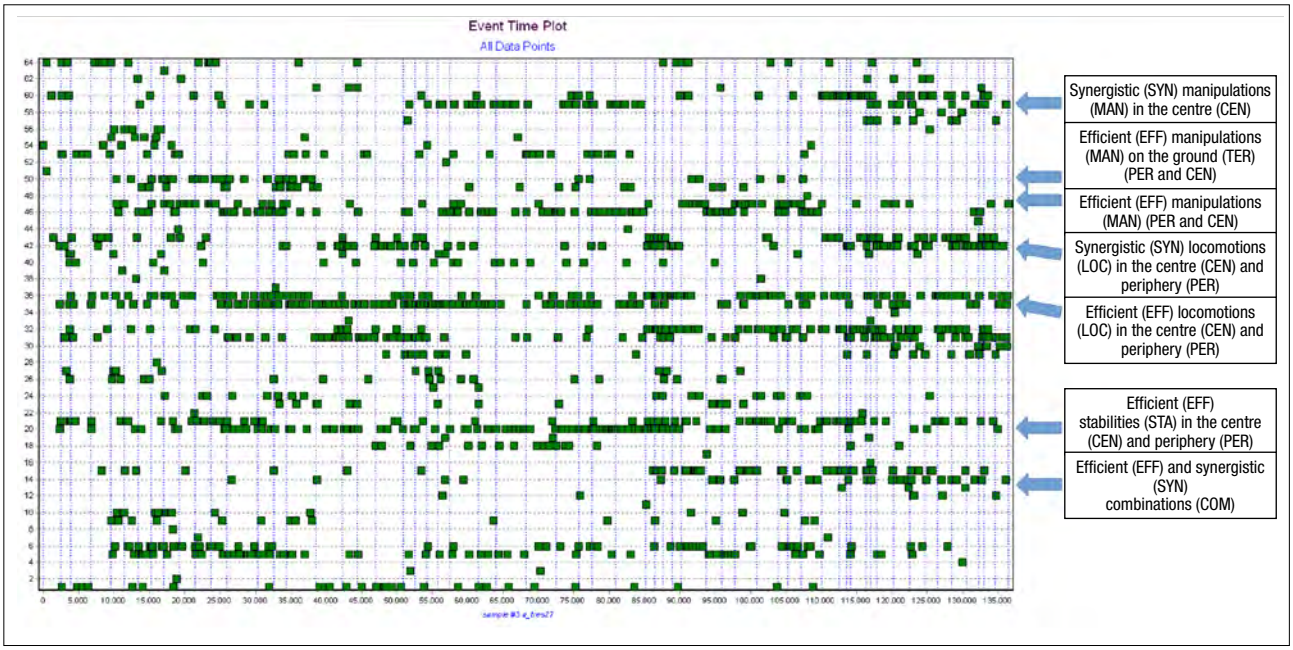


Figure 8
Third term T-patterns two-level sequential relationship.

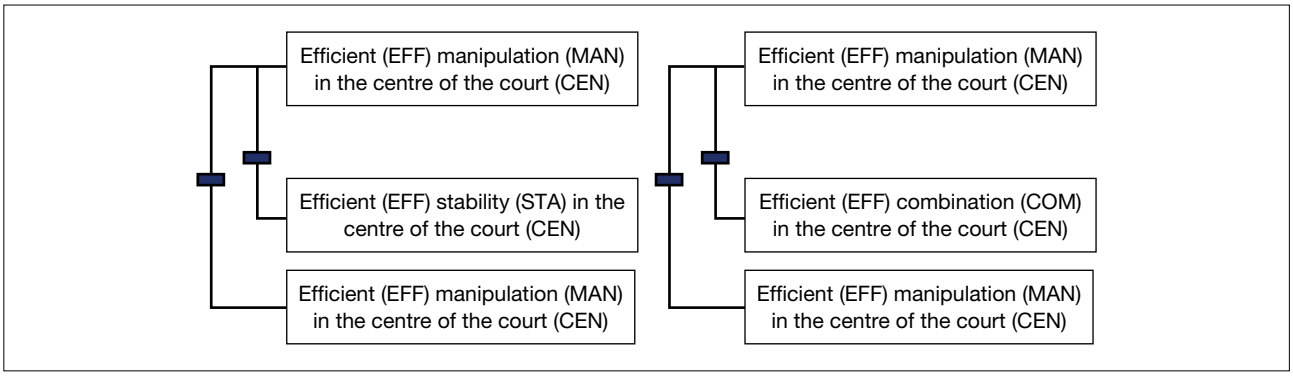


Figure 9
Complex third term T-patterns three-level sequential relationship.

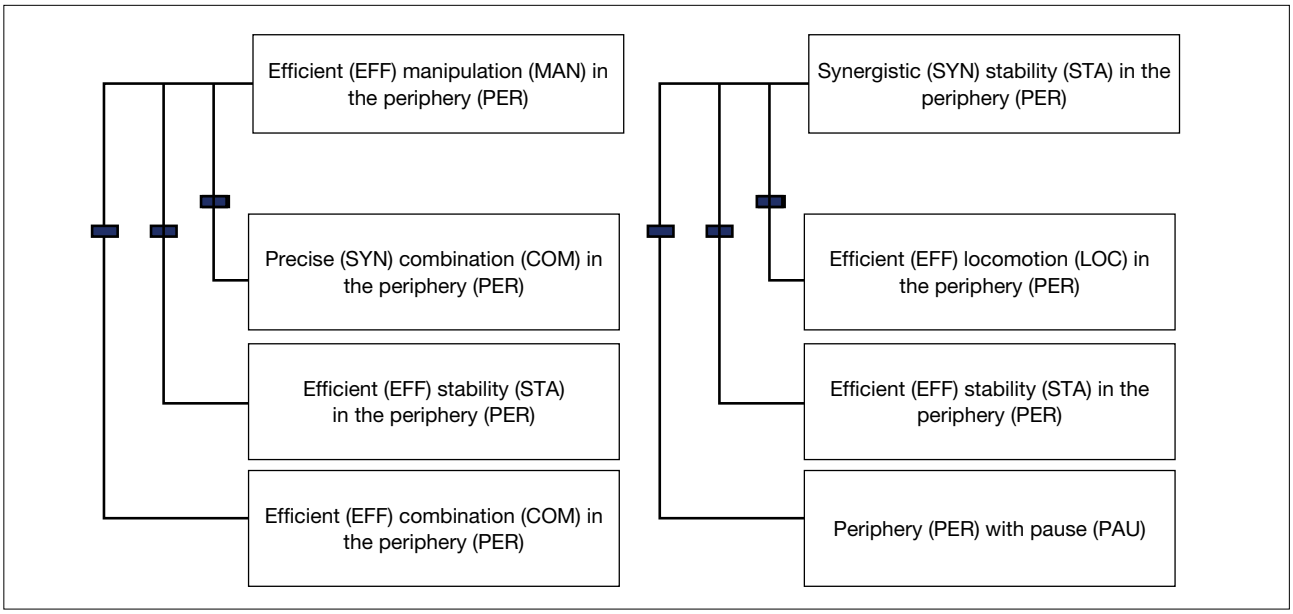


Tabla 3
Difference in 3JS test score pre-post intervention.

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7
Average	0.86	0.27	0.81	1.04	0.36	–0.09	–0.36
Improved	13	8	14	14	11	3	2
Worsened	2	2	1	0	4	3	9
The same	6	11	6	7	6	15	10

In some cases, as shown in figure 9, even more complex motor patterns were also detected. In the first T-pattern, it was observed how from an effective manipulation on the periphery of the court a combination of varied motor skills was performed with precision on the court periphery. Occasionally, an effective posterior motor stability was produced in the same space of the court which, in some cases, was followed by a new effective varied motor skill in the periphery. In the second T-pattern, synergistic stability was observed at the court periphery followed by efficient locomotion in the same court space. At times, there was effective stability on the periphery of the court which, in some cases, ended with a pause in the same space of the court.

3JS test results

The mean score difference between the pre-intervention test and the post-intervention test for test 1 is 0.8, reflecting an almost one point increase in the test score. The mean for test 2 is 0.2, slightly higher. The mean for test 3 is 0.8. The mean for test 4 is 1. The mean for test 5 is 0.3. Test 6 and 7 gave slightly negative results, –0.09 and 0.3, respectively.

Correlation between the results obtained in the 3JS test before and after the intervention was analysed. The correlation detected was .82.

Discussion

The results of the study show that a rich, participatory and diverse motor intervention has a positive effect on children's coordination development during their schooling process (Coetze, 2016; Walhain et al., 2016). In accordance with the methodological orientation followed during the motor intervention that formed part of this study, the aim was to ensure that the learner was faced with the maximum number of motor experiences possible (Herlitz et al., 2020) throughout the sessions, combining all the elements available to make this possible in terms of the use of diverse material, the approach of changing situations (Sánchez-Lastra et al., 2019), multidimensional programming that went beyond the sporting dimension of Physical Education and focused on content related to coordination development and the increase in time of motor engagement in the sessions.

Based on this approach to the implementation of the teaching intervention and the design of the teaching programme, the results of the study show that the motor patterns in the first and third terms are substantially different. At the end of the didactic intervention, in the third term, more motor patterns were observed that were richer in terms of diversity and quality (Castañer et al., 2011), as not only could they be observed in greater quantity and with more variations, but the patterns detected were performed with high levels of motor coordination in most of the participants. The T-patterns obtained in the third term, in contrast to those observed in the first term, contained fewer pause elements between skill and executed skill, indicating that the motor patterns were of higher quality or, at least, more complex in terms of realisation.

Given the nature of the activities offered during the first term, it is logical that locomotion and stability were the most observed motor skills, as the tasks given by the teacher were mainly focused on developing these two basic skills. However, in terms of the quality of the execution of these skills, the coordination elements of precision, efficiency and synergy were not detected. In contrast, during the third term, new motor skills were observed that were directly related to the task performed; however, the key and the objective of this study was to analyse the development in the quality of execution of the skills that were performed (Castañer et al., 2011) and, therefore, to observe the improvement in coordination capacity (Rosa et al., 2020).

In addition to the systematic observation throughout the course, the results of the 3JS test also demonstrated how in most of the tests the participants improved their scores. It is interesting regarding the object of study, therefore, to see how the results relating to the improvement of coordination have been positive, both in qualitative data, such as those obtained through the systematic observation of the sessions, and in the quantitative data of the 3JS test, an observation that has been confirmed using the Mixed Methods approach designed (Anguera et al., 2012; Camerino et al., 2012).

Taking into account the evidence from many other studies that demonstrate the importance of working on coordination content in the pubertal and prepubertal periods because of the body's great capacity for adaptation (Hirtz & Starosta, 2002), the results of the present study add a new criterion that focuses on the quality of how this content should be worked on. This study has shown how, through a specific motor intervention, students can improve their coordination performances, both through the quantitative data of the 3JS test and the qualitative data and detection of T-patterns (Magnusson et al., 2016) using systematic observation with the COS coordination observation instrument.

Conclusions

The results of this study suggest that, in the context of a collegiate school setting and with prior programming, a rich and diverse motor intervention is beneficial for the improvement of students' coordination and, ultimately, their motor skills. Using a Mixed Methods approach that combines qualitative data from systematic observation with quantitative data from a standardised test, it has been demonstrated how a focused physical education intervention that targets motor skill diversity can enhance students' motor skills, resulting in students improving their coordination and demonstrating a higher level of motor control over their bodies.

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Prosocial Behaviours, Physical Activity and Personal and Social Responsibility Profiles in Children and Adolescents

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Abstract

The present study aimed to identify possible responsibility profiles in adolescent students and their relationship with prosocial variables, empathy, violence and the perception of physical activity undertaken. A sample of 296 students aged 10-17 (M = 12.60; SD = 1.65) from different schools (138 boys and 158 girls) was assessed for personal and social responsibility using the Personal and Social Responsibility Questionnaire, for social skills using the Social Skills Inventory for Adolescents, for empathy using the Spanish version of the Interpersonal Reactivity Index, for perception of school violence using the Everyday School Violence Questionnaire, and for perceived level of physical activity and physical exercise (Comparative PA Scale and Physician-based Assessment and Counselling for Exercise). The profile analysis identified one profile with "high responsibility" and one profile with "low responsibility". MANOVA provided significantly higher values for prosocial behaviours, empathy and perception of physical activity undertaken in the "high responsibility" profile. Promoting these values could be key to improving the climate of coexistence in schools and promoting a healthy lifestyle.

Keywords: empathy, healthy habits, prosocial behaviour, responsibility, violence.

Introduction

Prosocial behaviour can be defined as any behaviour that is voluntarily performed for the benefit of others regardless of whether it is for one's own good (Pacheco et al., 2013). Antisocial behaviour, on the other hand, is behaviour that breaks established rules or laws. Individuals who are able to regulate their vicarious emotional response (experiencing emotions and sensations through the stories of others) are more likely to feel sympathy for the needs of others, which facilitates prosocial behaviour (Pacheco et al., 2013).

Prosocial behaviour acts as a barrier to behavioural problems and depression during adolescence, predisposing individuals to personal and social adjustment (Tur, 2003). Authors such as Martínez González et al. (2010) conclude that aggressive behaviour and prosocial behaviour play a key role in the physical and psychological well-being of adolescents. These behaviours are positively related to social skills, peer acceptance and popularity, assertiveness and academic performance. However, such behaviours are negatively associated with social inadequacy, loneliness, social anxiety, aggression and antisocial behaviour. Chalco and Medina (2016) have reported positive relationships between prosocial behaviour and personal and social responsibility, improving interpersonal relationships, academic results and increasing efficacy and adaptability in new situations. In addition, it has been demonstrated that a high score regarding relationship skills and social skills correlates with the importance of social aspects in childhood and pre-adolescence (Martínez de Ojeda et al., 2021). Similarly, the relationship identified between prosocial behaviour and empathy is also noteworthy (Sánchez-Queija et al., 2006).

In contrast, antisocial behaviour is positively related to aggression, social inadequacy, loneliness and social anxiety and negatively related to submissiveness and assertiveness (Inglés et al., 2009). However, there is discordance in the results according to age, and more research is needed to shed light on this important stage of life.

As for the psychological construct of "responsibility" in relation to individuals, it is considered to be an acquired personal value that becomes a personality trait, manifested through behaviour (Filiz & Demishan, 2019). In terms of social responsibility, this is regarded as a set of personal values or commitments to improve the community or society in which one is immersed (Wray-Lake et al., 2016). Thus, responsibility is developed in individuals through experience, along with attitudes and skills. To this end, opportunities must be available to exercise responsibility in the various contexts of human development, such as personal (the relationship with oneself, one's emotions and cognitions), educational, social and cultural contexts (Ginott, 2009).

Research provides evidence on the psychological and behavioural consequences of prosocial and antisocial behaviours. Thus, a lack of personal and social responsibility behaviours could be a predictor of antisocial behaviour (Hipwell et al., 2016). Specifically, social responsibility is a positive developmental indicator for young people (Lerner et al., 2003) that is linked to positive outcomes, such as increased motivation to be physically active and sportsmanship behaviours (Merino-Barrero et al., 2019). Likewise, self-determined motivation, autonomy-supportive climates, task orientation or coaching style are also conducive to prosocial behaviour (Kavussanu & Al-Yaaribi, 2021).

According to what has been established regarding the socioemotional constructs reviewed above, their importance in regulating a healthier coexistence in schools is evident. Therefore, the main objective of the present study was to identify possible profiles of personal and social responsibility in a large group of children and adolescents and to reveal possible connections between this variable and other psychosocial variables, such as social skills, violence, empathy and the practice of physical activity.

Method

Research design

The present study is a quantitative study (Hernández-Sampieri et al., 2014), with a descriptive subtype or approach (collection, analysis and presentation of data through quantitative measures) and a correlational approach (non-experimental relationship between closely related variables) (Montero & León, 2007). Approval was obtained from the Ethics Committee of the University of Murcia and informed consent was obtained from the centre and the parents.

Participants

The study population consisted of primary and secondary schoolchildren in the Region of Murcia. A total of 296 students (138 boys and 158 girls) from year 5 of Primary Education to year 4 of Compulsory Secondary Education (CSO) (Table 1), aged 10-17 (M = 12.60; SD = 1.65) from 4 public and 2 state schools in south-eastern Spain participated.

Table 1
Sociodemographic characteristics of participants.

Sociodemographic variables	Characteristics
Sex	Boys and girls
Location	Schoolchildren from the region of Murcia from the provinces of Torre Pacheco, San Javier, Murcia.
Course enrolled in and current status	Primary and secondary school pupils, academic year 2019/20020.
Socioeconomic background	Mean.
Parents' or guardians' level of education	School graduates and vocational training, mainly

Table 2
Inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
Primary and secondary school pupils.	Schoolchildren under 10 years of age, in order to ensure understanding of the items in the questionnaires.
Schoolchildren who understand written Spanish.	Participants over the age of 18.
Schoolchildren without a diagnosed mental or cognitive pathology.	Schoolchildren with a diagnosed mental or cognitive pathology.
Correct completion of all questionnaires.	Participants who do not fill in the questionnaires correctly.

Non-probabilistic convenience sampling (Cohen et al., 2011) was used, according to the groups comprising the classes predetermined by the schools. The teachers who participated in the study taught Physical Education, with 4 participants in total (2 in the control group and 2 in the experimental group). Their ages ranged from 31 to 59 years, they were permanent staff at the school and had more than 5 years of teaching experience, and they agreed to participate in the study. None of the teachers had previous experience of using the Personal and Social Responsibility Model. Teachers were randomly assigned to the experimental and control groups by the school's own administration.

In order to select the sample, inclusion and exclusion criteria were established (Table 2) and the schools were contacted by telephone call (with the head of studies) to inform them of the aim of the research as part of the development of a doctoral thesis. Once the approval of the school heads had been obtained, a meeting was organised with the teachers who expressed their interest in participating in the data collection, within the teaching timetable of their subjects. In addition, the participants' relatives were informed of the purpose of the study and the type of tests to be implemented for data collection.

Resources

Personal and social responsibility. We used the Spanish version (Escartí et al., 2011) of Li et al. (2008) Personal and Social Responsibility Questionnaire (PSRQ). The questionnaire consists of 14 items, divided into two factors comprising seven items each: social responsibility (i.e., "I respect others") and personal responsibility (i.e., "I try to make an effort, even if I don't like the task"). Participants are required to respond on a 6-point Likert scale, ranging from 1 (Strongly Disagree) to 6 (Strongly Agree). Instructions for completing the questionnaire are provided at the beginning of the questionnaire: "It is normal to behave well sometimes and badly at other times. We are interested in how you normally behave during classes". The internal consistency of the subscales, measured by Cronbach's α coefficient, was .76 for social responsibility and .75 for personal responsibility.

Prosocial and antisocial behaviour. The Spanish version (Inglés et al., 2003) of the Teenage Inventory of Social Skills (TISS) (Inderbitzen & Foster, 1992) was used. It consists of 40 items grouped into two factors: prosocial behaviour (i.e., "I stand up for other students when someone says mean things behind their back") and antisocial behaviour (i.e., "I laugh at other students when they make mistakes"). Answers are

provided on a Likert-type scale from 1 to 6 points, from 1 (Does not describe me at all) to 6 (Describes me completely). The questionnaire is headed: "Teenagers do a lot of things with other peers every day. You probably do some things more often than others...". Cronbach's α values were .85 for prosocial behaviour and .76 for antisocial behaviour.

Empathy. The Spanish version (Mestre et al., 2004) of the Interpersonal Reactivity Index (IRI) (Davis, 1983) was used. Scale consisting of 28 items divided into 4 factors consisting of 7 items each and measuring the integral concept of empathy: perspective taking (PT) (i.e., "I try to take into account each of the parties -opinions- in a conflict before making a decision"), fantasy (FS) (i.e., "I dream and fantasise, quite often, about things that could happen to me"), empathic concern (EC) (i.e., "I often have sensitive feelings and concern towards things that could happen to me"), and personal distress (PD) (i.e., "In emergency situations I feel apprehensive and uncomfortable"). The preceding sentence at the top of the questionnaire is: "The following sentences refer to your thoughts and feelings in a variety of situations...". Answers are provided on a Likert-type scale from 1 to 5 points, 1 (Does not describe me well) to 5 (Describes me very well). Due to the low values obtained for Cronbach's α on the overall scale despite following the trends obtained by Pérez-Albéniz et al. (2003) and Mestre et al. (2004) in their studies, those items (-3, -4, -7, -12, -13, -14, -15, -18, -19) that improved the coefficient after deletion were removed. Ultimately it was decided that only positively stated items should be included and Cronbach's α values improved: .71 for PT; .74 for FS; .65 for EC and .66 for PD.

Violence. The Everyday School Violence Questionnaire (CUVECO) validated in Spanish (Fernández-Baena et al., 2011) from the California School Climate and Safety Survey (CSCSS) developed by Rosenblatt and Furlong (1997) was used. It assesses the perception of having experienced or observed peer violence. This scale is composed of a total of 14 items divided into two factors: experienced violence (i.e., "I was pushed") and observed violence (i.e., "Students smash things"). The items are presented in a Likert-type response format from 1 to 5 points, 1 (Never) to 5 (Always). The preceding sentence at the top of the questionnaire is "Please indicate whether the following has happened to you in your classroom during this school yar". Cronbach's α values were .77 for experienced violence and .82 for observed violence.

Comparative perception of the level of physical activity. The Spanish validated version of the Comparative Physical Activity Scale (Sallis et al., 1988) for adolescents (Martínez-Gómez et al., 2009) was used. It assesses the perception of the amount of physical activity undertaken in relation to the level of physical activity in the environment. This scale consists of a single question: "Compared to others of the same age and sex, how much physical activity do you do?". It is a Likert-type response scale ranging from 1 to 5 points, 1 (much less) to 5 (much more).

Perception of the level of physical activity. The Spanish version of Prochaska et al.'s (2001) Physician-based Assessment and Counselling for Exercise (PACE) developed by Martínez-Gómez et al. (2009) was used . Although initially designed for adults, it was later approved for young people between the ages of 13 and 17, obtaining an acceptable correlation with the measurement of the amount of physical activity undertaken using accelerometers (Prochaska et al., 2001). This scale is composed of 2 items assessing the amount of physical activity undertaken for at least 60 minutes in the last week (PACE1) and in a normal week (PACE2). Participants are asked to answer on an 8-point Likert-type scale, 0 (0 days) to 7 (7 days). It consists of the following introductory information: "Physical activity is any activity that increases your heart rate and causes your breathing to quicken. Physical activity can be undertaken by playing sports, playing with friends or walking to school or high school. Examples of physical activity include running, brisk walking, rollerblading, skateboarding, dancing, swimming, football, basketball, volleyball, handball. Do not include time spent in school PE classes". Cronbach's α value was .88.

Procedure

Firstly, a satisfactory report was obtained from the Bioethics Committee of the researchers' university in order to carry out the research. Secondly, contact was made with the schools to inform them of the objectives pursued, describing the assessment tool and also requesting their voluntary collaboration in participating. Thirdly, families were contacted and informed consent was obtained for student participation. Finally, each teacher was provided with a booklet containing all the questionnaires grouped together, clarifying the rules to be followed. The importance of completing the booklets in full, voluntarily and independently in the classroom was emphasised. Throughout the survey administration, the teacher was always present to resolve any issues that might arise and to verify that the subjects had completed the survey, ensuring the anonymity of their

responses. The project complied with the ethical standards required for research on human subjects: informed consent, right to information, personal data protection, confidentiality, non-discrimination, gratuity and the option to withdraw from the study at any time (McMillan & Schumacher, 2001).

Statistical Analysis

First, the database was cleaned and the Mahalanobis distance was calculated to check for outliers. Descriptive statistics, means, standard deviations, skewness and kurtosis values of the latent variables were calculated. The internal consistency of each of these was calculated using Cronbach's alpha coefficient. Subsequently, a bivariate correlation analysis was carried out to determine the association or linear relationship between the variables analysed. Next, a cluster analysis or K-means cluster analysis was performed, grouping the responsibility variable (personal and social) in an attempt to achieve maximum homogeneity in each group (internal) and maximum heterogeneity between groups (external). For the normality test, the Kolmogorov-Smirnov statistic was used in order to detect normality in samples of a variable nature and larger than 50 participants (Steinskog et al., 2007). Due to the normal distribution of the sample, the multivariate analysis of variance test (MANOVA) was applied in order to explore the significant differences of the variables under study in the cluster profiles obtained. Next, the assumption of homogeneity of variances was calculated to assume equal or unequal variances, which determined the use of Fisher's *F* statistic. Analyses were performed with IBM SPSS 25.0 statistical packages.

Results

Descriptive and bivariate correlation analysis

Table 3 shows the means, standard deviations, skewness and kurtosis of the different variables. The variables related to personal and social responsibility values obtained a higher average score for both component factors, compared to the rest of the variables with similar ranges. On the other hand, the scores obtained for the prosocial behaviours dimension were significantly higher than those for antisocial behaviours on the social competence scale. In terms of empathy, lower values were obtained in the personal distress dimension compared to the fantasy, perspective-taking and empathic concern dimensions. The perception of violence variable had lower values for observed violence compared to experienced violence. And for the variables related to physical activity, the comparative perception of the level of physical activity, which ranged from 1 to 5, showed increasing values. On the other hand, the perception of the level of physical activity practice obtained intermediate-low scores compared to the comparative perception of physical activity. The variables' skewness and kurtosis indices obtained adequate values of less than 2, except for personal and social responsibility in the kurtosis data, which indicated univariate normality of the results, except for those mentioned above (Bollen & Long, 1993). Finally, the correlation analysis showed that the variables under study related to responsibility (personal and social) and social competence (prosocial and antisocial behaviours) had the highest level of correlations with all the variables studied. In addition, factors related to empathy correlated with each other. Likewise, the factors corresponding to violence and perception of the level of physical-sports activity undertaken revealed correlations with some factors.

Cluster Analysis

To carry out this type of analysis, the steps recommended by Hair et al. (1998) were followed. Firstly, the existence of missing cases that might be present in some of the variables studied was checked in order to exclude them from the study sample, but in this case none were obtained. All variables were then standardised using Z-scores (this process transforms each original data score into a standardised value with a mean of 0 and a standard deviation of 1); 8 scores above 3 were found, so these subjects were eliminated as outliers in the whole sample (n = 296). The univariate distribution of all pooled variables was then tested for normality.

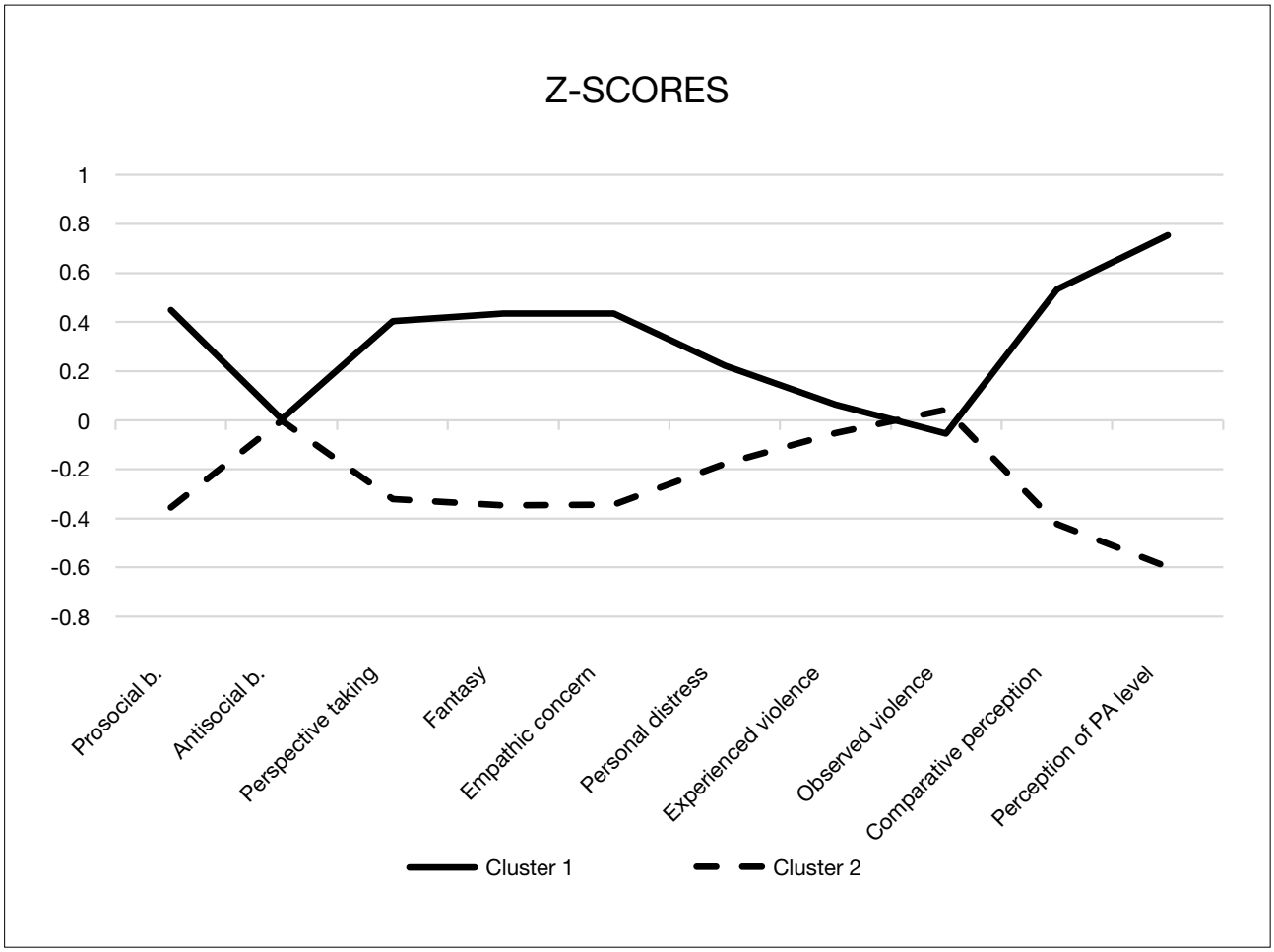
From this stage, the hierarchical cluster analysis was initiated. It is suitable for determining the optimal number of clusters in the data and the content of the data. In this case, the existing personal and social responsibility groups in the sample were defined using the Ward Method. A dendogram was obtained suggesting the existence of two groups. It relies on the increase of agglomeration coefficients from one cluster to two clusters in order to determine the suitability of the generated clusters. Small coefficients indicate high homogeneity among cluster participants, while large coefficients indicate large differences among cluster participants (Norusis, 1992). Therefore, it was concluded that there were two different types of student profiles with respect to the responsibility variable (Figure 1): a "high responsibility" profile (Cluster 1), with higher scores on the different dependent variables of the study, and the other "low responsibility" profile, with the opposite scores (Cluster 2), except for the observed violence variable, which has higher values for Cluster 2, and antisocial behaviour, which has the same scores for both clusters.

Table 3
Descriptive statistics, reliability and bivariate correlations of the variables.

Variables	M	SD	Range	A	C	α	1	2	3	4	5	6	7	8	9	10	11	12
1. Social responsibility	5.25	.58	1-6	-1.41	3.09	.76	-	.50**	.27**	-.24*	.26**	.17**	.25**	.02	-.23**	-.15*	.08	.07
2. Personal responsibility	5.22	.69	1-6	-1.36	2.27	.75		-	.30**	-.14*	.25**	.17**	.27**	.07	-.10	-.14*	.21**	.26**
3. Prosocial behaviour	4.25	.84	1-6	-.47	.02	.85			-	.01	.56**	.48**	.58**	.21**	.03	.03	.07	.18**
4. Antisocial behaviour	2.24	.64	1-6	.71	.21	.76				-	-.09	.14*	-.09	.22**	.31**	.26**	.01	.08
5. Perspective-taking	3.44	.89	1-5	-.35	-.22	.71					-	.53**	.59**	.19**	-.03	-.12*	.07	.10
6. Fantasy	3.06	1.10	1-5	.13	-.67	.74						-	.52**	.38**	.10	.13*	-.04	.13*
7. Empathic concern	3.43	.92	1-5	-.23	-.77	.65							-	.33**	.04	-.08	-.01	.07
8. Personal distress	2.75	.86	1-5	.30	-.16	.66								-	.12*	.00	.10	.13*
9. Experienced violence	1.67	.58	1-5	1.03	.45	.77									-	.38**	.03	.14*
10. Observed violence	2.28	.82	1-5	.64	-.10	.82										-	-.07	-.01
11. Comparative perception of PA	3.32	1.15	1-5	-.15	-.82	-											-	.58**
12. Perception of PA level	3.63	1.09	0-8	-.20	-.91	.88												-

Note: * $p < .05$; ** $p < .01$; *M* = Mean; SD = Standard Deviation; S = Skewness; K = Kurtosis; α= Cronbach's alpha coefficient; PA = Physical Activity.

Figure 1
Scores of the variables studied in a sample of Physical Education students according to the level of personal and social responsibility.



After obtaining the optimal number of clusters, the K-means method was used to process the data on the basis of the personal and social responsibility variable, which corroborated the existence of the two responsibility profiles. The first cluster was labelled "high responsibility" (Cluster 1) (n = 131; 44%) consisting of 52 boys and 79 girls, 64 from primary and 67 from secondary school (M = 12.53; SD = 1.58), who scored higher on the variables of perceived prosocial behaviour, perspective-taking, fantasy, empathic concern, personal distress, experienced violence, comparative perception of physical activity and level of physical activity; and lower on antisocial behaviour and observed violence. Scores contrary to those in the second cluster, which was labelled "low responsibility" (Cluster 2) (n = 165; 56%), composed of 86 boys and 79 girls, 75 from primary and 90 from secondary school (M = 12.65; SD = 1.70).

Multivariate analysis according to personal and social responsibility profile

To examine the characteristics of each profile according to the psychosocial variables mentioned and to assert the predictive validity of the clusters obtained, a differential analysis (MANOVA) was carried out, with the clusters as independent variables and the dimensions of the questionnaires as dependent variables (Table 4). The results obtained revealed differences (Wilk's $\Lambda = .37$, $F(29, 803) = 16$, $p < .01$) between both clusters and the variables: prosocial behaviour ($F(1, 33.43) = 56.21$, $p < .01$), antisocial behaviour ($F(1, 0.0) = 0.0$, $p > .05$, perspective taking ($F(1, 30.11) = 43.71$, $p < .01$), fantasy ($F(1, 46.37) = 52.33$, $p < .01$), empathic concern ($F(1, 37.33) = 52.06$, $p < .01$), personal distress ($F(1, 8.55) = 12.02$, $p < .01$), experienced violence ($F(1, 0.33) = .99$, $p > .05$), observed violence ($F(1, 0.47) = .69$, $p > .05$), comparative perception of PA ($F(1, 88.52) = 86.28$, $p < .01$) and perception of PA level ($F(1, 416.17) = 243.10$, $p < .01$), in favour of the profile with high scores in general responsibility.

Table 4
Multivariate analysis of the variables under study within each cluster of personal and social responsibility.

	Cluster 1		Cluster 2		
	n = 131; 52 boys, 79 girls; 64 primary, 67 secondary		*n* = 165; 86 boys, 79 girls; 75 primary, 90 secondary		
	M	SD	M	SD	F
Prosocial behaviour	4.63	0.71	3.96	0.82	56.21**
Antisocial behaviour	2.24	0.60	2.23	0.67	0.00
Perspective-taking	3.80	0.81	3.16	0.84	43.71**
Fantasy	3.51	0.97	2.71	0.92	52.33*
Empathic concern	3.83	0.85	3.12	0.84	52.06**
Personal distress	2.94	0.89	2.60	0.80	12.02**
Experienced violence	1.74	0.59	1.64	0.57	0.99
Observed violence	2.24	0.78	2.32	0.86	0.69
Comparative perception of PA	3.93	0.99	2.83	1.03	86.28**
Perception of PA level	4.82	1.40	2.43	1.23	243.10**
Wilksα					.369
Multivariate f					.16**

Note: *$p < .05$; **$p < .01$; M = Mean; SD = Standard Deviation; PA = Physical Activity; F = Fisher (ratio of two variances); Wilksα= Wilk's lambda (variance ratio to test the hypothesis).

Discussion

The main objective of the study was to identify possible profiles of personal and social responsibility in a large group of children and adolescents. A second objective was to reveal possible connections between this variable and other psychosocial variables such as social skills, violence, empathy and physical activity. The results revealed two clear profiles: "high responsibility" and "low responsibility". The former had significantly higher values for prosocial behaviours, empathy and perception of physical activity undertaken.

In relation to the first objective, the cluster analysis revealed the existence of two clear profiles associated with personal and social responsibility in the primary and secondary school students who participated in the study: a) a "high responsibility" profile, with significantly higher scores on the prosocial behaviours, empathy and perceived level of physical activity undertaken variables; and b) a "low responsibility" profile, with these same variables scoring in the opposite way. Although to date it has not been possible to find research that studies personal and social responsibility profiles, let alone relate them to psychosocial variables in the field of education, in this study the results obtained can be interpreted in accordance with the contributions made by Chalco and Medina (2016) or Hipwell et al., who discuss the positive relationship between personal and social responsibility and prosocial behaviour, even considering the former as a predictor of the latter. This positive link has also been observed in other research in different contexts (Brunelle et al., 2007; Chalco & Medina, 2016; Gutiérrez et al., 2011), indicating that these behaviours have considerable implications for people's health and social adjustment (Taylor et al., 2013). The results of the present research therefore reinforce this. In this same line, different research has highlighted the direct relationship between personal and social responsibility and empathy (Brunelle et al., 2007; Gutiérrez et al., 2011; Sánchez-Queija et al., 2006); as well as its inhibitory function regarding aggressive and antisocial behaviour (Gutiérrez et al., 2011; Mestre et al., 2004; Nolasco, 2012). Going a step further, Gutiérrez et al. (2011) consider empathy and prosocial behaviours as good predictors of personal and social

responsibility in schoolchildren. Finally, the level of physical activity undertaken was also directly and positively linked to responsibility in the "high responsibility" group. In this regard, in a study on the application of MRPS in physical education (Prat et al., 2019), it was demonstrated that teacher intervention that promotes a positive classroom climate based on students' personal autonomy and the importance of attitudes of personal and social responsibility, stimulates a positive perception of a more active lifestyle in adolescent students. In the same line of study, the application of MRPS in PE increases motivation to engage in physical-sports practice and the perception of sportsmanship (Merino-Barrero et al., 2019).

The "high responsibility" group included a smaller number of participants, with a majority being girls and a balanced number of primary and secondary school students. The "low responsibility" group included a larger number of participants, with more boys, the same number of girls and more secondary school students. In this sense, in studies such as that of Valero-Valenzuela et al. (2020), in which MRPS was combined with gamification strategies, girls' motivation and perception of personal and social responsibility improved after the intervention. Boys, on the other hand, experienced no change in motivation and personal and social responsibility.

Among the limitations of the study is the sample selection, which was made according to accessibility and not in a randomised fashion, thus compromising the external validity of the study. The data analysis focused on finding differences in terms of levels of personal and social responsibility, but it would be interesting in future studies to address differences in terms of the age of the participants, distinguishing between children and adolescents and according to gender. Another aspect to consider is the cross-sectional descriptive research design. Studies of a quasi-experimental nature are necessary to verify the causal relationships between the variables analysed. With regard to the administration and completion of the questionnaires, cognitive fatigue could be experienced due to the large number of questions, so it is recommended that the number of scales included in a single session be reduced. Future lines of research should be quasi-experimental in nature and longitudinal in approach, pre-test and post-test.

Conclusions

Two clearly differentiated profiles were found in the group of participating primary and secondary school students: a "high responsibility" profile with higher levels of empathy and prosocial behaviours, as well as a higher perception of physical activity undertaken, and a "low responsibility" profile with significantly contrasting levels. Therefore, the promotion of values, in this case personal and social responsibility, is postulated as a key element in teaching with the clear objective of improving the climate of coexistence in schools, the socio-emotional development of pupils and achieving a healthy lifestyle.

Practical applications

It has been demonstrated that higher levels of personal and social responsibility in school children and adolescents are related to prosocial behaviours and less to antisocial behaviours such as observed violence and personal distress. Therefore, didactic interventions based on the application of Hellison's Personal and Social Responsibility Model are necessary in any educational context, providing teachers with tools that allow them to master the conceptual principles of this model in order to be able to apply it effectively in their classrooms. The following are examples of strategies based on the application of MRPS to promote personal and social responsibility, prosocial

a) Awareness-raising: the teacher explains the behaviours to be learned that day, motivating the students and explaining the educational objective of the day together with the activity to be carried out.
b) Strategies for dealing with group conflicts: "time-out", the teacher stops the class when he/she observes a tense or uncomfortable situation among the participants, in order to discuss what is happening and propose a solution(s).
c) Autonomy, empathy and help: the teacher encourages one or more pupils to explain to the rest of the class how they have done an exercise or how to perform a certain activity. In addition, this helps them to collaborate, in an empathetic and positive way, with their peers who have more difficulties in completing tasks.

d) Education of values through physical education curricular activities: promoting the teaching of individual and group sports, the improvement of physical fitness or the discovery of body expression techniques in which decision making, sharing among equals, cooperation for the resolution of tasks, debate, etc. are worked on, thus promoting prosocial behaviour, at the same time as increasing the level of daily physical activity of schoolchildren. Therefore, this proposal aims to simultaneously contribute to mitigating violent behaviour and sedentary lifestyles among young people. The main behavioural consequences of such practical applications are expected to be: (i) improvement of students' executive functions, academic performance and psychosocial aspects such as motivation, responsibility, basic psychological needs and classroom social climate; (ii) promotion of improvement of health-related quality of life (motivation to be physically active, level of physical activity, body composition and healthy habits); (iii) modification of teachers' behavioural patterns towards the assignment of personal and social responsibility and autonomy in practice to increase students' active participation, autonomy and cognitive involvement.

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Variables Involved in Ball Possession in Rugby: A Systematic Review

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Abstract

The aim of this article was to identify game variables related to ball possession in top-level rugby teams. Using a systematic review, the scientific literature on studies published between 2001 and 2021 analysing ball possession in the context of rugby in professional leagues was examined, identifying outcome variables and patterns of play. A search of specialised databases was carried out: PubMed, Scopus, SportDiscus and Web of Science, and a total of 176 articles were found. Each study was analysed by two reviewers independently; and in the event of discrepancy, a third reviewer decided on its inclusion. Ultimately, 16 studies met the inclusion criteria. The review identified three variables related to ball possession outcome: (a) field location and initial possession action, (b) ruck characteristics, and (c) line breaks. The results demonstrate interdependence in the different studies on ball possession. These variables are considered to be responsible for the continuity of offensive play and may be predictors of the final outcome of possession.

Keywords: competition, pace of play, patterns of play, performance analysis, team sports.

Introduction

Rugby is a team sport characterised by territorial invasion, involving interaction and struggle between players for ball possession and space, within a constantly changing and dynamic context (Colomer et al., 2020). The internal logic of the game results in constant organisation and reorganisation, meaning that the game is influenced by player-team-opponent interactions (Torrents & Balagué, 2006). Given the sport's high level of complexity, using a game model allows for simplification of a team's gameplay (Ashford et al., 2020). Strategies and patterns of play have evolved with a view to gaining advantages over the opponent, in order to improve team performance (Kraak et al., 2016). Taking into account game styles and the influence of the opposition, Watson et al. (2017) and Colomer et al. (2020) agreed on the need to analyse the game as a whole, emphasising the importance of the periods when a team has ball possession.

A team's attacking phase begins with gaining possession, and is developed through a series of actions in space and time from the moment they gain control of the ball until they cease to control it. Villarejo et al. (2014) suggested the instrumentalisation and categorisation of possession to assess its effectiveness, taking into account the spatial location where ball possession is obtained and the manner in which it originates.

In relation to the categorisation of possession, Ungureanu et al. (2019) concluded that, in rugby, regardless of possession time and frequency, teams that used possession effectively were more likely to win.

Williams et al. (2017) considered that in order to study possession in rugby it would be necessary to ascertain the total time the ball is in play, i.e. the amount of time the ball is in possession of one of the players or is in a position to be contested by the two teams. Furthermore, they showed that increased ball-in-play time could contribute to greater continuity and increased match time, resulting in an increase in the number of actions, and thus a higher number of total possessions (Williams et al., 2017).

In order to analyse offensive play, Mckay and O'Connor (2018) categorised possession according to the period of play and the origin of possession, establishing two main groups; offensive organisation and offensive transition. Play based on offensive organisation would arise from pre-established scenarios in which attack and defence would act in fixed and predictable patterns, while the development of play in offensive transitions would arise from scenarios where teams initiate possession in open play situations with a high degree of unpredictability. Mckay and O'Connor (2018) also observed that teams had an average of 48 total possessions per game, of which 27 came from offensive transition play situations and 21 from offensive organisation situations, reporting that 56% of possessions originate from attacking transition scenarios.

Taking possession as the central focus of all the articles included in the bibliography of the current study, the main objective of this review is to determine, through the analysis of the variables of ball possession play, which variables have the greatest influence on a team's success, understood as the winning of a match or obtaining a greater number of points, with the aim of understanding their impact on the result.

Method

In order to identify the performance-related variables during ball possession in rugby, a systematic review was carried out following the methodological guide of Perestelo-Pérez (2013).

Studies related to observational and statistical analysis of the game, rugby performance indicators and ball possession indicators were included. In addition, the studies needed to be from the period between 2001, when professional rugby XV started, and 2021; and include data from teams participating in professional competitions, as this type of competition has the largest amount of data and publications to be analysed. Studies which did not disclose the data extraction protocol and sample size, literature reviews, as well as letters to the editor and conference abstracts were excluded. An analysis of the methodological quality of the studies was carried out using the PICO system (acronym for P: Participants; I: Interventions; C: Comparisons; O: Outcomes) (Table 1).

Table 1
Analysis of the methodological quality of studies using the PICO system.

Authors	Population	Intervention	Comparison	Outcome
Bennett et al., 2018	English Premiership - Season. 2016/17 (*n* = 127 matches)	Observational (Opta Analysis)	Comparison not applicable	Game outcomes are related to basic skills such as ball carrying, tackling and kicking.
Bunker et al., 2020	Japan Top League - Season. 2018 (*n* = 24 matches)	Observational (SPP - Safe Pattern Prunning)	Comparison not applicable	Line breaks and side kicks are the factors that bring a team closest to scoring.
Bunker & Spencer, 2020	Rugby World Cup 2019 (*n* = 45 matches)	Observational (Stats Perform / Opta Analysis)	Difference between winning and losing teams. - Variables analysed: • Points scored • Running metres • Line breaks • No. rucks	There are differences between winning and losing teams regarding the number of rucks and line breaks.
Coughlan et al., 2019	Super Rugby - Season. 2017 (*n* = 135 matches)	Observational (Stats Perform / Opta Analysis)	Comparison not applicable	Possession that begins near the opponent's scoring zone results in a greater likelihood of scoring.
Den Hollander et al., 2016	Super Rugby - Season. 2013 (*n* = 125 matches)	Observational (SportsCode Elite)	Comparison not applicable	Line breaks are associated with team success and provide more opportunities for scoring tries.
Kraak et al., 2016	Super Rugby - From 2008 to 2013 season (*n* = 646 matches)	Observational (Performance Analysis ISPAS)	Comparison of game time and actions across different seasons. - Variables analysed: • Points scored • Game time • Running with ball • Line breaks • No. rucks • Footwork	Rugby has evolved towards an increase in playing time, leading to a greater number of actions per game.
Kraak & Welman, 2014	Six Nations Tournament 2010 (*n* = 15 matches)	Observational (Performance Analysis ISPAS)	Comparison not applicable	The number of players involved in the ruck affects the performance of a team.

Table 1 (Continuation)
Analysis of the methodological quality of studies using the PICO system.

Authors	Population	Intervention	Comparison	Outcome
Mosey & Mitchell, 2019	Queensland Premier Rugby - Season. 2018 (*n* = 76 matches)	Observational (Opta Analysis)	Comparison not applicable	A team's performance is affected by the number of times it loses possession, the number of line breaks and metres gained in possession.
Schoeman et al., 2017	Super Rugby Season. 2014 Currie Cup Season. 2014 (*n* = 60 matches)	Observational (Versuco TryMaker Pro)	Technical-tactical comparison between different competitions. - Variables analysed: • Possession • Set formations (Mele and touche) • No. rucks	Differences between the two competitions are found in terms of the place of origin of possession, the number of rucks and the number of tackles.
Schoeman & Schall, 2019	Aviva Premiership Season. 2016/17 Guinness Pro 12 Season. 2016/17 Top 14 - Season. 2016/17 Super Rugby Season. 2017 (*n* = 581 matches)	Observational (Versuco TryMaker Pro)	Comparison not applicable	Possessions that start from turnovers in static phases and line breaks are the actions that average the highest ratio of points.
Ungureanu et al., 2019	Guinness Pro 12 Season. 2016/17 (*n* = 127 matches)	Observational (Video)	Comparison not applicable	The speed and effectiveness of the ruck, as well as the number of line breaks, correlates with a greater ability to score points.
Van Rooyen et al., 2006	Rugby World Cup 2003 (*n* = 25 matches)	Observational (SportsCode)	Difference between winning and losing teams. - Variables analysed: • Points scored • Point origins • Initial possession zone	The ability to maintain possession and initiate possession near the opponent's try zone influences the team's performance.

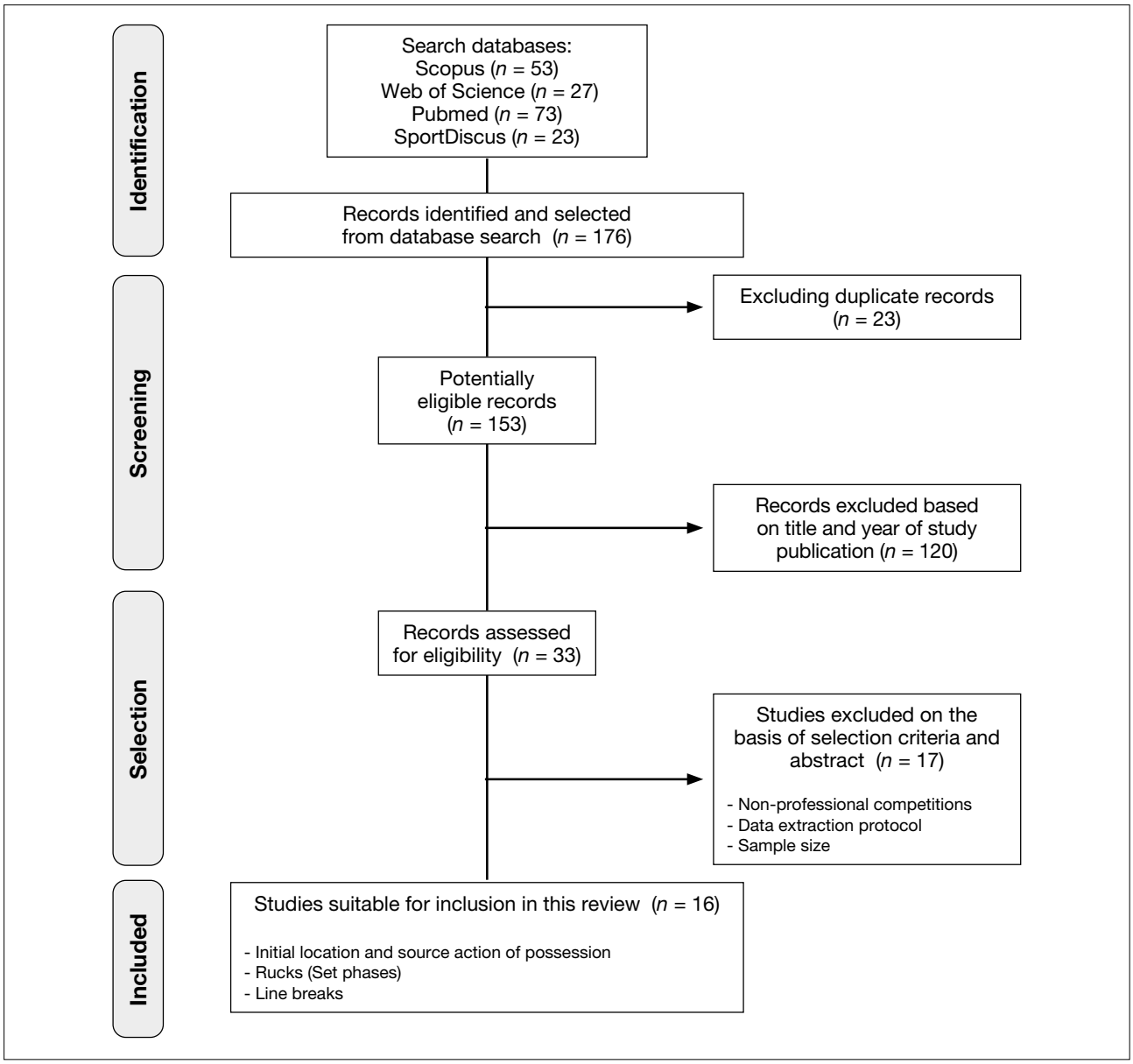
Table 1 (Continuation)
Analysis of the methodological quality of studies using the PICO system.

Authors	Population	Intervention	Comparison	Outcome
Vaz et al., 2011	IRB - 2003 to 2006 period Super 12 - 2003 to 2006 period (*n* = 159 matches)	Observational (Video)	Difference between winning and losing teams. - Variables analysed: • Points scored • Footwork • No. rucks • No. tackles	Winning teams make fewer errors during possession, are involved in fewer rucks and accumulate a greater number of tackles.
Vaz et al., 2019	Rugby World Cup Finals (*n* = 8 matches)	Observational (SportsCode)	Difference between winning and losing teams. - Variables analysed: • Points scored • Initial possession action • No. rucks	The more possessions initiated from static phases, as well as fewer offensive rucks, the greater the likelihood of winning.
Watson et al., 2017	Heineken Cup Season. 2013/14 European Rugby Championship Season. 2014/15 Super Rugby Season. 2015 Six Nations Tournament 2013, 2014 and 2015 Rugby Championship - Season. 2014 (*n* = 313 matches)	Observational (Opta Analysis)	Difference between winning and losing teams. - Variables analysed: • Points scored • Line breaks • Metres gained • No. rucks	Winning teams have a higher number of line breaks and possessions that start in the opponent's half than losing teams.
Wheeler et al., 2010	Super Rugby Season. 2006 (*n* = 7 matches)	Observational (Video)	Comparison not applicable	Ball runs that result in line breaks or tackle breaks are associated with an increased ability to score tries.

Table 2
Search strategy and equation.

Database	Equation
SCOPUS	(TITLE-ABS-KEY (rugby*) AND TITLE-ABS-KEY (professional* OR professional AND league*) AND TITLE-ABS-KEY (ball AND possession* OR possession*) AND TITLE-ABS-KEY (key AND performance AND indicators* OR performance AND analysis* OR patterns AND of AND play*))
Web of Science (WoS)	#1 TS=(rugby*) #2 TS=(professional* OR professional league*) #3 TS=(ball possession* OR possession*) #5 TS=(key performance indicators* OR performance analysis* OR patterns of play*) #1 AND #2 AND #3 AND #5
PubMed	((((rugby*[Title/Abstract]) AND (professional*[Title/Abstract] OR professional[Title/Abstract] OR league*[Title/Abstract])) AND (ball[Title/Abstract] OR possession*[Title/Abstract] OR possession[Title/Abstract])) AND (key performance indicators*[Title/Abstract] OR performance analysis*[Title/Abstract] OR patterns of play*[Title/Abstract])
SPORT Discus	rugby AND (professional* OR professional OR league*) AND (ball OR possession* OR possession) AND (key performance indicators* OR performance analysis* OR patterns of play*)

Figure 1
PRISMA flowchart of the literature selection process for variables related to performance during ball possession in rugby union.



Search strategy and information sources

A literature search was conducted in the Scopus, Web of Science (WoS), PubMed and SPORTDiscus databases, using the search terms "rugby", "professional" or "professional league", "ball possession" or "possession" and "key performance indicators" or "performance analysis" or "patterns of play" (Table 2). The languages in which the search was conducted were English, as the main language in the countries where rugby has the greatest impact, and Spanish, as the researchers' mother tongue.

Study selection and data extraction

A selection was made using the PRISMA 2020 (Preferred Reporting Items for Systematic Review and Meta-Analysis) methodology (Page et al., 2021). Following the search, 176 studies were identified and extracted into a spreadsheet. The duplicates were then eliminated, leaving 153. Subsequently, the titles and years of study publication were reviewed against the selection criteria by the researchers.

During this selection process, the researchers carried out a review of all the shortlisted articles and then pooled them together. In the event of any discrepancy, a third reviewer decided on its inclusion. A total of 16 studies met all selection criteria (Figure 1).

The data related to ball possession variables and the number of matches observed in the articles were extracted and analysed according to their results (Table 2, 3 and 4), for further comparison and discussion.

Results

The 16 studies included in the review revealed three main variables associated with ball possession and attacking play. The methodology used in all articles was observational. The results revealed the possession location and initial possession action, the number of rucks (set phases) and line breaks as the main factors influencing the outcome of possession in rugby.

Possession location and source action revealed frequency ($n = 5$) in relation to the total, studies related to rucks ($n = 7$) and publications about line breaks ($n = 10$). It was ascertained that the 16 articles included in the review analysed more than one indicator per study.

With respect to possession location and source action (Table 3) it was revealed that teams with greater ability to initiate possession in the opponent's half averaged a higher ratio of points to opponent (Van Rooyen et al., 2006; Watson et al., 2017). Furthermore, play restarts and ball recoveries from static phases in the opponent's half were the source actions with the highest scoring capacity (Vaz et al., 2019; Schoeman & Schall, 2019). Other authors have also considered the importance of addressing possession location and source action together, due to the importance of territorial occupation in rugby (Coughlan et al., 2019; Vaz et al., 2019).

Table 3
Content analysis of articles dealing with the location and source action of ball possession.

Authors	Sample	Contributions
Van Rooyen et al., 2006	(n = 25) *matches	Teams that take possession closer to the opponent's try zone have a higher ratio of points in that sequence of play.
Vaz et al., 2019	(n = 8) *matches	Winning teams initiate more possessions from static phases than their opponents.
Schoeman & Schall, 2019	(n = 1,162) *matches	Possession that is initiated from turnovers in static phases averages the highest ratio of points compared to other possession initiations.
Coughlan et al., 2019	(n = 135) *matches	Possession that is initiated from static phases within the opposing 22m zone is identified as the source with the highest percentage of success.
Watson et al., 2017	(n = 313) *matches	Winning teams gain possession of the ball inside the opposing 22m zone twice as often as losing teams, also averaging twice as many points when playing in that zone.

Table 4
Summary of articles studying the characteristics of the ruck set phases during ball possession.

Authors	Sample	Contributions
Kraak et al., 2016	(*n* = 646) *matches	The results indicate increased playing time results in an increase in the total number of rucks per game.
Schoeman et al., 2017	(*n* = 60) *matches	More effective offensive rucks lead to a higher standard of play, greater continuity and a greater ability to keep the ball in possession.
Vaz et al., 2019	(*n* = 8) *matches	Losing teams are involved in a higher number of rucks than winning teams.
Bunker & Spencer, 2021	(*n* = 45) *matches	Winning teams are involved in fewer than 78 rucks in their total offensive match sequences.
Ungureanu et al., 2019	(*n* = 132) *matches	Increased efficiency and speed of rucks generates greater speed in the game, which relates to a greater ability to score points.
Vaz et al., 2011	(*n* = 159) *matches	In close matches, winning teams are involved in fewer rucks than losing teams, and demonstrate a greater ability to generate quick set phases to provide more attacking options.
Kraak & Welman, 2014	(*n* = 15) *matches	Winning teams use fewer players in the rucks than losing teams, thus creating a greater availability of attacking options in open play.

In terms of rucks (set phases), two factors were identified as influencing ball possession: the total number of rucks per match and the effectiveness of these set phases (Table 4). Regarding the number of rucks, winning teams were involved in a lower number of total rucks than losing teams (Vaz et al., 2019; Bunker & Spencer, 2021; Vaz et al., 2011).

In terms of efficiency, successful teams reportedly exhibited a greater ability to maintain possession and generate continuity through faster set phases involving fewer players, resulting in a greater number of attacking options and greater ability to score points (Vaz et al., 2011; Schoeman et al., 2017; Ungureanu et al., 2019; Kraak & Welman, 2014).

Line breaks were the variable most frequently studied within the studies included in this review (Table 5). In relation to these, it was observed that winning teams had a greater ability to generate line breaks than losing teams, indicating that a greater number of breaks increases the likelihood of victory (Watson et al., 2017; Schoeman & Schall, 2019; Bunker & Spencer, 2021). Line breaks were also found to be associated with a greater number of metres gained in possession (Mosey & Mitchell, 2019; Ungureanu et al., 2019) generating continuity in attacking play and a greater ability to score tries in that same phase of play or in the actions immediately following (Bennett et al., 2018; Bunker et al., 2020; Den Hollander et al., 2016; Wheeler et al., 2010).

Table 5
Studies reviewed on line breaks during ball possession.

Authors	Sample	Contributions
Kraak et al., 2016	(*n* = 646) *matches	The results indicate increased playing time results in an increase in the total number of line breaks per match.
Watson et al., 2017	(*n* = 313) *matches	Winning teams generate a higher number of line breaks than losing teams.
Bennett et al., 2018	(*n* = 127) *matches	A higher number of line breaks significantly increases the probability of successful possession.
Schoeman & Schall, 2019	(*n* = 581) *matches	More line breaks lead to a higher score, which is the most decisive factor in terms of winning and losing.
Bunker et al., 2020	(*n* = 24) *matches	Line breaks are the actions that generate the most points, indicating that the higher the number of breaks a team makes, the greater the scoring capacity.
Bunker & Spencer, 2021	(*n* = 45) *matches	Winning teams win the advantage line more than 55 times in their total offensive sequences, generating a higher number of line breaks than losing teams.
Mosey & Mitchell, 2019	(*n* = 76) *matches	More line breaks are related to more metres gained, and this is related to a higher probability of winning.
Den Hollander et al., 2016	(*n* = 125) *matches	39% of line breaks result in a try. In 66% of the cases where the line break did not result in a try, the attacking team was able to keep possession of the ball in the next phase.
Wheeler et al., 2010	(*n* = 7) *matches	Line breaks are associated with scoring tries in the phases of play immediately following them.
Ungureanu et al., 2019	(*n* = 132) *matches	More line breaks increase the number of metres gained, resulting in greater speed and continuity of play, which is related to a greater ability to score points.

Discussion

The purpose of this review was to identify the possession-related variables involved in the outcome.

According to the results obtained, the location and source action of ball acquisition were considered as an initial scenario in which to develop the game (Coughlan et al., 2019). The findings show that possession that begins in the opponent's half, from static phases or through turnovers, both in open play phases and from fixed sets, are variables that influence the success of possession (Vaz et al., 2019; Schoeman & Schall, 2019; Watson et al., 2017), as they allow initiation of the attack closer to the scoring zone. Possession that originates from static phases offer the opportunity to launch the attack in an organised and strategic manner, with the aim of disrupting the opposition's defensive organisation and moving towards the scoring zone. On the other hand, if this possession is initiated from a turnover, the defensive disorganisation at that moment of the game is greater and the transition to attack scenario provides the opportunity for finding more space to move quickly towards the try line.

In this sense, Villepreux (1993) has already differentiated attacking play into simple and complex possessions, distinguishing them according to whether they are made

up of a single phase or several phases, with complex possessions having a greater impact on the efficiency and quality of possession, alternating different forms of play and generating greater defensive destructuring.

Based on the results, it was considered that set phases have a significant impact on the game, both in terms of the number of set phases and their effectiveness, as it is a tactical situation that results in reorganisation at offensive and defensive level, caused by an interruption in the continuity of the movement of the ball during possession and attacking play. A lower number of rucks is related to a higher turnover of play and ball actions, resulting in a higher pace of play during possession (Solé, 2017), thus generating greater stress on the defensive system (Vaz et al., 2019; Kraak et al., 2016).

The results demonstrated that defensive line breaks were the game variable that produced the highest number of metres gained from ball possession (Mosey & Mitchell, 2019; Ungureanu et al., 2019). Actions that allow the advantage line to be won create a situation of imbalance and defensive disorganisation, allowing the attacking team to gain metres and advance towards the scoring zone (Bunker & Spencer, 2021; Schoeman & Schall, 2019; Schoeman et al., 2017), thus generating a greater likelihood of scoring tries (Vaz et al., 2011; Den Hollander et al., 2016).

It is considered that the game variables "Location and source of possession", "Set phases" and "Line breaks" observed in this review could have an interdependent relationship, as it was observed that the possession source and initial possession action can result in a greater number of line breaks, producing a greater defensive destructuring, in turn generating a lower number of rucks and thus providing a greater attacking speed, which can lead to an increased chance of success in the possession outcome.

The main limitations are that, despite analysing the most relevant variables in ball possession according to the literature, this review has studied offensive variables. The constant changes in the rules are also considered a limitation, as they produce significant changes in the development of the game that can affect the variables analysed.

It is proposed that future research should focus on the analysis of defensive game variables and their possible interrelationship with the possession-related variables studied in this review.

The contributions provided by this research can offer relevant information regarding the actions during attacking play that determine and impact outcomes. The number of rucks and line breaks a team completes during the time it has ball possession can guide the study of pace of play and offer a new way of categorising possessions and their outcome, with the aim of designing training tasks that optimise player performance.

Conclusions

From the results obtained, three possession game variables were identified as influencing the outcome of possession. These variables are the possession location and initial possession action, rucks or set phases and line breaks. The three game variables were studied in isolation, although the results suggest possible interdependence between them, with the possession location and initial possession action, being considered as the source of the game and the set phases, together with the line breaks, as the actions that have the greatest impact on the continuity and outcome of possession.

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Sport Events and Sustainability: A Systematic Review (1964-2020)

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Abstract

Since the adoption of the Sustainable Development Goals in 2015, sustainability has become an indisputable factor in the organisation of sporting events. Historically, sustainability has been the subject of study by the scientific community. However, to date, there is no analysis of published research. The aim of this study was to analyse the way in which the sports sector has integrated sustainability into the organisation of sporting events, by means of a systematic review. The systematic review was conducted taking the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) guidelines as well as the risk-of-bias (RoB) assessment into consideration. The literature review was based on a consideration of 17 databases, covering the period from 1964 to 2020, with the string: sport, events, sustainability and sustainable. Initially 1,590 records were collected, of which a total of 224 were analysed in depth after the screening process was completed. One of the main findings is the identification of a steady increase in the number of publications over the whole period, with two peaks in 2012 and 2020. In terms of sustainability, the most studied aspect of this was environmental (41.5%), followed by social (32.1%), economic (17%) and the combination of the three (9.4%). The results obtained were reviewed in relation to the evolution of the sustainability milestones.

Keywords: sporting event, sustainable event, sustainable sport.

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Introduction

On 25 September 2015, the United Nations (UN) Assembly established the guidelines for the development of the 2030 Agenda for Sustainable Development by proposing 17 major Sustainable Development Goals (SDGs 2030), comprising a total of 169 milestones and indicators. Through this proposal, the UN, based on the concept of sustainable development already defined in the Brundtland report in 1987 as development that meets the needs of the present without compromising the ability of future generations to meet their own needs, sought to lay the foundations for ending extreme poverty, fighting inequality and injustice, and combating climate change.

In recent years, sport has gained weight as an economic activity. The grey press estimates that sport contributed 3.3% of the EU's GDP in 2021 and 3.6% of Spain's GDP in 2021. Therefore, as an economic engine, sport is not exempted from the responsibility of being a sustainable activity, especially with regard to one of its main economic exponents, namely sporting events (Bácsné et al., 2021).

In the words of the same author, sporting events should not only be considered because of the impact they have, but also for the opportunity they provide to transmit values and principles, for their high visibility, for the impact they can have before and during the event, and also for the legacy they leave in the host community. According to Sánchez (2019), these can generate positive social, economic and environmental effects, as well as negative ones, disrupting the daily lives of many people living in the areas where sporting events take place. For this reason, the main international organisations in the field of sport, such as the International Olympic Committee (IOC) and some international federations, have been incorporating sustainability standards for organising international sporting competitions for some years now, thus promoting the involvement of the scientific community in the study of the benefits and results of these new standards (Bianchini & Rossi, 2021). In this sense, four main areas of study have been developed: i) elements required in strategic planning and attributes necessary to achieve sustainability in sporting events, determining which elements and/or attributes of the destination are necessary for successful and sustainable event organisation (Chersulich et al., 2020; Chen, 2022); ii) roles and impacts derived from sporting events as generators of sustainable sport tourism, identifying the role of the sport tourist and their impact on nature at the destination (Rivera, 2018; Ito & Hinch, 2020; Tadini et al., 2021); iii) the environmental sustainability of the sport tourism market, analysing the environmental impact on sport tourism and the contribution of sporting events (Ardoin et al., 2015; Mascarenhas et al., 2021); and iv) social impacts of mega-events, documenting the economic benefits that mega-events can generate (Chien et al., 2012; Mair & Smith, 2021). Alongside these are many other published studies linked in one way or another to the sustainability of sporting events. Therefore, taking into account the three fundamental pillars of sustainability considered in the development of sustainable sporting events (social, environmental and economic), the aim of this article is to carry out a systematic review of the publications to date on this subject, with the aim of understanding their evolution and scope for development.

Sporting events

The definition of the term is not a straightforward one and there are many authors who have contributed to shed light on the concept by looking at different elements in order to determine its taxonomy and classification.

Añó (2000) defines "sporting event" as a sporting activity that has a high level of social repercussion reflected in a strong media presence and that generates economic income in itself. Other authors consider sporting events as social, but also economic catalysts and promoters of the host city's brand image (Dwyer & Fredline, 2008). Roche (2000), who focuses on defining ways to classify them, goes so far as to propose the grouping of sporting events according to the market or target audience, such as international events —Olympic Games or World Cups—, national events —national championships of any kind—, regional events —Pan American Games—, and local events —local championships of any kind—. In this sense, Graham et al. (2001) propose another classification according to the status of the organiser, for example national bodies, federations, clubs, associations, companies, educational institutions and others. Other authors such as Desbordes and Falgoux (2006) even make a classification according to the type of service offered by the organisation; they differentiate between events organised by public service providers, events organised by private providers, events of extraordinary scope that depend on a public entity with the support of private entities and events organised by an association. Finally, Müller (2015) develops a ranking framework based on four constitutive dimensions: i) visitor appeal, ii) media outreach, iii) cost,

and iv) impact on infrastructure transformation. According to the number of attendees or costs generated by the events in the four dimensions, the author objectively assigns a weighting, which ultimately leads to the categorisation of events as giga-event, mega-event and big event.

Sustainability and dimensions

Of the many definitions of sustainability, most coincide that in order to be sustainable, economic growth policies and actions must respect the environment and also be socially equitable (Lein, 2017). Therefore, according to these authors, sustainability must be understood as an action-centred assumption that frames the conflict between environmental processes and social and economic connections.

Likewise, according to López et al. (2018), the concept of sustainable development must address social injustices if it is to achieve the fundamental principles set out in the Brundtland report, promoting the creation of practical means to reverse the environmental and socio-economic problems of today's society in an integrative way. Taking into account reports and authors as diverse as the WCED (1987), the United Nations (2015), Takeuchi et al. (2016), among others, social, economic and environmental objectives must be intertwined in order for sustainable development to be achieved, as it is the result of the integration of the objectives of the three dimensions: economic, environmental and social.

In this regard, it should be noted that there are three principles set out in the Brundtland Report to be considered in the integrative implementation of a more sustainable set of actions: i) with regard to economic growth, this should take place in accordance with the capacity of ecosystems, to ensure that future generations have the same or a better quality of life; ii) the principle of social equity implies that the emphasis is placed on equity and social justice, the fair distribution of resources, both intragenerational and intergenerational, and iii) environmental protection is approached from a long-term perspective, ensuring that economic growth is consistent with the rate of consumption of natural resources and the degradation of ecosystems, avoiding, among other things, the collapse of the planet (WCED, 1987; United Nations, 2015; López et al., 2018).

The United Nations, together with the Organisation for Economic Co-operation and Development (OECD, 2001) and the International Union for Conservation of Nature (IUCN, 2006), proposes that the three dimensions of sustainable development are interrelated on the basis of three principles or analytical categories, namely livability, equity and viability. Therefore, the three pillars should focus on profit, environmental care of the planet and social care of people's well-being (Purvis et al., 2019).

Finally, it is worth highlighting some authors' proposals for adding a fourth dimension to the three previous ones, the political-constitutional dimension. This dimension functions as a system of interactions within the indicators of each dimension and the interactions of the dimensions themselves (Inglés & Puig, 2015; Inglés et al., 2016).

Sports and sustainability

The relationship between sport and sustainable development is indisputable and heterogeneous, substantially transcending the widely contrasted purely environmental connotations (McCullough et al., 2020) which Domínguez et al. (2019) can cover aspects as varied as contributions to the development of basic skills such as teamwork and self-improvement, the eradication of gender barriers, the increase of equitable quality education or sport inclusivity, and the generation of alliances that contribute to the implementation of its principles.

Sustainability has established itself as a factor that is increasingly present in sport organisations, sporting events and actions linked to corporate social responsibility (McCullough et al., 2019). However, several authors indicate that recognition is not enough and more effort is required from stakeholders to promote sustainability in sport (McCullough & Cunningham, 2010). In this sense, nowadays, sustainability has been firmly established as one of the emerging scientific research topics in the field of sport management (Lis & Tomanek, 2020), generating a large area of interest for further development of scientific literature linked to the SDGs (Fonseca et al., 2022). In the same vein, it is worth mentioning the proposal by McCullough et al. (2020) for the recognition of a new sub-discipline within sport management, which has become known as sport ecology.

Table 1
Keywords and string creation.

Keywords	String in English	Search period
Sport	Sport AND Events AND Sustainability	1964-2020
Events	Sport AND Events AND Sustainable	
Sustainability		
Sustainable		

The scientific community has paid increasing attention to the relationship between sport and sustainability factors (Mallen, 2018), mainly because of the impact of sporting events on the destination region. Therefore, research on sporting events from a sustainability perspective is relevant, even though different literature reviews have followed contrasting approaches especially with regard to the relationship between sport organisations and sustainability (Mallen, 2018; Trendafilova & McCullough, 2018). In addition, the relationships between leisure activities and environmental sustainability have been investigated, setting aside the sport component (Vaugeois et al., 2017).

Sustainability can be incorporated at both the individual and institutional level, and has recently become a trend in the sporting event industry (Córdova et al., 2019). The term "sustainable" or "sustainability" has become a part of events' guidelines or handbooks, specifically the policy aspect under which they operate and how they contribute to sustainability (Gulak-Lipka & Jagielski, 2020). However, despite the potential benefits, recently, some sporting event destinations have shown little interest in hosting sporting events (Mair & Smith, 2021). This situation is attributed to the lack of event hosts to strategically plan and efficiently capitalise on the potential benefits (O'Brien & Gardiner, 2006; Smith & Sparkes, 2019).

Taking into account the above context, the aim of this article was to identify the trends in scientific publications related to the sustainability of sporting events. This served to establish the question: where have we come from, and where are we now, from which further analysis can be made: where and how can/should we move forward?

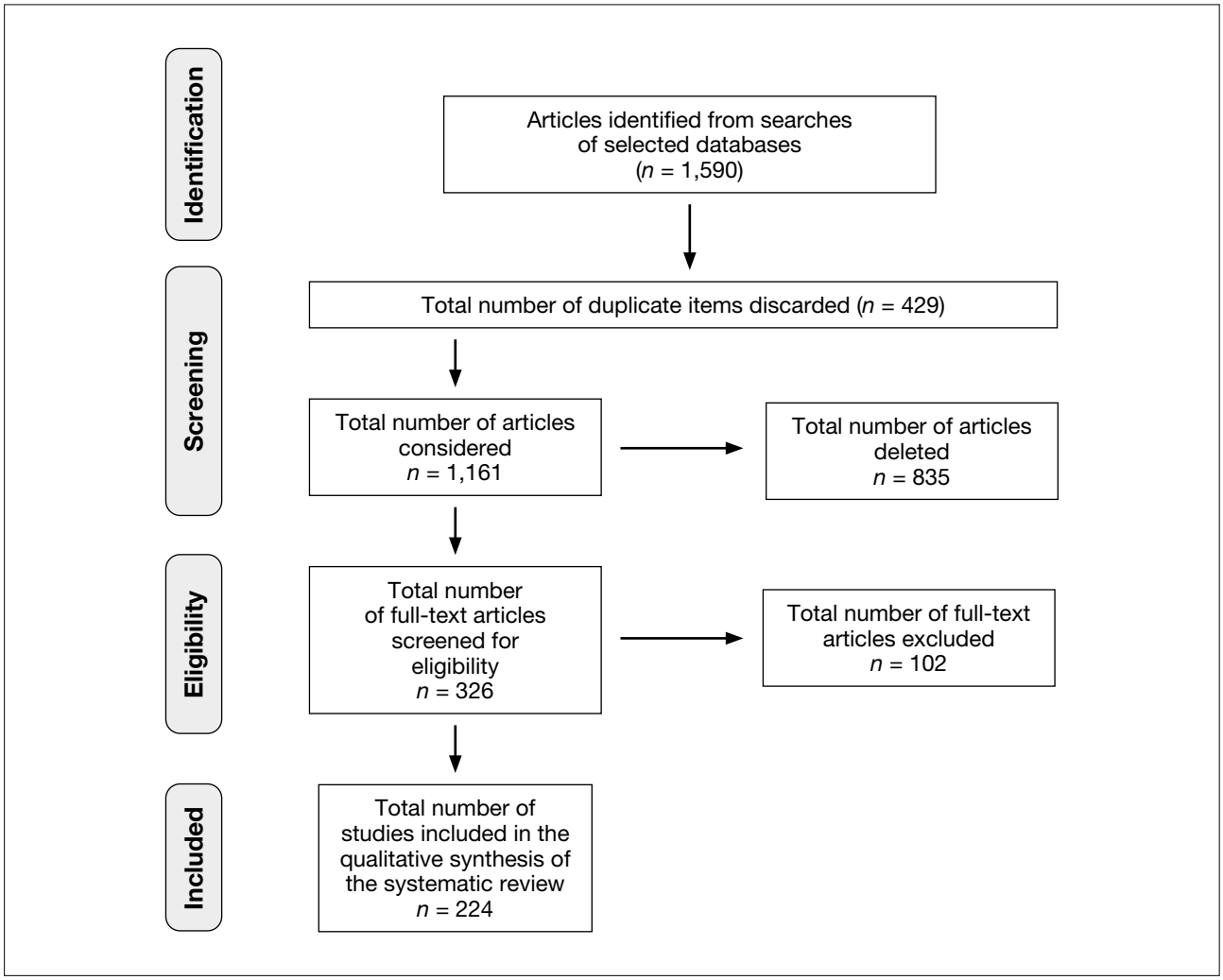
Methodology

The methodology used for this research was the application of the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) guidelines for systematic reviews (Moher et al., 2010; Urrutia & Bonfill, 2010), implementing a risk-of-bias (ROB) assessment system. A total of 17 databases were analysed: Ebscohost, SportDiscus, GreenFILE, Web of Science, Core Core Collection, CABI, Current Contents Connect, BIOSISCitation Index, BIOSIS Previews, MEDLINE, Zoological Record, KCI-Korean Journal Database, Derwent Innovations Index, SciELO Citation Index, Russian Science Citation Index, and Scopus. The search limit for published scientific articles was extended to December 2020.

The string was configured by combining the following words: "sport", "events", "sustainability" and "sustainable" (Table 1).

The initial collection of articles comprised 1,590 records. After discarding duplicates (n = 429), the title and abstract were screened (n = 835) using the Abstrackr programme (peer review). Once the articles were selected, they were read (n = 26) and a total of 102 articles were excluded. The reasons for the exclusion of articles were based on consideration of the following aspects: i) in relation to the event dimension, not specifying the event to which they referred —they referred to sporting events in general— or not including, within the dimension, strictly sporting events; and ii) with regard to the sustainability dimension, not including the study of sustainability as such. The Figure shows the database ultimately considered, which in this case, after the application of the different screening phases, consisted of a total of 224 articles.

Figure 1
Flow chart of the selection process bibliography.



In order to extract information from the articles, a categorisation table was drawn up based on the following dimensions: i) characterisation of the article: year of publication and identifier; ii) characteristics of the sporting event: origin —country and continent—, year or years in which it was held, event typology based on the proposal by Müller (2015) —giga, big and mega-event—, including the classification of regional/national events, not included by this author, and sport discipline —polysport or single-sport—, and iii) relationship with the areas of sustainability proposed by Purvis et al. (2019) —social, economic and environmental—, type of study —qualitative, quantitative or mixed—, type of methodology used —literature review, case study, survey, interview, questionnaire and others—, and subject matter —event database, residents, organisation, athletes, infrastructure, tourists, spectators, volunteers, experts and others—.

For a better understanding of the results, taking into account the trend in the number of articles published between 1964 and 2020, some of the results were analysed according to three main periods: 1964-1999, 2000-2014, and 2015-2020. The first period begins in 1964 with the hosting of the Tokyo Olympics up to 1999, when the IOC's Agenda 21 was set, and marks the end of a period in which the concept of sustainability emerged as a challenge to be met by national, regional and local governments around the world. In the year 2000, the MDGs (8 goals related to human development) were established, implying the need to ensure environmental sustainability, especially in the Olympic Games within this period, up to 2014. The year 2015 marks the beginning of the final period, due to the development of the 2030 Agenda for Sustainable Development, up to 2020, when this systematic review will come to an end.

Figure 2
Trend in the number of articles published (1999-2020).

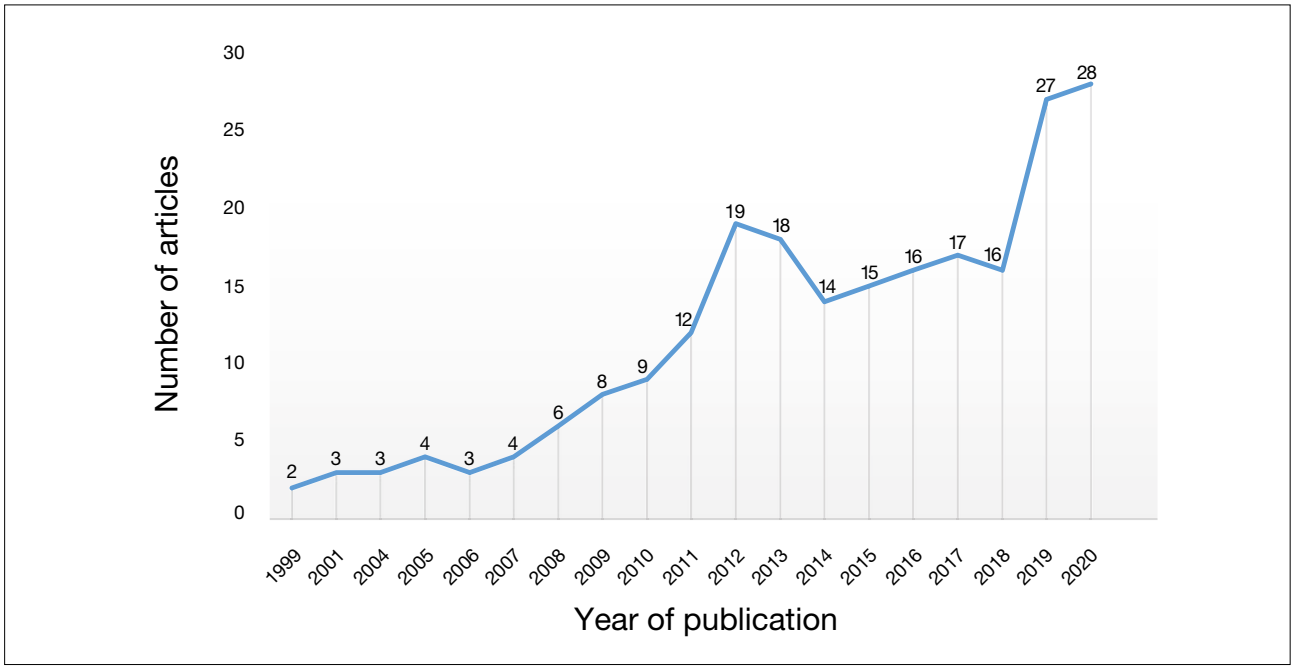
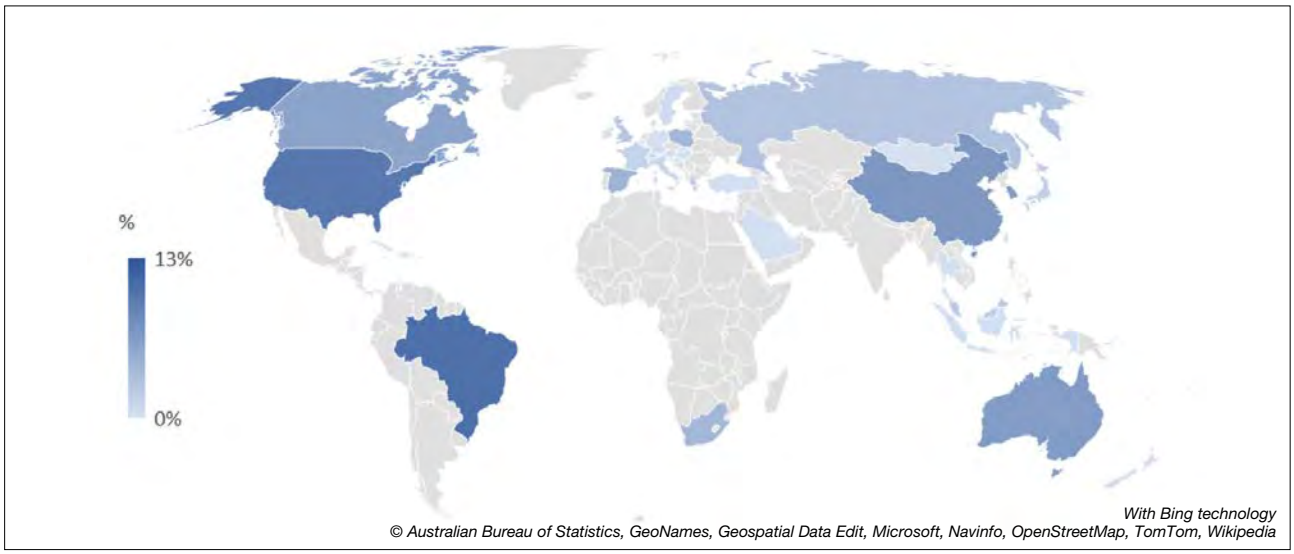


Figure 3
Distribution of publications according to country (1999-2020).



Results

Trend in the number of articles with respect to the years of publication

In the analysis of the results obtained in the study of the trend in the number of publications, it was possible to observe the existence of a constant and gradual increase over time in the number of publications, with the presence of two major peaks: 2012 and 2020, within the periods 2000-2014 and 2015-2020, respectively. It is also interesting to note that in 2012 the upward trend that began in 1999 was broken for the first time, and after two years the number of articles published began to rise again.

Characteristics of sporting events

Location

Of the 224 articles analysed, there was a clear predominance of events based on the European continent (37%), followed by the Asian continent (23.2%) (Figure 3).

Table 2
Events analysed by continent.

Continent	Total		Period %		
	Events	%	1964-1999	2000-2014	2015-2020
Europe	102	37.0	44.2	45.2	30.4
Asia	64	23.2	22.2	14.0	39.2
North America	43	15.6	33.3	17.8	11.8
South America	29	10.5	0.0	5.7	16.7
Oceania	19	6.9	0.0	10.2	2.0
Africa	11	4.0	0.0	7.2	0.0
Various	8	2.9	0.0	0.0	0.0
Total	224	100	100	100	100

Table 3
Event size.

Event size	Total		Period %		
	Events	%	1964-1999	2000-2014	2015-2020
Giga	125	45.3	100.0	47.5	37.9
Mega	49	17.8	0.0	20.0	13.7
Big	24	8.7	0.0	8.1	9.5
National/regional	78	28.3	0.0	24.4	38.9
Total	224	100	100	100	100

When analysed according to periods and continents, it can be seen that the European continent had the highest concentration of events in the period 1964-1999 (44.2%) and in 2000-2014 (45.2%), with the Asian continent having the highest concentration in 2015-2020 (39.2 %) (Table 2).

Size

Following the classification made by Müller (2015), there was a clear predominance of giga-events (45.3%), followed by national/regional events (including those events not included in Muller's category), accounting for 28.3%, and mega-events (17.8%). These results, analysed from the point of view of distribution according to periods, maintain this trend with nuances: a higher percentage of mega-events in all periods, although a higher proportion of national/regional events in the 2015-2020 period (Table 3).

Sport discipline

There was a clear predominance of the multisport discipline (63.4%), represented by the Olympic Games (90%). Of the single-sport events (36.6%), football (36.6%), athletics (12.2%), cycling (8.5%) and motor racing (7.3%) stand out, accounting for 64.6% of all single-sport events (Table 4).

Table 4
Sport-related event discipline.

Event discipline	Multi-sports (63.4 %)	Single-sports (36.6 %)
Olympic Games	90.1	-
European or continental games	9.9	-
Football	-	36.6
Athletics	-	12.2
Cycling	-	8.5
Motor racing	-	7.3
Trail running	-	4.9
Skiing	-	4.9
Athletics	-	3.7
Hiking	-	3.7
Tennis	-	2.4
Mountain biking	-	2.4
Baseball	-	2.4
American football	-	1.2
Cricket	-	1.2
Golf	-	1.2
Indoor football	-	1.2
Martial arts	-	1.2
Rugby	-	1.2
Fencing	-	1.2
Handball	-	1.2
Karate	-	1.2
Total	100	100

Sustainability

Areas of study

The most recurrent study theme was environmental sustainability (41.5%), followed by social sustainability (32.1%). In this respect, it is worth noting the limited presence of articles focusing on economic sustainability. If the analysis is carried out according to distribution by time periods, the environmental area presents a higher concentration in the period 2000-2014 (46.6%), while in the period 2015-2020 it was the social area (37.3%) (Table 5).

Type of Study and Methodology

With regard to the study methodology, the results obtained demonstrated the presence of a clear predominance of qualitative studies in the three areas of sustainability: economic (75.1%), social (63.2%) and environmental (70.6%), with literature reviews being the most recurrent methodology in the study of the economic area (31.9%) and the social area (30.6%), followed by case studies in the environmental area (32.1%) (Table 6).

Object of study

The predominance of database use was observed in all areas: economic (73.3%), social (59.1%) and environmental (65.3%). Residents in the social area (15.2%) and event participants in the environmental area (8.7%) also stand out as the study objects with the highest occurrence after database use (Table 7).

Table 5
Areas of study.

Type of area	Total		Period %		
	Articles	%	1964-1999	2000-2014	2015-2020
Environmental	93	41.5	0.0	46.6	36.4
Social	72	32.1	66.7	27.2	37.3
Economic	38	17.0	0.0	16.5	16.9
Combination of areas	21	9.4	33.3	9.7	9.3
Total	224	100	100	100	100

Table 6
Type of Study and Methodology.

Type of study	Total		Areas of study			
	Articles	%	Economic *n* = 91	Social *n* = 134	Environmental *n* = 153	Combination of areas *n* = 20
Study type (*n* = 224)						
Qualitative	157	70.4	75.1	63.2	70.6	100.0
Quantitative	48	21.4	19.7	28.9	20.2	0.0
Mixed	19	8.5	4.6	7.8	9.0	0.0
Methodology (*n* = 354)						
Literature review	113	31.9	31.9	30.6	31.7	25.0
Case study	111	31.3	26.3	28.5	32.1	45.0
Survey	43	12.1	12.5	13.2	13.4	10.0
Interview	38	10.7	12.5	9.1	10.4	20.0
Questionnaire	14	4	4.1	5.1	2.6	0.0
Others	35	10	12.5	13.2	9.5	0.0

Table 7
Object of study.

Study type (n = 285)	Total		Areas of study			
	Articles	%	Economic *n* = 91	Social *n* = 134	Environmental *n* = 153	Combination of areas *n* = 20
Database	145	50.8	73.3	59.1	65.3	0.0
Residents	31	10.9	7.8	15.2	7.3	58.3
Organisation	23	8.1	7.8	4.5	6.0	0.0
Athletes	26	9.1	3.3	6.8	8.7	0.0
Infrastructure	13	4.6	2.2	0.8	5.3	33.3
Tourists	12	4.2	2.2	5.3	2.0	0.0
Spectators	11	3.9	1.1	3.0	2.7	0.0
Volunteers	8	2.8	1.1	4.5	1.3	0.0
Experts	6	2.1	1.1	0.8	0.7	0.0
Others	10	3.5	0.0	0.0	0.7	8.3

Figure 4
Relationship between sporting events and areas of sustainability.

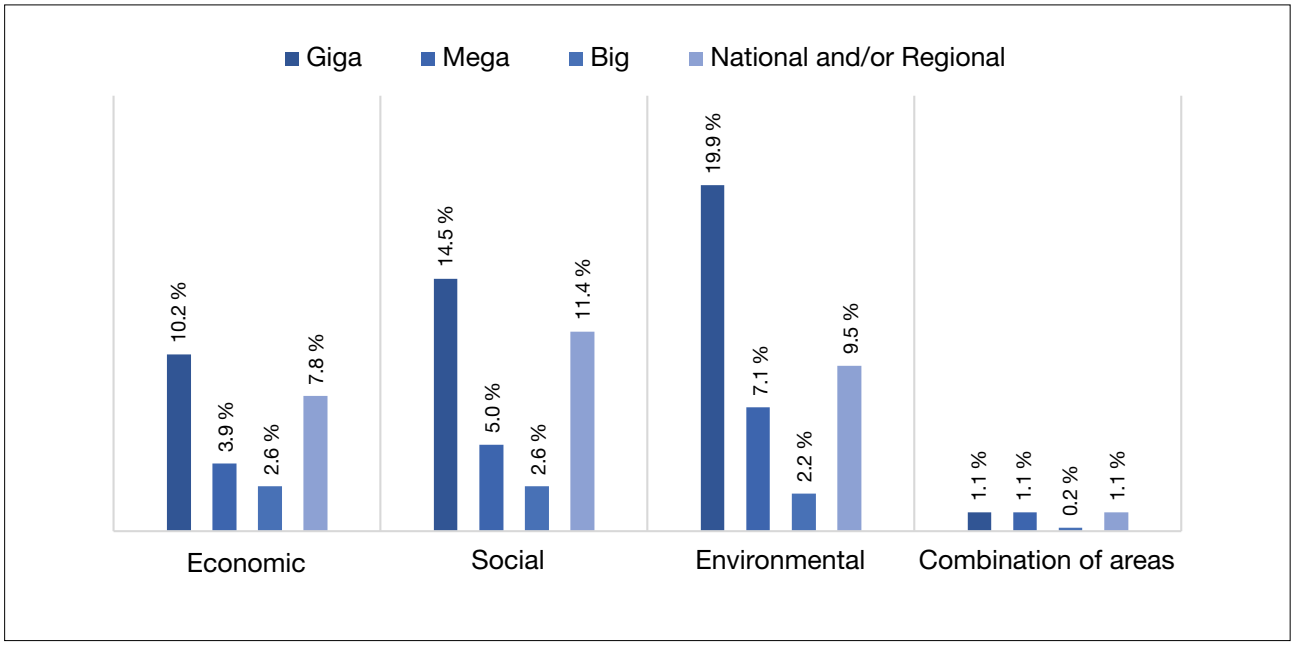


Table 8
Trends in the study of sustainability areas in relation to type of events.

	Total		Period %		
	Articles	%	1964-1999	2000-2014	2015-2020
Giga-event (*n* = 219)					
Economic	52	23.7	25.0	20.5	28.8
Social	70	31.9	31.3	31.5	33.3
Environmental	87	39.7	43.8	41.7	34.8
Others	10	4.7	0.0	6.3	3.0
Mega-event (*n* = 87)					
Economic	22	25.3	0.0	22.8	26.9
Social	25	28.7	0.0	29.8	30.8
Environmental	39	44.8	0.0	45.6	42.3
Others	1	1.2	0.0	1.8	0.0
Big event (*n* = 33)					
Economic	8	24.3	0.0	25.2	9.1
Social	13	39.4	0.0	35.0	54.5
Environmental	11	33.3	0.0	40.0	27.3
Others	1	3.0	0.0	0.0	9.1
National/regional (*n* = 134)					
Economic	35	26.1	0.0	27.4	24.6
Social	54	40.3	0.0	34.2	47.5
Environmental	45	33.6	0.0	38.4	27.9
Others	0	0	0.0	0.0	0.0

Relationship between sporting events and areas of study

Regarding the relationship between event size and sustainability (areas of sustainability investigated in each event typology), giga-events stood out as the most studied in the three areas of sustainability: economic (10.2%), social (14.5%) and environmental (19.9%). The results of national/regional events are relevant, particularly in the social (11.4%), environmental (9.5%) and economic (7.8%) areas. (Figure 4)

If the trend in sustainability studies according to the type of sporting event is considered (Table 8), giga-events were the only type of event investigated in the period 1964-1999, occurring in the environmental field (43.8%). In the period 2000-2014 the trend of studying the environmental field continued (41.7%), as well as in the period 2015-2020 (34.8%).

In relation to mega-events, the most studied area was environmental (45.6%) in the period 2000-2014 and 2015-2020 (42.3%), the opposite applies to big events, where the most recurrent area of study is social, especially in recent years (54.5%). The national/regional category also stands out, where in the years 2000-2014 the predominant area of study was the environmental area (38.4%), which, in the final period, has shifted to the social field (47.5%).

Conclusions and discussion

Based on the number of articles published on the subject, it is clear that sustainability in sporting events has been a recurring theme over the last six decades, even though it was initially neither an economic nor a political priority for governments around the world. From this fact it can be inferred that the sports sector has been integrating, to a greater or lesser extent, the global sustainable development agenda in sporting events, a policy that can be observed through the constant and gradual increase in the number of articles published since 2006, with two key years identified: 2012 and 2020. The first, possibly linked to the London 2012 Olympic Games, considered by the IOC to be the greenest games in history. In this case, the Games were a milestone, not only because they successfully integrated the concept of sustainability from the very beginning of the Olympic project, designing a sustainable and environmentally friendly urban transformation strategy, known as the "London 2012 Sustainability Plan", but also because of numerous innovative actions such as the construction of the first Olympic stadium built using surplus gas supply pipes, and the creation of the Olympic Park on polluted industrial land, turning it into the largest urban park in Europe, among others. And the second, probably linked to the implementation of the SDGs already proposed at the Sustainable Development Summit held in September 2015, reinforced in the first annual review of progress towards these goals in 2019 in the Sustainable Development Agenda organised by the UN.

On the other hand, considering international sporting events as a forum for expressing political positions (García Reyes, 2007) enables us to understand the trends regarding the organising continents. Thus, it can be observed that it is initially the European continent that upholds sustainability policy in the period 1964-2014, only to be relegated to second place by the Asian continent in the period 2015-2021. This is probably linked to the increase in the number of giga and mega sports venues on this continent, in the quest to be the world's leading power, with one further avenue being sustainable sporting events.

Another aspect to highlight is the power of some sports organisations such as the IOC and how they act as a model and guide for other sports organisations. The IOC established the IOC Sport and Environment Commission in 1995, and amended the Olympic Charter in 1996, which led to the inclusion of sustainable strategies for the hosting of the Olympic Games. In 1999, the IOC introduced Agenda 21, with the main objective of actively engaging the Olympic movement (international federations and national Olympic committees) and the world of sport in sustainable development. This can be observed by looking at how, among the typologies of events analysed, the giga-events —Olympic Games and World Cups— were always the most studied events, regardless of the time, continent, discipline or type of sustainability considered.

A few years after the wake initiated by the IOC, the democratisation of sustainability can be regarded as arriving, or having arrived, mainly seeking to extend the awareness of sustainability to society at large. In other words, while initially in the period 1964-2014 it was giga-events that were studied the most, in the period 2015-2020 these were replaced by the study of more national and regional sporting events, which demonstrates the interest and dedication of resources to implement sustainable policies in smaller sporting events.

Likewise, and in relation to the study subject, the clear predominance of environmental issues over other subjects could be linked to the growing public concern about the effects of climate change that alert the public to the need to rethink the current production system, including, in the words of Schulenkorf (2012), the organisation and hosting of sporting events in all their magnitudes, highlighting the importance they can have when it comes to reducing the negative impact on the environment.

Finally, it should be noted that there is still a long way to go. This is a relatively recent field with no consensus on the definition of sustainability and, although there are studies, they are very heterogeneous and partial. For example, studies assessing sustainability by combining the three domains are in the minority, such as that of Varnajot (2020), which reveals the sustainable implications for communities hosting the Tour de France 2020 cycling race, or that of Kim et al. (2020), which investigates how local residents perceive the impact of the three areas of sustainability at the Pyeongchang 2018 Olympic Winter Games. It would be necessary to develop a model of analysis with an integral overall perspective, bearing in mind that in integrating these three areas they must be intertwined and dependent in order for a sporting event to be sustainable. It should take into account care for the planet and people's social well-being, ensure greater equity in the social and economic dimemsions, prioritise social and environmental liveablity and environmental and economical viablity.

It can be determined that development towards the integration of sustainability in the organisation of sporting events has been steadily increasing since the emergence of the concept in the Brundtland report and its development in international sport organisations, such as the IOC, and has been integrated into the handbook on the organisation of sporting events in an undisputed way.

Limitations and future prospects

The main limitation of this study is the superficiality of the analysis of the publications identified.

With regard to future perspectives, it is recommended that the content of each research project be analysed in depth. This would allow progress to be made in identifying the development of analysis methodologies and whether or not there is a consensus on their use, as well as identifying analysis indicators and how to quantify the impact generated by sporting events.

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Physical Activity in Schoolchildren: Effect on Executive Functions, Academic Performance and Quality of Life

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Abstract

Although the literature on the effect of physical activity on different areas of human development is extensive, there are still insufficiently conclusive results on some questions concerning its potential cognitive and psychological benefits. The aim of this study was to analyse whether there were differences in the executive functions, academic performance and quality of life of primary school students according to the level of physical activity performed. The sample consisted of 333 students from Year 3 to 6 of primary school at two public schools. The PAQ-C, SENA and KIDSCREEN-27 questionnaires were administered to assess, respectively, physical activity, executive functions (attention, inhibition and emotional regulation) and quality of life. Academic performance was measured according to the grades obtained by the students. The results revealed statistically significant differences according to the level of physical activity performed by students in terms of quality of life (specifically, in the five dimensions comprising it: physical well-being, psychological well-being, autonomy and relationship with parents, relationship with friends and social support, relationship and support in the school environment). No significant differences were found in any of the three executive functions studied (attention, inhibition, emotional regulation) or in academic performance. It is important to promote socio-educational policies aimed at increasing the practice of quality physical activity among schoolchildren (i.e. ones that have the quantitative and qualitative characteristics associated with a higher quality of life in the literature). Intervening at this age is of great importance since this is when habits that will last throughout life are established.

Keywords: academic performance, cognition, executive functions, physical activity, primary school, quality of life.

Introduction

There is a large body of literature that demonstrates that the practice of physical activity (which nowadays should be considered not only from a biological perspective —"all bodily movement produced by the locomotor apparatus involving energy expenditure" (World Health Organization, 2020, p. 6)—, but from a more holistic and human perspective in which emotional facets, perceptual-motor and socio-motor capacities are included (Anguera et al., 2017; Buscà, 2022; Camerino et al., 2012; Devís, 2000), has numerous benefits on a physical level. Although its potential benefits have also been extensively studied at the cognitive and psychological level, the results on some issues have not yet been sufficiently conclusive (Chacón-Cuberos et al., 2020; Padial-Ruz et al., 2022), which explains the need for this study.

Thus, with regard to the benefits of physical activity in the cognitive domain, a topic of great interest in recent years has been determining whether the practice of physical activity is associated with an adequate level of executive functioning and academic performance in students. Executive functions are higher-level cognitive (attention, inhibition...) and affective (such as emotional regulation) processes that allow for the resolution of new or complex situations that arise in everyday life (Zelazo & Carlson, 2012). Often, studies that have analysed the effects of physical activity on executive functions have done so by adopting a limited —and therefore outdated— conception of executive functions, considering only their cognitive components and overlooking the affective ones (Pesce et al., 2021). Some of these studies indicate that children's cognitive executive functions improve after participating in a physical activity programme (Berrios-Aguayo et al., 2022). However, there are also studies that found no positive relationships between physical activity and cognitive executive functions (Padial-Ruz et al., 2022) and even those that found negative relationships (Tarp et al., 2016). Regarding affective executive functions, there are no known studies focused on their relationship with physical activity in children. All this explains the need to address this issue, assuming a contemporary conception of executive functions which also considers their affective dimension.

Academic performance, understood as the degree to which students acquire the skills and competences of an education system (Romero Sánchez & Hernández Pedreño, 2019), is a matter of political and social interest, as the progress of a country is associated with the academic level achieved by its citizens (García Prieto et al., 2021). In view of the high levels of school dropouts (Mullis et al., 2016, 2019), analysing the possible variables that affect school dropouts is of interest in order to intervene in this area. In this regard, there are certain assumptions about the positive effects of physical activity on academic performance (Berrios-Aguayo et al., 2022; De Greeff et al., 2018), although the literature shows that this is not always the case (Donnelly et al., 2017; Tarp et al., 2016). These heterogeneous results explain the need for further research.

On the other hand, and with regard to the psychological field, a construct that is currently the object of great interest is quality of life, defined as "the degree of satisfaction that the person experiences in relation to the fulfilment of their needs and objectives in relation to the living conditions that the environment offers them" (Muntaner Guasp, 2013, p. 38). It is a multidimensional construct and its assessment involves understanding the individual's own perception of his or her physical, psychological and social well-being. This perception, in turn, is affected by the degree of satisfaction of three basic psychological needs (Ryan & Deci, 2007, 2017): autonomy (the origin or source of one's own behaviour), competence (feeling of confidence and effectiveness) and relatedness (feeling connected and integrated with others). The relationship between physical activity and quality of life has been extensively studied in both healthy and unhealthy adults (Helmrich et al., 2022; Pallanch et al., 2022; Peters et al., 2019; Pucci et al., 2012), as well as in children and adolescents with different pathologies and neurological disorders. However, studies in healthy children have been scarcer (Marker et al., 2018). The results of some of these studies suggest a possible relationship between physical activity, provided it is well guided and educational, and quality of life (Jiménez Boraita et al., 2021) or one of its dimensions (Halasi & Lepes, 2022). The relevance of the topic justifies further research in this area in order to increase its understanding.

In relation to all this, the aim of this study was to analyse whether there were differences in the executive functions (attention, inhibition and emotional regulation), academic performance and quality of life of Primary School (PS) students according to the level of physical activity performed. The hypothesis postulated that there would be significant differences in the three variables (executive functions, academic performance and quality of life) depending on the level of physical activity performed, such that students who practised a higher level of physical activity would demonstrate higher levels of these variables.

Methodology

In this study, given its objective, there was no experimental manipulation of the only independent variable studied (physical activity). The absence of such a manipulation allowed participants to be classified according to their level in the independent variable, and participants' values for the dependent variables (executive functions, quality of life and academic performance) were recorded. Moreover, these values were recorded at a single point in time. All this meant that the research was a non-experimental study whose design was ex post facto prospective and simple cross-sectional (León & Montero, 2003).

Participants

The sample consisted of 333 students aged 9-12 (M = 9.90; SD = 0.50). 50.1 % were female and 49.9 % were male. The participants (selected by means of convenience sampling) belonged to two public schools in the province of Huesca, which are mainly attended by students from middle socio-economic backgrounds. All participants belonged to this socio-economic level.

The inclusion criteria were: (1) be in the 3rd, 4th, 5th or 6th year of primary school and (2) have the informed consent of parents/legal guardians. The exclusion criteria were (1) lack of an adequate level of spoken and written Spanish and (2) students with special educational needs (Organic Law for the improvement of the quality of education, 2013).

The study was carried out in compliance with the 1975 Helsinki Declaration —revised in 2013— and the Organic Law 3/2018 of 5 December on the Protection of Personal Data and Guarantee of Digital Rights. This research was approved by the Research Ethics Committee of the Autonomous Community of Aragon (PI22/066).

Materials and resources

To measure the level of physical activity, the Physical Activity Questionnaire for Children (PAQ-C) validated in Spanish by Manchola-González et al. (2017) was administered. It consists of ten items assessing the physical activity of the students in the last week (e.g. item 7: "Last weekend, how many times did you participate in sports, dance or play games in which you were very active?"). Participants have to select (on a Likert-type scale of five options, where 1 = None and 5 = 6 or more times) which response option best suits their level of physical activity. The arithmetic mean of the scores of the first nine items forms the final score, which is higher the more active the child is. The last item is not considered since it collects information on illnesses or situations that have prevented the child from carrying out this type of activity in the last seven days. In the present research, the internal consistency of the questionnaire was α = .797, which was considered an adequate value and similar to that obtained by the authors of the version validated in Spanish (Manchola-González et al., 2017).

The SENA Questionnaire (Fernández-Pinto et al., 2015) was used to assess attention, inhibition and emotional regulation (executive functions), specifically the Attention Problems, Hyperactivity/Impulsivity and Emotional Regulation Problems scales, respectively. The first consists of ten items and measures the existence of symptoms related to distractibility and inattention, focusing on lack of attentional control, which makes it possible to detect problems in directing attention to the task and maintaining it (e.g. item 4: "I get distracted and make mistakes without realising it"). Its internal consistency was α = .867. Using ten items, the Hyperactivity/Impulsivity scale (α = .878) assesses the existence of impulsive and hyperactive behaviours, characterised by motor activities that are inappropriate and excessive for the context, i.e. it assesses impairments of inhibitory control (e.g. item 3: "I find it difficult to wait for my turn"). The Emotional Regulation Problems scale (α = .853) consists of seven items measuring difficulties in understanding, regulating and expressing emotions (e.g., item 2: "Some things bother me and I don't know why"). In all three scales, high scores indicate problems in the corresponding executive functions.

Quality of life was assessed using the KIDSCREEN-27 Questionnaire (Ravens-Sieberer et al., 2014). It consists of 27 items grouped into five dimensions: (1) physical well-being: this assesses, through five items, the child's energy, physical activity and physical fitness (e.g. item 2: "Have you been able to run properly?"). Its internal consistency was α = .776; (2) psychological well-being: this assesses satisfaction with life and emotions. It consists of seven items (e.g. item 2: "Have you been in a good mood?"). An α = .730 was obtained after the removal of item 18, which moderately affected internal consistency; (3) autonomy and relationship with parents: this assesses parent-child relationships and self-perceived autonomy. It consists of seven items (e.g. item 1: "Have you had enough time for yourself?"). The α value was .787; (4) relationship with friends and social support: this assesses the child's relationships with peers including the feeling of support. It consists of four items (e.g. item 4: "Have you been able to trust your friends?"). Its internal consistency was α = .787; and (5) relationship and support in the school environment: this measures the child's perception of his/her emotions towards school through four items (e.g., item 1: "Have you felt happy at school?"). The α value was .817.

Each item should be answered on a five-point Likert-type scale where 1 = Not at all and 5 = A lot. The questionnaire provides a score for each dimension: the higher the score, the higher the quality of life in that domain.

Academic performance was assessed through the grades obtained by the participants in the core subjects in the second term in year 3-6 of primary school: Mathematics, Language, Foreign Language, Social Sciences, Natural Sciences, Physical Education and Art Education. Grades ranged from 0 to 10, with 0 being the worst grade and 10 being the best. A mark of ≥ 5 meant passing the subject.

Procedure

The management teams of the participating schools were informed of the research. Subsequently, the same was done with the parents/legal guardians of the potential participants, and those who so wished signed the informed consent form. Management teams advised on the exclusion criteria.

In order to administer the questionnaires, the researchers went to the schools on the days agreed with the respective management teams. For each class there was a 50-minute session in which a researcher and the class tutor were present. Due to the different IT resources available at each school, and even the different access to these resources among classes in the same school, the administration and completion of the questionnaires was carried out in two different formats/modalities: on paper (all students in one school and 4th year students in the second school; $n_1 = 191$) and online using the school's computers (the remaining classes in the second school; $n_2 = 142$). In all cases, students completed the questionnaires in the same order: PAQ-C, KIDSCREEN-27 and SENA (Scales of Attention Problems, Hyperactivity/Impulsivity and Emotional Regulation Problems).

In order to ascertain the academic performance of the participants, the management teams were asked for the marks obtained by the students in the seven core subjects in the second term from year 3 to 6 of Primary School: Mathematics, Language, Foreign Language, Social Sciences, Natural Sciences, Physical Education and Art Education. From these grades, the average academic performance of each participant was calculated (arithmetic mean of all the above-mentioned subjects).

Statistical Analysis

Before carrying out the corresponding data analyses to address the objective of the study, it was necessary to prepare the data in the following way.

(1) The scores referring to executive functions (attention, inhibition and emotional regulation) were inverted so that they could be interpreted in the same way as the rest of the variables, since the SENA questionnaire assessed executive function problems, meaning that, originally, high scores indicated executive problems. Thus, after this inversion, high values implied high capacity in the corresponding executive function.

(2) A student t test was calculated for each of the variables assessed through the questionnaire (physical activity, executive functions and quality of life) in order to find out whether the questionnaire administration method (paper/online) influenced the results.

(3) Participants were assigned to different groups according to their PAQ-C score, i.e. according to the level of physical activity performed: low, medium or high. Tertiles were used to establish these three levels, following the procedure used in previous studies (García-Perujo & Carrillo López, 2020).

The normality of the data and the homogeneity of variances could then be assessed using the Kolmogorov-Smirnov and Levene tests, respectively. Given the normality of the data and homogeneity of variances, one-factor ANOVAs analyses were carried out to address the research objective (to analyse whether there were differences in executive functions, quality of life and academic performance according to the level of physical activity performed). Additionally, the effect size was calculated using eta squared (η^2). In those cases where the ANOVAs results revealed significant differences, a post hoc analysis using the Scheffé test was conducted in order to determine between which levels of physical activity these differences occurred.

All analyses were performed with SPSS 23.0 (IBM, Chicago, IL, USA), with statistical significance set at $p < .05$.

Results

No significant differences were found in executive functions, quality of life or physical activity performed according to the mode of completion (paper/online) of the assessment instruments (Table 1). Therefore, no variables were excluded from the research.

Table 1
Executive functions, quality of life and physical activity: Comparison of averages according to the mode of completion of the assessment instruments (paper/online).

Variable		*t*	*p*
Executive functions	Attention	1.743	.083
	Inhibition	–1.024	.919
	Emotional regulation	1.15	.249
Quality of life	Physical well-being	1.846	.066
	Psychological well-being	0.364	.716
	Autonomy and relationship with parents	0.579	.569
	Relationship with friends and social support	–1.613	.107
	Relationship and support in the school environment	0.176	.862
Physical activity		1.335	.194

Table 2
Descriptive statistics and analysis of variance. Executive functions, academic performance and quality of life according to the level of physical activity performed (low, medium, high).

Variable		Physical activity									
		Low level		Medium level		High level					
		M	SD	M	SD	M	SD	gl	*F*	*p*	η^2
Executive functions	Attention	1.98	0.82	1.81	0.67	1.91	0.73	332	2.020	.134	.01
	Inhibition	1.90	0.86	1.84	0.76	1.99	0.82	332	0.874	.418	.01
	Emotional regulation	2.02	0.88	2.05	0.83	2.16	0.93	332	0.798	.451	.01
Academic performance		7.67	1.35	7.73	1.14	7.79	1.26	332	0.281	.754	.00
Quality of life	Physical well-being	3.40	0.70	3.86	0.58	4.20	0.56	332	38.911	.000***	.19
	Psychological well-being	3.95	0.91	4.20	0.83	4.22	0.76	332	3.441	.003**	.02
	Autonomy and relationship with parents	3.56	0.80	3.81	0.81	3.91	0.75	332	5.577	.004**	.03
	Relationship with friends and social support	1.74	0.78	1.72	0.75	2.20	0.69	332	22.731	.000***	.08
	Relationship and support in the school environment	4.02	0.80	4.30	0.67	4.38	0.59	332	14.332	.000***	.05

Note. ** = $p < .01$; *** = $p < .001$.

The ANOVAs results (Table 2) indicated the absence of statistically significant differences in the three executive functions studied (attention, inhibition and emotional regulation) and in academic performance according to the level of physical activity performed (low, medium, high). Significant differences were found according to the level of physical activity performed in all the dimensions comprising quality of life, the effect size being significant (high) in the dimension physical well-being ($F_{(2, 330)} = 38.911$; $p = .000$, $\eta^2 = 19$); medium in the dimensions relationship with friends and social support ($F_{(2, 330)} = 22.731$; $p = .000$, $\eta^2 = .08$) and relationship and support in the school environment ($F_{(2, 330)} = 14.332$; $p = .000$, $\eta^2 = .05$); and small (low) on the other two remaining dimensions: psychological well-being ($F_{(2, 330)} = 3.441$; $p = .003$, $\eta^2 = .02$) and autonomy and relationship with parents ($F_{(2, 330)} = 5.577$; $p = .004$, $\eta^2 = .03$).

Table 3
Post hoc analysis of differences in quality of life according to the level of physical activity performed.

Variable		Physical activity level		
		Low vs. Medium	Medium vs. High	Low vs. High
Quality of life	Physical well-being	.000***	.005**	.000***
	Psychological well-being	.093	.991	.049*
	Autonomy and relationship with parents	.074	.637	.005**
	Relationship with friends and social support	.985	.000***	.000***
	Relationship and support in the school environment	.011*	.752	.001**

Note. * = $p < .05$; ** = $p < .01$; *** = $p < .001$.

Table 3 presents the results of the post hoc tests, indicating between which levels of physical activity the significant differences in quality of life were found.

The results of the post hoc comparisons revealed statistically significant differences between low and high levels of physical activity in all dimensions of quality of life. In addition, in three dimensions, significant differences were also found between other levels of physical activity. Specifically: in the physical well-being dimension, significant differences were also found between the low and medium level, and between the medium and high level, meaning that in this dimension of quality of life, significant differences were detected between the three levels of physical activity; in the relationship with friends and social support dimension, significant differences were also found between the medium and high level of physical activity; and in the relationship and support in the school environment dimension, between the low and medium level of physical activity.

Discussion

The aim of this research was to analyse whether there were differences in the executive functions, academic performance and quality of life of students from Year 3 to Year 6 of primary school according to their level of physical activity. The hypothesis postulated the existence of significant differences across all variables, such that higher levels of physical activity would be associated with higher levels of executive functions, academic performance and quality of life.

The results obtained only partially corroborated this hypothesis, given that significant differences were only found in quality of life (in its five dimensions) but not in executive functions or academic performance. Therefore, it can be concluded that, in this research, a high level of physical activity was positively associated with a higher quality of life level. This result is in line with previous works (Halasi & Lepes, 2022; Jiménez Boraita et al., 2021). Lubans et al. (2016) proposed a model attempting to explain how physical activity affects quality of life by operating through neurological, psychosocial and behavioural mechanisms. These authors argue that being physically active releases neurotransmitters, improves mood, increases social connectedness and enhances sleep quality (in addition to other mechanical processes), all of which interact and have an effect on subjective perceptions of well-being and quality of life.

On the other hand, the fact that no significant differences were found in the three executive functions analysed or in academic performance contrasts with much of the existing literature (Berrios-Aguayo et al., 2022; De Greeff et al., 2018; Escolano-Pérez & Bestué, 2021). However, there are also studies which, like this one, reported no effect on executive functions or academic performance depending on the level of physical activity performed (Donnelly et al., 2017; Tarp et al., 2016). These discrepancies between results may be due to the different procedures and instruments used to assess the variables of interest, as well as differences in the characteristics of the samples studied in each case. Other variables that may help explain the differences in results between studies include the following. According to various authors (Berrios-Aguayo et al., 2022), different features of physical activity (such as duration, frequency, intensity and specific type of physical activity performed) have been found to be significant moderators of the association between physical activity and cognitive functions. Thus, a minimum of 150 minutes per week of moderate-intensity, cognitively demanding physical activity (i.e. requiring attention and cognitive effort/commitment as is the case, for example, in

team and competitive sports where numerous and rapidly changing stimuli are involved) is considered to be the most cognitively beneficial (Chacón-Cuberos et al., 2020). However, in the present study, despite establishing 3 groups/levels of physical activity practice (low, medium and high), the instrument used does not allow for ensuring that the group of participants which corresponds to a high level of physical activity practice performed said physical activity with sufficient intensity, frequency and/or duration to produce benefits at a cognitive level (Contreras-Osorio et al., 2021). The instrument also does not reveal what kind of physical activity they performed. It could be that even with regular moderate-vigorous physical activity, there is no effect on cognitive processes as the activity in question is not cognitively demanding but rather involves automated movements, for example, running (Van der Niet et al., 2015). Thus, in the future it would be interesting to look at the qualitative information provided by participants in item 1 of the PAQ-C, requiring them to indicate which specific type/s of physical activity were performed during the last week.

There is also research indicating that physical activity affects some executive functions, but not others, with discrepancies between studies as to which executive functions are affected and which are not (Contreras-Osorio et al., 2022; Van Der Niet et al., 2015). Moreover, there are studies that indicate that, even when considering the same executive function, its relationship with physical activity will depend on the task used for its assessment or even on the parameters considered in that task. In this respect, Van Der Niet et al. (2015) found that, based on global assessment parameters, only the executive function of planning (considered highly complex and late-developing) was affected by physical activity performed, but not other less complex and earlier-developing executive functions, such as working memory, flexibility, attention or inhibition (the latter two addressed in this research). However, when looking at different assessment parameters of the executive planning function individually, it was found that only total task execution time was affected by physical activity, not reaction time. This evidences the complexity of the physical activity-cognition relationship and the need for further research on this topic.

The results obtained in this study may be of interest to researchers, policy makers and practitioners in the field of physical activity, education and health. However, they should be considered with caution in view of the following limitations. Firstly, in the present study, self-reporting was used as the main instrument for collecting information. Its use entails two well-known limitations: social desirability and the fact that it assesses not the behaviours under study but the informant's perception or recollection of them (Hildebrand & Ekelund, 2017). For this reason, it would be interesting in the future to combine the information collected through this type of instrument with that collected through other procedures and instruments, since all instruments have advantages and limitations (Van Der Veer et al., 2020). Thus, accelerometers could be used as a complementary instrument for the assessment of physical activity, although the PAQ-C questionnaire has already been validated since its creation by Kowalski & Crocker (1997), and good correlations have been obtained compaired to accelerometry. For the assessment of executive functions, information collected through self-reporting could be complemented with information obtained through the administration of performance tests, information from third party informants (teachers and/or parents/guardians) and information obtained through systematic observation. The literature evidences that each of these procedures focuses on the assessment of different aspects of executive functions (Escolano-Pérez et al., 2022), so their complementary use would facilitate a more holistic understanding of these cognitive processes and the effect that the practice of physical activity can have on them. In relation to the assessment of quality of life, given that by its very definition quality of life implies a subjective component and its assessment arises from lived experiences (Muntaner Guasp, 2013), the use of self-reporting would be a study strength rather than a limitation in this case. Understanding the key aspects of quality of life from the perspective of its protagonists is a topic of recent interest in research and among the various educational, social and political agents (Requejo et al., 2022). On the other hand, although students' academic performance was not assessed through self-reporting but through the grades provided by teachers, this could also be a limitation. Although this method is widely used in the literature, and it is the legal procedure that determines whether or not a student progresses to a higher grade in Spain, it may constitute another limitation, since the level of demand each teacher places on their students may be different (Escolano-Pérez & Bestué, 2021). To overcome this limitation, standardised assessment instruments for academic performance and academic competences could be applied, although this requires greater investment in terms of human and material resources. Other limitations of the study are the size of the sample, its non-random selection and the fact that it was only drawn from public schools located in one province. Consequently, it would be appropriate to increase the sample size, such that it

could also be randomly selected from all the schools in the province, autonomous community, or even in Spain, with the aim of generalising the results. Finally, the fact that this is a one-off study, and therefore causal inferences cannot be drawn, is another limitation. In this respect, it would be desirable to be able to carry out longitudinal studies.

Future research would need to overcome the above limitations and explore other relevant questions such as whether the type and level of physical activity performed affects academic performance in each of the subjects considered individually, or whether it affects executive functions other than those addressed in this study (e.g., planning or problem solving, which are considered to be more complex functions). It would also be interesting to analyse the effect that other variables (gender, grade, socio-economic level, etc.) may have on the variables studied, as these all depend on a multitude of factors that are impossible to address in a single study. In this sense, it would be of particular interest to identify which factors influence the type and levels of physical activity among students. Intervening in these areas would contribute to improving the quality of life of students, which is an international goal. This is stated in the 2030 Agenda for Sustainable Development adopted by the member states of the United Nations, and specifically in Sustainable Development Goal (SDG) 3: health and well-being, which aims to ensure healthy lives and promote well-being for all people at all ages, especially the most vulnerable —including children—. Intervening during the school years is of great importance since this is when habits that will last throughout life are established (Pastor-Vicedo et al., 2021). In this sense, a socio-educational policy and educational organisational structure is needed to enable professionals to implement innovative strategies based on neurocognitive contributions such as, for example, planning activities that require students to be physically active through different games (especially open games in which the rules and objective are explained, but not instructions on how to play the game) and varied sports activities that can be chosen by the students themselves according to their preferences; that these are carried out with peers who provide social support and positive interactions; that these are cognitively challenging as well as enjoyable and interesting; that these are carried out regularly and continuously (the longer the intervention, the greater the benefits) and during the early hours of the day (before the start of formal lessons, so that their benefits on neurotransmitters that improve concentration and attention can be exploited). Moreover, the benefits are maximised if these physical activities are carried out in nature (e.g. parks) and are supervised by a professional who, guided by the Self-Determination Theory, develops an autonomy-supportive style (since building autonomy support not only increases the perception of this basic psychological competence but also that of the other two: competence and relationship) (Alesi et al., 2016; Campos et al., 2018; De Greeff et al., 2018; Egger et al., 2019; Ellinger et al., 2022; Kolovelonis et al., 2022; Lamoneda & Huertas-Delgado, 2019; Vella et al., 2023).

Conclusions

The findings of this study indicate that students' self-perceived quality of life, but not their executive functions or academic performance, varied according to their level of physical activity, with those who reported a higher level of physical activity experiencing a higher quality of life.

Helping students to achieve and maintain a level of physical activity that improves their quality of life and health is one of the main objectives of the physical education curricula (Kolovelonis & Goudas, 2022), and is certainly a foundation for achieving SDG 3 of the 2030 Agenda. All this requires the development and implementation of socio-educational policies that promote the inclusion of educational and innovative physical activities based on neurocognitive contributions, i.e. physical activities that have certain quantitative characteristics (in terms of duration, frequency or intensity) but also qualitative ones (type of activity, variety, novelty, contribution to the satisfaction of students' basic psychological needs, execution in nature, etc.).

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