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School Bullying and Sports Participation Among Adolescents in the Andorran Educational System

David Escofet-Martín^{1*} , Agnès Ros-Morente² , and Cristina Torrelles-Nadal³

¹ National Institute of Physical Education – Pirineus, University of Lleida, Lleida (Spain).

² University of Lleida, Lleida (Spain).

³ National Institute of Physical Education – Lleida, University of Lleida, Lleida (Spain).



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*Corresponding author:

David Escofet Martín
dem5@alumnes.udl.cat

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Abstract

The present study aimed to examine school bullying (SB) among lower secondary education students in the Andorran educational system, considering sociodemographic variables, the perception of being bullied, and sports participation. A descriptive, comparative, cross-sectional research design was used. The sample consisted of 353 lower secondary education students from the Andorran educational system (49.01% female; $M_{age} = 13.76$; $SD = 1.22$). The Cisneros Self-test questionnaire was used to assess the SB index and its dimensions. Questions were also included to determine gender, educational cycle, perception of being bullied, whether participants practiced sports, and sport type. Descriptive analyses, nonparametric Mann-Whitney U tests, and binary logistic regression were performed. The results showed an SB prevalence of 29.18% and a substantial discrepancy between the perception of being bullied and the score obtained on the Cisneros Self-test, with a high proportion of inaccurate SB identification (26.06%). No significant differences were observed between sports participants and nonparticipants or between sport types, although gender differences were found among sports participants ($p = .049$; $r = .138$). The dimensions of contempt and ridicule ($OR = 4.761$; 95% CI [2.206, 10.275]; $p < .001$) and theft ($OR = 2.356$; 95% CI [1.154, 4.809]; $p = .019$) were also associated with a greater likelihood of inaccurate SB identification, whereas aggression ($OR = 0.289$; 95% CI [0.116, 0.720]; $p = .008$) facilitated more accurate identification. These findings underscore the importance of developing comprehensive policies aimed at improving the identification and prevention of SB among young people.

Keywords: adolescence, bullying, gender differences, sports, unperceived victimization

Introduction

School bullying (SB) is a problem that affects approximately 32% of young people worldwide (UNESCO, 2019). Being bullied can have short-, medium-, and long-term consequences (Arseneault, 2017; Sigurdson et al., 2015) in various areas, including psychological, occupational, academic, and physiological domains (Agle et al., 2021; Galán-Arroyo et al., 2023; González-Cabrera & Machimbarrena, 2023).

SB is defined as repeated aggression over a prolonged period through negative behaviors carried out by one or more peers in a situation involving a power imbalance (Olweus, 1998). Consistent with this definition, UNESCO (2020) states that SB involves intentionality, causes social, emotional, and/or physical consequences for the victim, and occurs in contexts in which the victim has difficulty receiving effective support.

Several authors have highlighted the limited literature on the relationship between SB and sports participation, as well as the need to further explore the variables that mediate this interaction (Carrasco-López et al., 2024; Escofet-Martín et al., 2025a; Martínez-Baena & Faus-Boscá, 2018). In this context, Tilindiené et al. (2010a) reported that athletes were less likely to be bullied, whereas other authors have described a higher prevalence among sports participants (Rusillo et al., 2024; Zapata-López et al., 2024).

Gender has also been shown to play an important role in this relationship. Several studies have emphasized the need to consider gender in analyses of SB (Martos-García et al., 2024; Rodkin et al., 2015), given the inconsistent findings in the existing empirical evidence. Marracho et al. (2021) and Vveinhardt and Fominiene (2022) reported higher prevalence rates among males than females; however, differences between genders have been reported to be smaller in terms of victimization (Díaz-Aguado et al., 2013). Other studies found no significant gender differences among sports participants (Benítez-Sillero et al., 2022; Escofet-Martín et al., 2025b; Tilindiené et al., 2010b). These contradictory findings justify the need for further research into the relationship between SB, sports participation, and gender.

The scientific literature has examined the incidence of SB in sports contexts by comparing individual and team sports. Marracho et al. (2021) found higher prevalence rates of SB in team sports (26.70%) than in individual sports (19.10%). However, they found no significant differences according to sport type. Vveinhardt and Fominiene (2022), in turn, identified a much higher prevalence of SB in team sports (36.60%) than in individual sports (16.60%), with significant differences between the two groups.

Another variable to consider is the perception of being bullied. Several studies have highlighted that adolescents are familiar with SB situations but do not always identify them as an actual form of violence (Postigo et al., 2019; Rawlings,

2019). They tend to interpret these acts of aggression as mere jokes among peers and, when they do identify them as SB, may ultimately blame the victims for being bullied because of their behavior.

Difficulty identifying SB behaviors may be related to theories concerning the normalization of violence (Bourdieu, 2000; Galtung, 1990), according to which certain forms of aggression eventually come to be perceived as natural or socially acceptable. Moreover, when adolescents identify these behaviors as SB, they may experience psychological distress arising from the contradiction between their perceptions and the reality they observe. This situation could be explained by the tendency to reduce such distress by reinterpreting or minimizing conflict situations, for example, by viewing SB as mere jokes, which could be interpreted through Cognitive Dissonance Theory (Festinger, 1957).

This phenomenon is amplified by the observation and reproduction of behaviors in the school environment, where students tend to imitate their peers' behaviors, particularly when these are accepted by the group, in line with the principles of social learning theory (Bandura, 1977). This is compounded by the influence of the family, media, and social contexts, which play an important role in the normalization of violence (Valente et al., 2024). In this regard, educational and sports settings are not isolated spaces but rather function as a social microcosm in which the dynamics, values, and problems present in society are reproduced (Bronfenbrenner, 1979), significantly influencing how adolescents interpret and respond to situations involving violence.

In their study, Connell et al. (2018) found a 34.10% mismatch in the perception of SB. Specifically, this mismatch was observed among victims of SB who did not identify themselves as such. The authors also explained that traditional SB (aggression, insults, pushing, etc.) and relational SB (social exclusion and rumors) are easier for adolescents who experience them to recognize. They also suggested that SB becomes normalized and is viewed as acceptable in situations in which it is perceived that all students experience it.

In a recent study, Larrañaga et al. (2024) reported an SB prevalence of 27.90%, while 7% of students perceived themselves as being bullied. These results indicated that 20.90% of students inaccurately identified SB. They also suggested that verbal and physical SB is more readily identified than relational SB. Another study reported an SB prevalence of 36.70%, while 24.20% of students perceived themselves as being bullied, with a discrepancy of 12.50%. In this case, victims who were able to identify SB were mostly those who experienced threats and social exclusion, whereas those who did not identify it accurately

tended to experience direct verbal aggression (Sidera et al., 2020). These findings reveal contradictions regarding the identification of SB and the types of bullying that mediate this interaction. Furthermore, female adolescents have been reported to use more indirect forms of SB (social exclusion and rumor spreading), whereas male adolescents tend to use direct forms (aggression or insults) (Jiménez-Barbero et al., 2012).

Based on the literature reviewed, the overall objective of the study was to examine SB and differences in SB according to sociodemographic variables (educational cycle and gender), perception of being bullied, and sports participation (sports participants/nonparticipants; individual/team sport) among lower secondary education students in the Andorran educational system. The following specific objectives were derived from this overall objective: (1) to describe the overall prevalence of SB and its prevalence according to its dimensions (contempt and ridicule, coercion, restriction of communication, aggression, intimidation and threats, social exclusion and blocking, verbal harassment, and theft); (2) to analyze the degree of agreement between the perception of being bullied and scores on the Cisneros Self-test; (3) to compare whether there were significant differences in the SB index according to gender, sports participation, sport type, and the perception of being bullied; and (4) to identify the dimensions of SB that best predict inaccurate SB identification using a logistic regression model.

With regard to the second objective, it was hypothesized that there would be a significant discrepancy between the perception of being bullied and the scores obtained on the Cisneros Self-test, with students underestimating SB. Regarding the third objective, it was hypothesized that adolescents in the Andorran educational system who participated in team sports would report a higher prevalence of SB than those who participated in individual sports. Finally, the fourth objective led to the hypothesis that individuals with higher scores on the more explicit dimensions of SB (aggression) would have a greater ability to identify SB. By contrast, the less explicit dimensions (social exclusion) would be less readily identified.

Because this study combines descriptive, comparative, and predictive analyses, some objectives do not have associated hypotheses because they are exploratory or descriptive in nature.

Methodology

Research Design

This study adopted a quantitative methodological approach, with a descriptive, comparative, cross-sectional design,

as data were collected at a single point in time without manipulating the variables. The comparative component involved comparisons among the different subgroups in the sample (gender, educational cycle, sports participation, and perception of being bullied). A predictive analysis was also conducted using binary logistic regression to explore the influence of the factors on the SB index.

Participants

The sample consisted of 353 students from the Andorran educational system, with a mean age of 13.76 years ($SD = 1.22$), from the lower secondary schools of Encamp ($N = 256$; 72.52%), Santa Coloma ($N = 59$; 16.71%), and Ordino ($N = 38$; 10.76%). Students from all grades at the three lower secondary schools in the Andorran educational system participated, with their legal guardians authorizing their participation through informed consent. Of the total participants, 173 were female (49.01%), 179 were male (50.71%), and one person identified with another gender option (0.28%).

The population of the second cycle of education in the Andorran educational system is approximately 1,200 students. With a sample size of 353 participants, the margin of error was 4.38%, with a 95% confidence level. These conditions provide an adequate basis for interpreting the study results.

Instruments

The instrument was divided into three sections: (a) Section 1. Sociodemographic variables, which included questions about the lower secondary school attended, grade, gender, age, and perception of being bullied (yes/no); (b) Section 2. Sports variables, which included questions to determine whether participants practiced sports (yes/no) and the type of sport they practiced (individual/team); (c) Section 3. Assessment of SB, consisting of items from the Cisneros Self-test (Piñuel & Oñate, 2012) to assess the SB index, intensity, and dimensions.

The Cisneros Self-test (Piñuel & Oñate, 2012) consists of 50 items that assess the SB index, intensity, and eight dimensions of the different types of SB: intimidation and threats, theft, verbal harassment, restriction of communication, coercion, social exclusion and blocking, aggression, and contempt and ridicule. Scores range from 50 to 150 points, with scores of 59 or higher considered indicative of SB. The instrument takes between five and 10 minutes to complete. Responses are provided on a three-point Likert-type scale: 1 (Never), 2 (Rarely), and 3 (Often), and the questions do not specify a time frame for SB. The instrument has a reliability coefficient (Cronbach's alpha) of 0.962.

Procedure

Participants were selected using nonprobability convenience sampling with institutional authorization. Data were collected between May and June 2025 using a Microsoft Forms questionnaire during school hours, in homeroom sessions, with informed consent from the families.

Once the study was completed, a detailed report on the prevalence rates found according to the variables analyzed was provided to the Andorran Ministry of Education and Higher Education. The possibility of implementing interventions and preventive actions aimed at case detection, awareness raising, and support for potential victims was also offered.

The study received approval from the Research and Transfer Ethics Committee of the University of Lleida, certified on December 18, 2024, as documented in minutes 14/2024, and complied with ethical principles for research involving human participants.

To ensure replicability and promote open science, the study data and results are openly available in the CORA data repository through the DOI: <https://doi.org/10.34810/data2470>.

Data Analysis

Data analysis was performed using IBM SPSS Statistics 30.0. After confirming the non-normality of the distribution using the Kolmogorov-Smirnov test, a descriptive analysis of the SB index and its dimensions, as well as of the different study groups, was conducted. Subsequently, inferential analyses were performed using the Mann-Whitney *U* test to examine differences according to educational cycle, gender, sports participation and sport type, as well as the perception and identification of SB. The SB identification variable was also created by cross-tabulating the perception of being bullied and SB according to the Cisneros Self-test, and binary logistic regression was performed to analyze the predictive power of the different SB dimensions for accurate and inaccurate identification of SB.

Results

The SB index had a mean score of 58.50 points ($SD = 12.30$), with 29.18% of the sample scoring at or above the cutoff established for SB (59 points).

As shown in Table 1, most of the groupings showed similar values for the SB index, with more pronounced descriptive differences in the variables related to the perception of being bullied and its identification.

Table 1

Descriptive analysis by grouping and SB index

Grouping	Groups	<i>N</i>	<i>Mdn</i>	IQR	P25 - P75	<i>M</i>	<i>SD</i>
Intensity	Low to medium	250 (70.82%)	52.00	5	50 - 55	52.70	2.73
	Almost high	53 (15.01%)	62.00	4	60 - 64	62.06	2.53
	High	36 (10.20%)	74.50	10	70 - 80	76.06	5.78
	Very high	14 (3.97%)	102.00	12	96 - 108	103.36	11.03
SB	No SB	250 (70.82%)	52.00	5	49.50 - 54.50	52.70	2.73
	SB	103 (29.18%)	67.00	16	60 - 76	72.56	14.90
Cycle	First cycle	243 (68.84%)	55.00	9	50.50 - 59.50	58.44	11.63
	Second cycle	110 (31.16%)	53.50	9	50 - 59	58.62	13.73
Gender ^a	Female	173 (49.01%)	54.00	11	48.50 - 59.50	60.01	13.86
	Male	179 (50.71%)	54.00	9	50 - 59	57.07	10.46
Sports participation	No	149 (42.21%)	54.00	10	50 - 60	58.62	11.83
	Yes	204 (57.79%)	54.00	10	50 - 60	58.40	12.67
Sport type	Individual	100 (49.50%)	53.50	10	48.50 - 58.50	58.06	11.94
	Team	102 (50.50%)	54.50	9	50 - 59	58.50	13.37
Sports participants	Female	81 (39.71%)	55.00	13	48.50 - 61.50	60.88	15.04
	Male	123 (60.29%)	53.00	8	49 - 57	56.77	10.57
Perception of being bullied	No	338 (95.75%)	54.00	8	50 - 58	57.60	11.10
	Yes	15 (4.25%)	75.00	14	68 - 82	78.60	19.75
SB identification	Accurate	261 (73.94%)	52.00	6	49 - 55	54.18	8.03
	Inaccurate	92 (26.06%)	65.50	16	58.50 - 73.50	70.75	14.00

Note. Authors' own work. a = other options/omitted, *Mdn* = median, IQR = interquartile range.

Table 2
Distribution of school bullying dimensions by standardized categories (n, %)

Dimension	Very low to medium	Almost high	High	Very high
Contempt and ridicule	271 (76.77%)	34 (9.63%)	35 (9.92%)	13 (3.68%)
Coercion	285 (80.74%)	37 (10.48%)	18 (5.10%)	13 (3.68%)
Restriction of communication	274 (77.62%)	29 (8.22%)	41 (11.61%)	9 (2.55%)
Aggression	319 (90.37%)	11 (3.12%)	17 (4.82%)	6 (1.70%)
Intimidation and threats	280 (79.32%)	66 (18.70%)	1 (0.28%)	6 (1.70%)
Social exclusion and blocking	244 (69.12%)	70 (19.83%)	25 (7.08%)	14 (3.97%)
Verbal harassment	290 (82.15%)	38 (10.76%)	12 (3.40%)	13 (3.68%)
Theft	285 (80.74%)	37 (10.48%)	18 (5.10%)	13 (3.68%)

Note. Authors' own work. Percentages = valid cases ($N = 353$), category results ($n, \%$).

Table 3
Cross-tabulation of perception, Cisneros Self-test results, and SB identification

Groups	N (%)	SB identification	N (%)
Does not perceive being bullied, Not bullied ¹	248 (70.25%)	Accurate	261 (73.94%)
Perceives being bullied, Bullied ¹	13 (3.68%)		
Does not perceive being bullied, Bullied ¹	90 (25.50%)	Inaccurate	92 (26.06%)
Perceives being bullied, Not bullied ¹	2 (0.57%)		

Note. Authors' own work. ¹ = according to the Cisneros Self-test.

Table 4
Results of the Mann-Whitney U test for the SB index according to grouped variables

Grouping	Groups	N	U	Z	p	r	Mean Rank
Cycle	First cycle	243	12795.000	-0.647	.518	.034	179.35
	Second cycle	110					171.82
Gender ^a	Female	173	13933.500	-1.636	.102	.087	185.46
	Male	179					167.84
Sports participation	No	149	14631.000	-0.603	.546	.032	180.81
	Yes	204					174.22
Sport type ^a	Individual	100	4957.000	-0.348	.728	.024	100.07
	Team	102					102.90
Sports participants	Female	81	4177.500	-1.967	.049	.138	112.43
	Male	123					95.96
Perception of being bullied	No	338	746.500	-4.659	< .001	.248	171.71
	Yes	15					296.23
SB identification	Accurate	261	1098.500	-13.056	< .001	.694	135.21
	Inaccurate	92					295.56

Note. Authors' own work. a = other options/omitted.

As shown in Table 2, most participants were concentrated in the very low or medium levels across all SB dimensions. However, dimensions such as restriction of communication, contempt and ridicule, and social exclusion and blocking showed a greater relative presence in the high and very high categories.

The comparison between the perception of being bullied and the classification obtained based on the SB index cutoff showed a high prevalence of errors in SB identification. Cross-tabulating the two variables identified four groups: those who did not perceive themselves as being bullied and did not present SB according to the Cisneros Self-test ($N = 248$; 70.25%), those who did not perceive themselves as being bullied but did present SB according to the index ($N = 90$; 25.50%), those

who perceived themselves as being bullied without reaching the established cutoff ($N = 2$; 0.57%), and those who perceived themselves as being bullied and did present SB according to the Cisneros Self-test ($N = 13$; 3.68%).

Based on this classification, two types of identification were distinguished: accurate, when there was agreement between the perception of being bullied and the results obtained on the Cisneros Self-test, and inaccurate, when there was a discrepancy between the two. This distribution is presented in Table 3.

Table 4 presents the results of the Mann-Whitney U test for the SB index according to the grouped variables. Statistically significant differences were observed only among sports participants according to gender, as well as for the variables perception of being bullied and SB identification.

Among adolescents who participated in sports, significant differences in the SB index were identified according to gender ($p = .049$), with higher mean ranks in the female group, although the effect size was small ($r = .138$).

With regard to the perception of being bullied, participants who reported being bullied obtained significantly higher scores on the SB index ($p < .001$), with a small-to-moderate effect size ($r = .248$).

Finally, significant differences were observed according to SB identification, such that adolescents with inaccurate identification had a considerably higher SB index ($p < .001$), with a large effect size ($r = .694$).

To analyze the SB dimensions associated with its identification, a binary logistic regression model was estimated using the standardized categories of the Cisneros Self-test to ensure model adequacy.

Table 5 revealed that three SB dimensions were significantly associated with inaccurate SB identification. First, the contempt and ridicule dimension was the most relevant predictor ($\beta = 1.560$; $p < .001$), with an odds ratio (OR) of 4.761 (95% CI [2.206, 10.275]), indicating that adolescents with high scores on this dimension were more than four times as likely to identify SB inaccurately. The theft dimension also showed a significant association ($\beta = 0.857$; $p = .019$), approximately doubling the risk of inaccurate identification (OR = 2.356; 95% CI [1.154, 4.809]). By contrast, the aggression dimension showed an inverse effect ($\beta = -1.240$; $p = .008$), indicating a lower likelihood of inaccurately identifying SB (OR = 0.289; 95% CI [0.116, 0.720]). The remaining dimensions did not reach statistical significance, so no association with identification error could be established in this model.

Table 5

Summary of binary logistic regression – dependent variable, inaccurate SB identification

Categorized dimension	β	SE	Wald	p	OR	95% CI for OR
Contempt and ridicule	1.560	0.392	15.809	< .001	4.761	[2.206, 10.275]
Coercion	0.456	0.291	2.449	.118	1.577	[0.891, 2.792]
Restriction of communication	0.458	0.251	3.331	.068	1.580	[0.967, 2.583]
Aggression	-1.240	0.465	7.111	.008	0.289	[0.116, 0.720]
Intimidation and threats	0.184	0.430	0.182	.669	1.202	[0.517, 2.790]
Social exclusion and blocking	0.245	0.323	0.577	.447	1.278	[0.679, 2.404]
Verbal harassment	-0.113	0.410	0.076	.783	0.893	[0.400, 1.994]
Theft	0.857	0.364	5.543	.019	2.356	[1.154, 4.809]

Note. Authors' own work. β = coefficient, SE = standard error, OR = odds ratio, CI = confidence interval (95%).

Discussion

The present study examined SB among lower secondary education students in the Andorran educational system, considering sociodemographic variables and sports participation. The results showed an SB prevalence of 29.18%, with a higher concentration in the high and very high categories for the dimensions of contempt and ridicule, social exclusion and blocking, and restriction of communication. A substantial discrepancy was also identified between the perception of being bullied and the results of the Cisneros Self-test, with adolescents who inaccurately identified SB obtaining significantly higher scores. No significant differences in SB were observed between genders, between sports participants and nonparticipants, or between sport types. However, differences were found among sports participants according to gender, as well as according to the

perception of being bullied and SB identification. Finally, SB dimensions with predictive capacity for inaccurate SB identification were identified, thereby addressing the objectives of the study.

The prevalence observed in the present study is consistent with previous literature (Ariani et al., 2025; Biswas et al., 2020; Modecki et al., 2014). However, the Andorran context has distinctive characteristics, such as population size, the educational system, and culture. Johansson et al. (2022) noted that the differences observed in SB may be attributable to social, cultural, and organizational factors specific to each educational system. They also indicated that schools are not isolated spaces but rather social contexts influenced by the sociocultural environment (Bronfenbrenner, 1979), which may affect both interaction dynamics and responses to SB situations.

With regard to sports participation, a significant gender difference was observed among sports participants. This result contradicts previous studies that reported higher prevalence rates among males (Marracho et al., 2021; Vveinhardt & Fominiene, 2022) or found no significant gender differences in SB (Benítez-Sillero et al., 2022; Escofet-Martín et al., 2025b; Tilindienè et al., 2010b), as females in the present study obtained significantly higher scores on the SB index.

This finding reinforces the need to continue investigating the role of gender in SB (Martos-García et al., 2024; Rodkin et al., 2015) and suggests the need to develop gender-sensitive policies for the prevention, detection, and intervention of SB to contribute to its eradication (Díaz-Aguado et al., 2013).

Regarding sport type, no significant differences in SB were observed between participants in team and individual sports, consistent with the results of Marracho et al. (2021), but in contrast to those of Vveinhardt and Fominiene (2022). Similarly, no differences were identified between sports participants and nonparticipants. These findings do not consistently support any of the previous studies suggesting that sports participants are less likely to be bullied (Tilindienè et al., 2010a) or, conversely, more likely to be bullied (Rusillo et al., 2024; Zapata-López et al., 2024). It is important to emphasize that the quality of the sports experience is a relevant factor. Factors such as the influence of role models for athletes, the team environment, the competitive setting, or the role of coaches may foster certain relational dynamics that increase the risk of SB, particularly when aggressive behaviors are normalized or supervision is insufficient (Evans et al., 2016; Kalina et al., 2024; Nery et al., 2018). Therefore, further research is needed into the different variables that mediate this relationship (Carrasco-López et al., 2024; Escofet-Martín et al., 2025a; Martínez-Baena & Faus-Boscá, 2018).

Another important finding in efforts to address SB is the high rate of inaccurate identification found in the sample. The data indicate a high proportion of inaccurate SB identification, suggesting a concerning normalization of violence among adolescents, as they regard SB as mere jokes or blame the victim (Postigo et al., 2019). The study results are close to the discrepancy reported in previous literature. Specifically, the discrepancy observed was 8.04% lower than that reported by Connell et al. (2018) and 13.56% higher than that described by Sidera et al. (2020), who reported an inaccurate identification rate of 12.50%. The study whose findings were closest to those obtained in the present study was that of Larrañaga et al. (2024), which reported a rate 5.16% lower. Taken together, these studies and the present research suggest inaccurate SB identification rates ranging from 34.10% to 12.50%, reinforcing the concern expressed above.

Furthermore, if these behaviors are observed and normalized by the group, they will be accepted as valid, a code of silence will emerge, and a culture of bullying will become established in schools. In this context, the lack of specific training among teachers, particularly Physical Education teachers, may hinder the detection of and intervention in SB situations. Therefore, training initiatives should be promoted for both practicing and preservice teachers, and the interventions they implement should also be reviewed (García-López & González, 2023; Ríos-Valdés et al., 2025). It is also essential to promote social and administrative policies aimed at curbing the normalization of violence in other contexts, including family, media, and social settings (Valente et al., 2024). Parenting styles also play a crucial role, as avoiding authoritarian parenting practices may help reduce SB behaviors. In this regard, it is essential to implement family guidance programs that promote positive parenting (Charalampous et al., 2018). Acting only within educational and sports contexts does not ensure effective intervention, as schools, secondary schools, and sports clubs or centers are settings in which the behaviors present in the societies to which they belong are reproduced (Bronfenbrenner, 1979).

To deepen our understanding of SB, it is essential to analyze how the different dimensions influence its identification by adolescents. The data from the present study indicate a statistically significant association between SB identification and three of its dimensions. First, the contempt and ridicule dimension showed a particularly relevant association, as high levels of this dimension increased the likelihood of inaccurate SB identification more than fourfold. The theft dimension was also associated with a greater risk of identification error, approximately doubling the likelihood of inaccurate SB identification.

By contrast, the aggression dimension showed an inverse association, as high levels were associated with a greater likelihood of accurately identifying SB and reduced the likelihood of inaccurate identification by more than 70%. This finding differs from that reported by Sidera et al. (2020), who observed no significant relationships between SB identification and the dimensions of aggression, intimidation and threats, or verbal harassment. However, the results partially agree with those of Connell et al. (2018) and Larrañaga et al. (2024), who indicated that physical aggression facilitates SB identification.

This difference could be explained by the explicit and overt nature of physical aggression, in contrast to more subtle forms of SB, such as contempt and ridicule and theft, which tend to become normalized in interpersonal interactions. Aggression occurs more explicitly and causes physical and psychological harm to victims, facilitating its recognition. By contrast, failure to identify covert forms of violence may contribute to their normalization, with important long-term implications, as being a victim or perpetrator during adolescence has been

associated with the continuation of violent behaviors into adulthood and even in intimate relationships (Adhia et al., 2019; Ruiz-Narezo et al., 2020), within what is known as the cycle of violence (Widom, 1989).

Therefore, there is a clear need to address the accurate identification of all dimensions of SB through the development of comprehensive educational policies. These policies should be accompanied by programs that foster self-esteem, emotional self-efficacy, the development of secure bonds, and resilience, recognizing that accurate identification of SB is a first step toward breaking the cycle of violence.

Conclusions

The results of the present study make assistance contribution to the understanding of SB among lower secondary education students in the Andorran educational system, providing data that should be taken into account in future educational and social policies. It should also be considered that the Andorran context has a limited research tradition in the study of SB, particularly in relation to sports.

One of the main limitations of the study is its cross-sectional design, which prevents analysis of how this issue evolves and how it interacts with the variables examined. Another relevant limitation is the exclusion of variables related to the family, social, or media contexts, as these may have an important influence on SB. Although the sample is representative of the Andorran context, the results have limitations in terms of external validity and cannot be directly generalized to other contexts. In addition, the use of convenience sampling also limits the external validity of the results.

One future line of research should involve longitudinal studies assessing how SB evolves and allowing potential causal factors and long-term effects to be identified. Further research integrating the family and social contexts is also essential to improve understanding of the impact of the environment on SB dynamics. Qualitative studies should also be conducted to interpret the processes involved in adolescents' identification of SB, exploring aspects related to peer pressure, shame, cognitive dissonance, and different thresholds for perceiving violence and identifying it as SB. Similarly, further research into gender differences in SB in sports would be valuable, with particular attention to indirect dimensions such as social exclusion and blocking.

In conclusion, the findings highlight the importance of developing comprehensive educational policies that address the multifaceted nature of SB, considering both its explicit and covert aspects. These efforts should extend beyond the school context to include family, media, and social settings in order to improve prevention, detection, and intervention.

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Fostering Sustainable Mobility in Higher Education: Design and Evaluation of a Bicycle Promotion Intervention

Isabel María Martín-López¹ , Pere Antoni Borràs^{2,3} , Antoni Aguiló^{4,5,6} and Olalla García-Taibo^{2,3*}

¹ Department of Physical Activity and Sport Sciences, CESAG, Comillas Pontifical University, Palma de Mallorca (Spain).

² Department of Pedagogy and Specific Didactics, Balearic Islands University, Palma de Mallorca (Spain).

³ Physical Activity and Sport Sciences Research Group (GICAFE), IRIE, Balearic Islands University, Palma de Mallorca (Spain).

⁴ Department of Nursing and Physiotherapy, Balearic Islands University, Palma de Mallorca (Spain).

⁵ Health Research Institute of Balearic Islands (IdISBa), Palma de Mallorca (Spain).

⁶ Global Health and Lifestyles Research Group (EVES), IUNICS, Balearic Islands University, Palma de Mallorca (Spain).

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Abstract

Active commuting offers health, social, and environmental benefits, yet remains uncommon in university settings. This study evaluated the effects of a three-month bicycle promotion intervention using a mobile app and gamified elements on bicycle commuting behavior and physical activity levels among university students and staff. A quasi-experimental pre-post design with self-selection into groups was applied, including an experimental group ($n = 27$) that participated in the app-based intervention, and a control group ($n = 25$). Both groups completed pre- and post-intervention questionnaires on commuting behavior and physical activity levels. Results showed a significant increase in bicycle commuting within the experimental group (55.6% to 77.8%; $p = .031$) and in vigorous physical activity ($p = .015$), with no meaningful changes in the control group. However, no clear improvements were found in overall physical activity levels, and baseline differences between groups limit causal interpretations. These findings suggest that gamified interventions may represent a promising strategy for promoting sustainable mobility in university settings, although their impact on overall physical activity is modest and may depend on contextual and environmental factors.

Keywords: active transport, behavior change techniques, bicycle commuting, gamification, university community

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*Corresponding author:

Olalla García-Taibo
olalla.garcia@uib.es

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Introduction

Promoting active commuting has garnered increasing attention as a strategy to address multiple global challenges, including physical inactivity, environmental degradation, and urban congestion (United Nations, 2021). Active commuting, primarily through walking or cycling, refers to commuting to work, school, or other destinations using non-motorized modes of transportation (Ogilvie et al., 2012). It has been associated with higher physical activity levels (PALs) and improved fitness (Henriques-Neto et al., 2020), which largely explain its related health benefits (Laeremans et al., 2017). Studies link active commuting with reduced mortality, lower incidence of cardiovascular disease, cancer, type 2 diabetes, overweight, and obesity (Dinu et al., 2019). Bicycle commuting is also associated with perceived health, well-being, fitness, and productivity (Henriques-Neto et al., 2020). Beyond individual benefits, it contributes to societal goals such as reducing pollution and greenhouse gas emissions, aligning with Sustainable Development Goals (SDGs) 3, 4, 11, and 13 (United Nations, 2015).

Despite its advantages, bicycle commuting remains uncommon: in Spain, only 3.5% commute daily by bicycle (GESOP, 2019), with car and public transport dominating university settings (Barranco-Ruiz et al., 2019; Chillón et al., 2016). Promoting cycling requires understanding determinants that vary across populations and contexts (Rowe et al., 2013), including personal, social, cultural, and environmental factors (Hermida et al., 2024; Ruiz-Hermosa et al., 2021). The COVID-19 pandemic also reshaped commuting habits (Buehler & Pucher, 2021). The effectiveness of bicycle promotion interventions depends not only on individual motivation but also on supportive infrastructure and institutional conditions. In this context, app-based strategies may be more effective when cycling is safe, feasible, and locally supported (Roaf et al., 2024).

Universities can act as agents of behavioral and environmental change by embedding sustainability into their operations and promoting active commuting through programs, biking schemes, apps, and sharing initiatives

(Bopp et al., 2018; Molina-García et al., 2015). Yet, such measures often lack systematic evaluation. Incorporating Behavior Change Techniques (BCTs) can enhance their effectiveness (Michie et al., 2015). In bicycle promotion, effective BCTs include behavior monitoring, environmental restructuring, and infrastructure improvements (Doğru et al., 2021). Many of these techniques are incorporated in gamified interventions (Cugelman, 2013; Deterding et al., 2011), which use elements such as goals, challenges, rewards, leaderboards, and feedback (Wang et al., 2022; Xu et al., 2022). Evidence supports the use of gamification to promote active commuting and increase PALs (Laeremans et al., 2017; Mildestvedt et al., 2020; Xu et al., 2022).

Several universities have implemented common gamification elements in their mobility initiatives to promote sustainable transport, such as the “European University Tournament on Sustainable Mobility” (U-MOB, 2019) or the “TrafficO2” project (Di Dio et al., 2018), although evidence regarding their effectiveness remains limited. In Spain, several universities have used the Ciclogreen app to promote sustainable commuting behaviors. Launched in 2014 and awarded the Gold Medal for Sustainable Mobility by the Spanish Ministry of the Agriculture and Fisheries, Food and Environment in 2017, the app aims to promote sustainable commuting (by bicycle, walking, public transport, carpooling, or electric scooter) through a system that converts kilometers travelled into points to achieve challenges and rewards, using both web and mobile technology. According to the Ciclogreen official website (<http://ciclogreen.com>) more than 50 organizations, including numerous Spanish universities, have used the app to promote sustainable commuting and reduce their carbon footprint, although no peer-reviewed studies have been identified to date. Based on this background and the identified research gaps, the present study aimed to evaluate the effects of a three-month bicycle promotion intervention using a mobile app and gamified elements on bicycle commuting behavior and PALs among university students and staff, as well as to assess participants’ perceptions and engagement with the intervention.

Materials and Methods

Study Design

This quasi-experimental study with self-selection bias was conducted within a broader initiative to promote active transportation, implemented by the Healthy and Sustainable University Office at the University of the Balearic Islands during the 2020–2021 academic year. The initiative included two main phases: (1) a diagnostic assessment of commuting patterns and determinants of bicycle use (Martín-López et al., 2025), and (2) the design, implementation, and evaluation of a three-month intervention using a mobile app and gamified elements. A two-group pre-post design was applied. Participants were not randomly assigned but instead selected their preferred group, resulting in a self-selection process. The experimental group (EG, $n = 27$) used the app and completed online questionnaires before and after the intervention, whereas the control group (CG, $n = 25$) completed the same questionnaires without receiving the intervention. This allocation procedure reflects the ecological and voluntary nature of the intervention but introduces potential baseline differences between groups and limits the ability to draw causal inferences from the observed effects.

Study Settings and Sample

The study was conducted on the main campus of a public university located in a peri-urban area, approximately 7–8 km from the city center. The campus is accessible by public transportation (bus, train, metro), private vehicles, and personal bicycles, with a dedicated bike lane connecting it to the city. Parking facilities and changing rooms are available, although at the time of the study there was no municipal bicycle-sharing station or bicycle loan service on campus.

The university community included approximately 13,500 students, 1,000 academic staff, and 600 administrative and service personnel. A total of 52 volunteers were recruited by convenience sampling. Upon signing informed consent, participants indicated their preference to join either the experimental group (EG, $n = 27$), which involved the use of the app, or the control group (CG, $n = 25$), which did not. The EG comprised 44.4% women

and 55.6% men, with a mean age of 31.0 ± 9.2 years; 37.0% were students ($n = 10$) and 63.0% were staff ($n = 11$ professors, $n = 6$ administrative and service personnel). The CG comprised 64.0% women and 36.0% men, with a mean age of 30.1 ± 10.9 years; 42.3% were students ($n = 12$) and 57.7% were staff ($n = 4$ professors, $n = 9$ administrative and service personnel). Given the small subgroup sizes, professors and administrative personnel were analyzed together as staff. The study protocol was approved by the Research Ethics Committee of the University of the Balearic Islands (Approval Code: 172CER20; February 11, 2021). Participation was voluntary and based on informed consent.

Instruments and Measures

Data were collected at baseline (February–March 2021) and post-intervention (June 2021) through: (1) an online questionnaire, and (2) the Ciclogreen app (EG only).

Online questionnaire

At baseline, all participants completed an ad hoc self-administered questionnaire (Google Forms, 15–20 min), including validated instruments and adapted items tailored to the university context. It comprised the following sections:

- Sociodemographic: gender, age, university role, residence, car and bicycle ownership, and self-rated health status.
- Commuting behavior: regular and university-specific travel patterns, assessed using the validated Modes of Commuting to University Questionnaire (MODU; Palma-Leal et al., 2020).
- Purpose of bicycle use: categorized as non-cyclists, commuters, leisure cyclists, or competitive cyclists (Rowe et al., 2013).
- Frequency of bicycle use: almost daily, 3–4 times per week, 1–2 times per week, weekends only, occasionally, or not at all.
- Intention to commute by bicycle: both general and university-specific.
- Physical activity levels (PALs): measured using the International Physical Activity Questionnaire-Short Form (IPAQ-SF; Cencela et al., 2019).

Ciclogreen app

For this intervention, a three-month license of the Ciclogreen app was acquired and customized with the university's visual identity and a distinctive program icon (Figure 1). EG participants downloaded the app using a unique password provided by the research team and accessed both the mobile and web interfaces. The intervention incorporated five BCTs aligned with gamification elements:

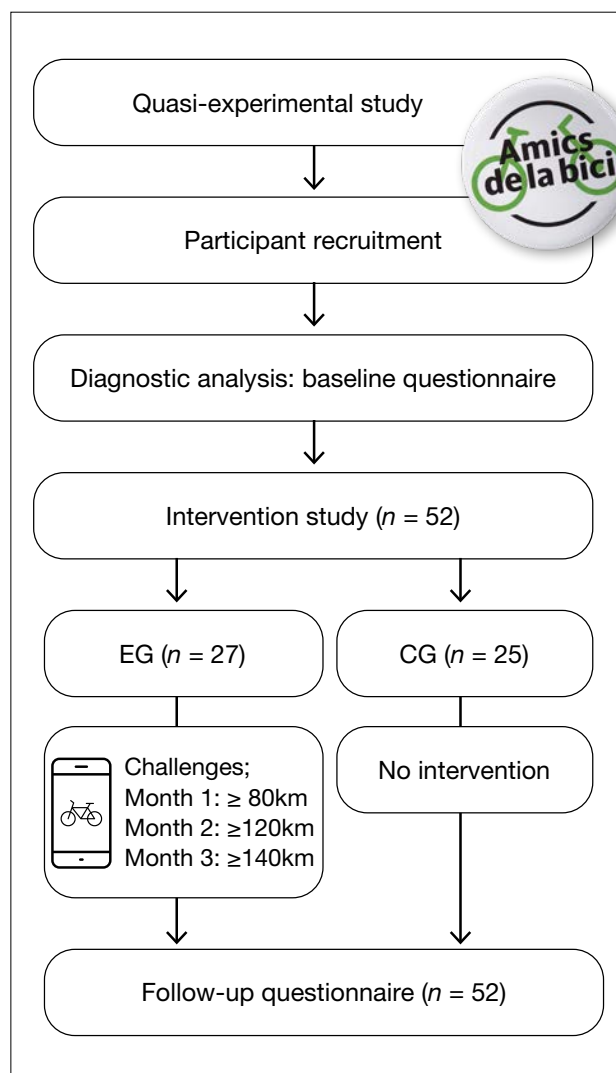
- **Goal setting.** Participants committed to the primary goal of increasing bicycle use for commuting and other daily trips, using conventional or electric bicycles.
- **Graded challenges.** Three monthly distance goals: 80 km (March), 120 km (April), 140 km (May), accumulated and distributed according to personal circumstances.
- **Rewards and reinforcement.** Challenge completers entered a €50 prize draw; those completing all challenges received an extra prize and a cycling kit. Rewards were both extrinsic and intrinsic (achievement, enjoyment).
- **Social comparison.** Real-time rankings by subgroup (students, administrative staff, academic staff).
- **Performance feedback.** Immediate trip data (e.g., distance, time, calories, CO₂ saved). Only distance was analyzed to verify challenge completion.

Procedure

Recruitment was carried out through a university-wide communication campaign (newsletters, websites, social media, and in-person channels), supported by a coherent visual identity. Recruitment strategies included an information booth alongside a bicycle exhibit, a raffle for a folding bicycle, and brief in-class presentations (20 min) delivered by several faculty members to encourage voluntary participation. Enrolment was completed via an online form, with participants providing informed consent. Both groups completed the baseline questionnaire (February–March 2021) and post-intervention questionnaire (June 2021). The EG used the Ciclogreen app for three months and received weekly emails containing information on the health and environmental benefits of cycling, recognition of challenge completion, and announcements of prize draw winners. The CG received no intervention during this period (Figure 1).

Figure 1

Flow diagram of the quasi-experimental design



Statistical Analyses

Data were analyzed using IBM SPSS Statistics, version 29.0.1.0 (171). Descriptive statistics were used to summarize participant characteristics and study variables, with frequencies and percentages for categorical data and means, and standard deviations (*SD*) for continuous data. Normality of continuous variables was assessed using the Shapiro–Wilk test. Given that most continuous variables were not normally distributed, non-parametric tests were applied. Between-group differences at baseline were analyzed using chi-square tests for categorical variables and Mann–Whitney *U* tests for continuous variables. Several

variables originally collected as multi-category or ordinal items were recoded to facilitate analysis and interpretation. Specifically, commuting modes were classified as active (walking, cycling) or passive (car, motorcycle, public transport, scooter, or mixed passive modes), bicycle use purpose was dichotomized into bicycle commuters (commuters) and non-bicycle commuters (non-users, leisure and competitive cyclists), and frequency of bicycle usage was recoded into two categories: high frequency (≥ 3 times/week) and low or no usage (< 3 times/week), based on previously established thresholds (e.g., Ek et al., 2020). To assess within-group changes from pre- to post-intervention, McNemar tests were used for paired categorical variables, and Wilcoxon signed-rank tests were used for paired continuous variables. Given the small sample size, baseline differences between groups, and the self-selection of participants into the experimental and control groups, the analysis primarily focused on within-group comparisons. This approach was considered more appropriate to explore changes over time within each group while minimizing bias derived from non-equivalent baseline characteristics. Effect sizes were calculated for continuous variables using Cohen's d , interpreted as small ($d \geq 0.2$), medium ($d \geq 0.5$), and large ($d \geq 0.8$). Additionally, absolute changes (Δ) from baseline to follow-up were reported for

each outcome. A post hoc power analysis was conducted using *G*Power* (Faul et al., 2007), targeting 80% power at an alpha level of .05, to determine the minimum sample size required to detect the observed effect sizes. Statistical significance was set at $p < .05$.

Results

Sample Characteristics and Baseline Comparisons

Table 1 summarizes baseline characteristics of participants. No significant differences were observed between groups in age, gender, university role, residential environment, car ownership, self-rated health, or PALs ($p > .05$). By contrast, the EG showed significantly higher bicycle ownership (96.3% vs. 72%; $p = .01$) and greater engagement in active commuting modes (81.5% vs. 40%; $p = .002$). Bicycle commuting was also more prevalent in the EG (55.6% vs. 8%; $p < .001$), with higher frequency across all commuting categories ($p < .001$). These differences reflect baseline imbalances due to the non-randomized allocation and participants' self-selection into groups.

Table 1
Baseline characteristics of participants in the experimental group (EG) and control group (CG)

Variables	Total (n = 52)	EG (n = 27)	CG (n = 25)	p
Gender % (n)				
Male	46.2% (24)	55.6% (15)	36% (9)	.16
Female	53.8% (28)	44.4% (12)	64% (16)	
Age ($\bar{x} \pm SD$)	30.6 $\pm$ 9.94	31.04 $\pm$ 9.20	30.12 $\pm$ 10.85	.57
Role % (n)				
Students	42.3% (22)	37% (10)	48% (12)	.42
Staff	57.7% (30)	63% (17)	52% (13)	
Residential setting				
Rural	9.6% (5)	3.7% (1)	16% (4)	.13
Urban	90.4% (47)	93.3% (26)	84% (21)	
Car ownership % (n)				
Yes	80.8% (42)	77.8% (21)	84% (21)	.57
No	19.2% (10)	22.2% (6)	16% (4)	

Note. $\bar{x}$ = mean; SD = standard deviation; EG = experimental group; CG = control group; METs = metabolic equivalents of task. Statistical analyses were performed using the chi-square for categorical variables and the Mann-Whitney U test for continuous variables. Statistical significance was set at: $p < .05$ (*), $p < .01$ (**) and $p < .001$ (***).

Table 1 (Continued)*Baseline characteristics of participants in the experimental group (EG) and control group (CG)*

Variables	Total (n = 52)	EG (n = 27)	CG (n = 25)	p
Bicycle ownership % (n)				
Yes	84.6% (44)	96.3% (26)	72% (18)	.01**
No	15.4% (8)	3.7% (1)	28% (7)	
Self-rated health % (n)				
Excellent	28.8% (15)	37% (10)	20% (5)	.38
Good	61.5% (32)	55.6% (15)	68% (17)	
Fair	9.6% (5)	7.4% (2)	12% (3)	
PALs (METs) ($\bar{x} \pm SD$)				
Total	4786.3 $\pm$ 3036.5	5224.2 $\pm$ 3767.2	4313.5 $\pm$ 1941.7	.72
Vigorous	1438.5 $\pm$ 1380.6	1484.4 $\pm$ 1610.0	1388.8 $\pm$ 1112.3	.93
Moderate	790.4 $\pm$ 863.3	1039.3 $\pm$ 1074.3	521.6 $\pm$ 434.1	.06
Walking	2557.5 $\pm$ 1590.2	2700.5 $\pm$ 1853.9	2403.1 $\pm$ 1265.8	.81
Sedentary behavior (hours) ($\bar{x} \pm SD$)	8.2 $\pm$ 3.1	8.3 $\pm$ 3.8	8.2 $\pm$ 2.2	.98
Regular mode of commuting				
Active	61.5% (32)	81.5% (22)	40% (10)	.002**
Passive	38.5% (20)	18.5% (5)	60% (15)	
Mode of commuting to university				
Active	25% (13)	44.4% (12)	4% (1)	<.001***
Passive	75% (39)	55.6% (15)	96% (24)	
Purpose of bicycle use				
Non-users	28.8% (15)	3.7% (1)	56% (14)	<.001***
Commuters	32.7% (17)	55.6% (15)	8% (2)	
Sport	17.3% (9)	25.9% (7)	8% (2)	
Leisure	21.2% (11)	14.8% (4)	28% (7)	
Frequency of bicycle use				
Almost or every day	13.5% (7)	22.2% (6)	4% (1)	<.001***
3–4/week	23.1% (12)	37% (10)	8% (2)	
1–2/week	9.6% (5)	14.8% (4)	4% (1)	
On weekends	9.6% (5)	11.1% (3)	8% (2)	
Once a month	15.4% (8)	11.1% (3)	20% (5)	
Non-users	28.8% (15)	3.7% (1)	56% (14)	

Note. $\bar{x}$ = mean; SD = standard deviation; EG = experimental group; CG = control group; METs = metabolic equivalents of task. Statistical analyses were performed using the chi-square for categorical variables and the Mann–Whitney U test for continuous variables. Statistical significance was set at: $p < .05$ (*), $p < .01$ (**) and $p < .001$ (***).

Intervention Effects

Table 2 presents the pre- and post-intervention outcomes. In the EG, the proportion commuting by bicycle increased significantly (from 55.6% to 77.8%; $p = .031$), with positive but non-significant trends for active commuting to the university and frequent cycling (≥ 3 /week). Intentions to cycle remained stable in the EG but rose slightly in the CG, though without statistical significance.

For PALs, total METs, and sedentary time declined slightly in both groups. A significant increase in vigorous PA was observed in the EG ($p = .015$, $d = 0.41$), while moderate PA increased in the CG ($p = .018$, $d = 0.55$). Walking decreased substantially in both groups (EG: $d = -1.00$; CG: $d = -0.93$). Sedentary time fell significantly in the CG (-0.9 h/day, $p = .025$) but showed no meaningful change in the EG.

Table 2*Pre- and post-intervention outcomes for the experimental group (EG) and control group (CG)*

Variables	G	Pre ($\bar{x} \pm SD/\%$)	Post ($\bar{x} \pm SD/\%$)	Δ	Within-group (<i>p</i>)	Cohen's <i>d</i>
Bicycle commuting (yes)	EG	55.6%	77.8%	+22.2	.031*	—
	CG	8%	24.0%	+16.0	.22	—
Frequency bicycle usage ($\geq 3/\text{week}$)	EG	59.26%	70.37%	+11.1	.25	—
	CG	12%	16%	+4	1.0	—
Mode of commuting to university (active)	EG	44.4%	59.3%	+14.9	.55	—
	CG	4%	8.3%	+4.3	.16	—
Intention to use bicycle for commuting (yes)	EG	96.3%	96.3%	0.0	1.0	—
	CG	48%	56%	+8	.73	—
Intention to use bicycle to university (yes)	EG	85.19%	74.07%	-11.1	.45	—
	CG	20%	40%	+20	.18	—
Total PALs (METs)	EG	5224.2 $\pm$ 3767.2	4893.3 $\pm$ 4614.2	-330.9	.19	-.3
	CG	4313.5 $\pm$ 1941.7	3877.4 $\pm$ 3150.5	-436.1	.078	-.17
VPA (METs)	EG	1484.4 $\pm$ 1610.0	2635.3 $\pm$ 3589.9	+1150.9	.015*	.41
	CG	1388.8 $\pm$ 1112.3	1617.6 $\pm$ 2154.2	+228.8	.962	.13
Moderate PA (METs)	EG	1039.3 $\pm$ 1074.4	1108.1 $\pm$ 856.4	+68.8	.78	.07
	CG	521.6 $\pm$ 434.0	968.8 $\pm$ 1057.6	+447.2	.018*	.55
Walking (METs)	EG	2700.5 $\pm$ 1853.9	1149.9 $\pm$ 1165.1	-1550.6	<.001***	-1.00
	CG	2403.1 $\pm$ 1265.8	1291.0 $\pm$ 1112.6	-1112.1	<.001***	-.93
Sedentary time (hours/day)	EG	8.31 $\pm$ 3.84	7.78 $\pm$ 1.87	-0.53	.98	-.17
	CG	8.16 $\pm$ 2.16	7.26 $\pm$ 4.04	-0.9	.025*	-.28

Note. G = group; EG = experimental group; CG = control group; SD = standard deviation; PALs = physical activity levels; VPA = vigorous physical activity; *p*-values refer to within-group comparisons (Wilcoxon or McNemar tests, as appropriate); Δ = absolute change from pre- to post-intervention; “—” indicates not applicable or not calculated (no statistical test conducted due to polytomous variables or low cell frequency). Statistical significance was set at: $p < .05$ (*), $p < .01$ (**) and $p < .001$ (***).

Post hoc Power Analysis

A post hoc analysis indicated that a minimum of 117 participants would have been required to detect the observed effect size for bicycle use (OR = 0.36) with 80% power ($\alpha = .05$).

Discussion

This study aimed to evaluate the effects of a three-month bicycle commuting promotion intervention using a mobile app and gamified elements on bicycle commuting behavior and PALs among university students and staff. While the intervention was associated with positive trends in bicycle commuting within the EG, the overall effects were modest and should be interpreted cautiously. The absence of between-group analyses, together with baseline differences and the self-selection of participants, limits the extent to which these changes can be attributed to the intervention.

Baseline findings showed a low prevalence of bicycle commuting, consistent with previous studies in university

settings (Barranco-Ruiz et al., 2019; Chillón et al., 2016). The intervention produced modest changes in commuting and no significant overall effects on PALs, but provides insights into the challenges and potential of gamified approaches in higher education.

Effects on Commuting Behavior

The intervention promoted positive trends in bicycle commuting, particularly among participants who actively engaged with the program. Although no statistically significant within-group changes were detected, these results are consistent with other university-based gamified interventions, which reported small improvements even without environmental changes (Di Dio et al., 2018; U-MOB, 2019). Structural barriers—such as campus location, distance from residences, terrain, or limited cycling infrastructure—likely constrained behavior change (Piatkowski et al., 2015). Many participants lived beyond a feasible cycling radius, limiting adherence regardless of motivation.

Thus, environmental factors should be taken into account when planning strategies to promote active mobility.

Our findings also point to ceiling effects, as the EG already exhibited higher baseline bicycle use. When participants are already predisposed, further increases are harder to achieve. This pattern has been described in other interventions using gamified or reward-based approaches (Bopp et al., 2018). Future interventions may benefit from tailoring digital strategies to address individual barriers and motivational profiles rather than relying only on general gamified elements.

Intention to bicycle commute was already high in the EG, leaving little scope for change. According to the Theory of Planned Behavior (Ajzen, 1991), intention is a key predictor of behavior, but practical barriers—distance, heavy materials, or concerns about appearance—may prevent the translation of intention into action. This may explain why intention to cycle to university was lower than general cycling intention, a discrepancy also noted in earlier studies (Milkovic & Štambuk, 2015). Broadening gamified challenges beyond commuting to include daily errands may help engage those for whom university travel by bicycle is impractical.

Finally, although this study recorded self-reported bicycle use purpose, the app did not differentiate trip types. Given that some participants may have cycled primarily to accumulate kilometers for rewards, future work should consider tracking purpose to improve data interpretability and optimize motivational strategies.

Effects on Physical Activity Levels

The intervention did not lead to an overall increase in PALs. Although VPA increased significantly in the EG, this was offset by a marked reduction in walking-related METs in both groups, resulting in a net decline in total PALs. This paradoxical pattern may be partially explained by a substitution effect, whereby participants replaced longer habitual walking commutes with shorter bicycle trips. This finding is consistent with previous research suggesting that increases in one form of active transport do not necessarily translate into higher overall physical activity levels, particularly when one active behavior displaces another (Mildestvedt et al., 2020; Xu et al., 2022). In the present study, cycling may have partially replaced longer walking commutes or other low-intensity activities, leading to a redistribution rather than an increase in total PA. Interventions aimed at promoting active commuting should not assume additive effects on PA but rather consider potential behavioral trade-offs between different activity domains. Designing strategies that complement, rather than replace,

existing active behaviors may be necessary to achieve meaningful increases in overall PALs.

Unexpectedly, the CG also showed a modest PALs increase, possibly due to uncontrolled contextual factors (seasonal variation, academic calendar, or personal routines). The quasi-experimental design and small sample make such influences plausible. Baseline activity levels were already high, limiting potential improvements and contributing to ceiling effects. Molina-García et al. (2015) also reported that students in advanced stages of behavior change did not experience major increases in activity levels after using a shared bike system, supporting this interpretation. It is also important to consider that PA was assessed through self-reported questionnaires, which are prone to recall and social desirability biases and may not accurately detect nuanced behavioral changes. Nevertheless, the increase in VPA observed in the EG suggests that gamified elements may be effective in encouraging higher-intensity PA in certain subgroups. Future studies should employ objective measurements and stratified analyses to better understand the domain-specific effects of active commuting interventions on PA behavior.

Strengths and Limitations

This study highlights the potential of gamified elements to foster healthier and more sustainable commuting in higher education. A key strength lies in its ecological validity, as the intervention was implemented in a real university context with institutional support and a commercial platform, providing practical insights for future applications.

Nonetheless, several limitations should be considered. The small and self-selected sample reduced statistical power and introduced baseline differences between groups, limiting generalizability of the findings. In particular, the self-selection of participants into the experimental or control group likely resulted in a more motivated and predisposed profile in the intervention group, which may have contributed to the observed changes independently of the intervention itself. Consequently, the results should be interpreted with caution, as causal inferences cannot be established. Similarly, the statistical approach relied primarily on within-group comparisons, and no group-by-time interaction analyses were conducted. Therefore, it is not possible to determine whether the observed changes differed significantly between the experimental and control groups, further limiting causal interpretation.

Recruitment proved challenging due to the low prevalence of regular bicycle commuters. Additionally, external factors

such as weather conditions, academic workload, and infrastructure availability could not be controlled and may have influenced behavior. The reliance on self-reported PA measures (IPAQ-SF) may have introduced recall and social desirability biases. Finally, the observed reduction in walking alongside increased cycling suggests a possible substitution effect, which complicates the interpretation of overall changes in physical activity levels. Future studies should include larger and more representative university samples to improve statistical power and strengthen the generalizability of the findings.

Conclusion

The three-month intervention delivered through a mobile app with gamified elements led to positive trends in bicycle use and active commuting, although its overall impact on PALs was modest. Despite limitations in sample size and study design, these findings add to the emerging evidence supporting gamification and Behavior Change Techniques as promising strategies to encourage active commuting in higher education. This study underscores the potential of such interventions to promote healthier lifestyles and advance sustainability goals while also providing evidence to guide campus mobility policies. Future studies should aim to recruit larger and more diverse samples, apply objective measures (e.g., accelerometry or GPS), and refine incentive structures while isolating specific gamification components to clarify their role.

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Author Contributions

Conceptualization, I.M.M.-L. and O.G.-T.; methodology, I.M.M.-L., P.A.B. and A.A.; investigation, I.M.M.-L.; resources, A.A. and P.A.B.; data analysis, I.M.M.-L.; writing—original draft, I.M.M.-L.; writing—review and

editing, I.M.M.-L., O.G.-T., P.A.B. and A.A.; supervision, O.G.-T., A.A., and P.A.B.; project administration, A.A. and P.A.B.; funding acquisition, A.A.

Policy and Ethics

The study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval was granted by the Research Ethics Committee of University of the Balearic Islands (Approval Code: 172CER20, February 11, 2021). Participation was voluntary, and informed consent was obtained from all participants.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Satisfaction and Frustration of Basic Psychological Needs and Intention to Engage in Physical Activity in Elementary Education

Enrique Cano-Cañada¹ , Sergio Diloy-Peña² , Diego Esteban-Torres³ , José Antonio Sayavera-Cidoncha⁴ , Ana Acedo-Castela⁴ & Miguel Ángel Tapia-Serrano^{4*}

¹ Department of Didactics of Musical, Plastic and Body Expression, Research Group on didactic and Behavioral Analysis of Sport (ADICODE), Faculty of Teacher Education, University of Extremadura, Cáceres, (Spain).

² Department of Health Sciences, Public University of Navarra, Pamplona, (Spain).

³ Department of Musical, Plastic and Body Expression, Research Group on Physical Education and Physical Activity Promotion (EFYPAF), Faculty of Social and Human Sciences, University of Zaragoza, Zaragoza (Spain).

⁴ Department of Didactics of Musical, Plastic and Body Expression, Behavioral Analysis of Physical Activity and Sport Research Group (ACAFYDE), Faculty of Teacher Education University of Extremadura, Cáceres (Spain).

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*Corresponding author:

Miguel Ángel Tapia-Serrano
matapiase@unex.es

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Abstract

Satisfaction and frustration of the basic psychological needs (BPNs) for autonomy, competence, and relatedness have been linked to various adaptive and maladaptive outcomes in physical education (PE) in high school, yet their role in elementary school remains underexplored due to a lack of studies. Based on self-determination theory (SDT), this study aimed to examine the relationship between BPNs satisfaction and frustration and the intention to engage in physical activity (PA), with motivation (autonomous motivation, controlled motivation, and amotivation) as the mediating variable. A cross-sectional study was conducted with 171 elementary school students from grades 3 to 6 ($M_{age} = 9.95$, $SD = 1.23$; 55% female) from five schools. Validated questionnaires were administered to assess BPNs satisfaction and frustration, motivation in PE, and intention to engage in PA. Structural equation modeling results showed that the satisfaction of competence and relatedness positively predicted autonomous motivation, which in turn was positively associated with the intention to engage in PA. In contrast, autonomy and competence frustration were positively associated with higher amotivation, which negatively predicted the intention to engage in PA. Overall, the findings highlight the important role of satisfying BPNs, as well as preventing their frustration in PE contexts to foster more self-determined forms of motivation and promote active lifestyles from childhood.

Keywords: healthy lifestyles, motivation, physical education, self-determination theory, students

Introduction

Regularly engaging in physical activity (PA) in childhood is an essential part of students' physical, psychological, and social development, and it also protects them against numerous short- and long-term health problems (García-Hermoso et al., 2021). Despite this well-known fact, international reports warn that most students do not meet the 60 minutes or more of daily moderate-to-vigorous PA recommended by international organisms (Guthold et al., 2020), resulting in negative physical, cognitive, and psychosocial consequences (Rollo et al., 2020). With that in mind, physical education (PE) offers an exceptional opportunity to promote students' participation in meaningful bodily movement and to equip them with skills, values, and tools that encourage engaging in PA outside the school setting (SHAPE America, 2014; Hollis et al., 2017). Physical education thus helps prevent health, self-esteem, and motor skills development problems associated with sedentary lifestyles (Carson et al., 2016).

In that regard, we must further explore the motivational mechanisms behind the adoption of active habits at young ages, and specifically in elementary education as this stage is rarely analyzed through the lens of self-determination theory (SDT; Ryan & Deci, 2017). With the aim of delving into this topic, this study examines these relationships within the context of PE.

Self-Determination Theory

Self-determination theory (SDT) provides an excellent framework for understanding the motivational processes involved in engaging in physical activity. With this approach, how students experience the satisfaction or frustration of their basic psychological needs (BPNs; autonomy, competence, and relatedness) is critical to explaining the quality of their motivation. Autonomous motivation lies at one end of the continuum, and emerges when an activity is perceived as pleasing, voluntary, and meaningful. This type of motivation includes different regulatory styles: intrinsic motivation (due to the enjoyment it produces), integrated regulation (due to alignment with own values or identity), and identified regulation (due to personal value). For example, a student may actively engage in PE classes because they enjoy the activities or because they value how the class benefits their life. This type of motivation is associated with higher levels of well-being, persistence, and commitment to the activity. As self-determination diminishes, controlled motivation rises, in which participation is influenced by external or internal pressure. This type of motivation includes two main

regulatory styles: introjected regulation, in which students are motivated by feelings of guilt, anxiety, or desire for approval, and external regulation, which involves completing an activity to obtain rewards or avoid punishment. For example, a student may participate in class to avoid getting marked as absent, to get a grade, or out of fear of feeling guilty if they do not. While this can produce some level of participation or engagement, this type of motivation tends to be less stable and beneficial in the long-term. At the other end of the continuum is amotivation, which is characterized by a lack of intention, meaning, or value attributed to the activity. In PE, this is seen in students who do not participate or who do so passively, believing that their effort is futile or doubting their ability to successfully complete the activity (Ryan & Deci, 2017).

According to SDT, the type of motivation that a student develops is significantly conditioned by the degree to which the educational setting satisfies or frustrates the three BPNs. In education, satisfying the need for autonomy refers to students feeling like they are acting of their own volition and are the source of their own behavior, acting in line with their interests, values, or personal goals. On the contrary, frustration of autonomy occurs when students feel that their actions are externally controlled and they feel pressured to act a certain way. Competence satisfaction involves feeling effective and capable of successfully meeting the challenges of an activity. This occurs when a student feels they are progressing, mastering skills, and achieving set goals. On the other hand, this need is frustrated when students feel ineffective, inept, or constantly overwhelmed by the difficulty of tasks. Lastly, relatedness satisfaction refers to feeling connected to, accepted, and valued by other important individuals such as classmates and teachers. On the contrary, this need is frustrated when students feel isolated, rejected, or lacking affectional bonds or when they do not feel that they belong to the group.

Empirical evidence has shown that satisfaction of BPNs in PE is positively associated with autonomous motivation and greater intention to engage in PA during free time (Di Battista et al., 2019; Gråstén et al., 2021). On the other hand, when these needs are frustrated, forms of controlled motivation or amotivation tend to arise, which are associated with lower enjoyment, diminished commitment, and a higher risk of not engaging in PA (Vansteenkiste et al., 2020; Vasconcellos et al., 2020). Therefore, since the satisfaction and frustration of BPNs are not simple opposites but rather conceptually different constructs, their joint analysis allows us to better understand the psychological mechanisms that promote or hinder the adoption of active habits during childhood (Vansteenkiste et al., 2020).

Nevertheless, and despite the growing interest around motivation in the field of PE given its importance in developing active and healthy lifestyles at a young age, most studies (Fernández-Espínola et al., 2021; González-Peño et al., 2025) have focused on later educational years, such as high school. As such, very few studies have analyzed simultaneously the effects of the satisfaction and frustration of these needs on motivation and the intention to engage in PA in elementary education (Vasconcellos et al., 2020). Likewise, there is a lack of research that uses structural equation modeling to jointly examine the satisfaction and frustration of BPNs, the different types of motivation (autonomous, controlled, and amotivation), and their mediating role in the intention to engage in PA during free time. This gap highlights the need to delve into how BPNs influence motivation and the intention to engage in PA in PE.

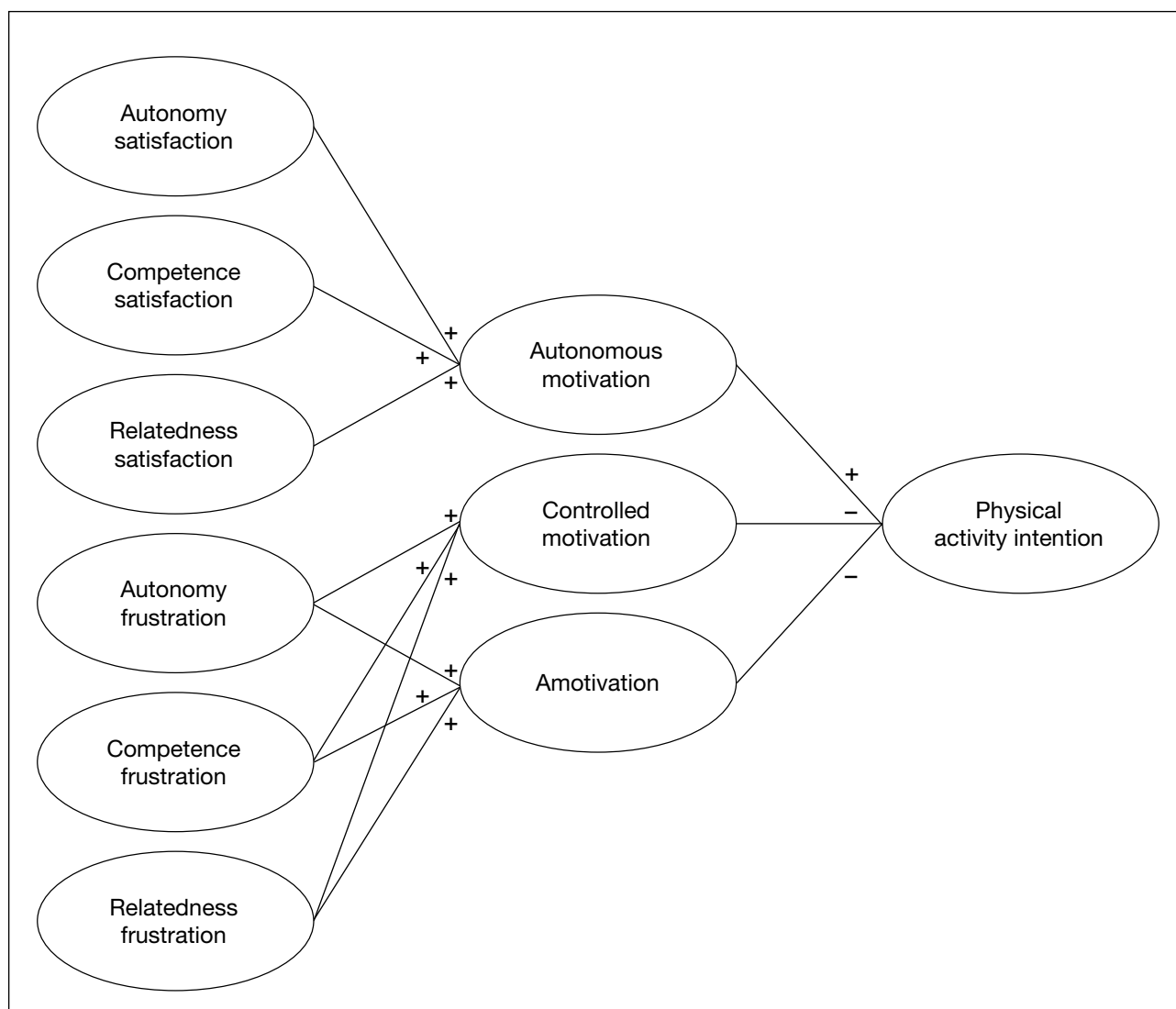
This Study

Considering the lack of studies that use SDT to analyze these relations in elementary education, this study aimed to analyze the relationship between BPNs satisfaction and frustration and the intention to engage in PA during free time among elementary school students, exploring the role of motivation as the mediating variable.

Based on the study objective and in light of the findings from the meta-analysis by Vasconcellos et al. (2020), we defined the following hypotheses: (H1) a positive association between satisfaction of autonomy, competence, and social relatedness and autonomous motivation, predicting, due to its mediating role, greater intention to engage in PA; (H2) a positive association between frustration of autonomy, competence, and relatedness and controlled motivation and amotivation, resulting in a lower intention to engage in PA.

Figure 1

Hypothetical theoretical model of relations between the study variables



Methodology

Participants

We conducted a cross-sectional study with a descriptive and correlational approach. A total of 171 elementary school students from five different schools participated in the study. They were recruited via convenience sampling. The exclusion criteria were as follows: students absent on the day the questionnaire was administered, lack of regular attendance in PE classes (less than 75% overall), incomplete questionnaires or with invalid response patterns, and missing informed consent from the legal guardians.

After eliminating the non-valid data, the final sample comprised 171 students ($M_{age} = 9.95$, $SD = 1.23$; 55% female), with ages ranging from 8 to 12 years old. In total, 94 were female ($M_{age} = 10.12$, $SD = 1.2$) and 77 were male ($M_{age} = 9.73$, $SD = 1.27$), divided into different elementary school grades (3rd grade = 32; 4th grade = 49; 5th grade = 41; 6th grade = 49).

Materials and Instruments

Satisfaction and frustration of basic psychological needs

The satisfaction and frustration of BPNs were measured using a 5-point Likert scale (1 = “Strongly disagree,” 5 = “Strongly agree”) in its Spanish version adapted to elementary school education and the PE environment (Sayavera-Cidoncha et al., 2026). This adaptation to an elementary school setting is based on previously validated instruments, such as the Basic Psychological Need Satisfaction and Frustration Scale (BPNSFS; Haerens et al., 2015), which was validated in the Spanish setting by Zamarripa et al. (2020). In the original validation study, the version adapted to the elementary school setting showed adequate fit values: $\chi^2(237, n = 336) = 574.53$, $p < .001$; Comparative Fit Index (CFI) = .98; Tucker Lewis Index (TLI) = .98; Root Mean Square Error of Approximation (RMSEA) = .04, (90% CI = .04 – .05). The instrument comprises 24 items distributed among six sub-scales (four for every dimension), which evaluate satisfaction of autonomy (e.g., “...I feel that I can make my own choices [games, materials, groups, etc.]”), competence (e.g., “...I feel capable of doing the activities well”), and relatedness (e.g., “...I feel like I get along well with my classmates”), as well as frustration of autonomy (e.g.,

“...I feel like I am told what to do without asking me”), competence (e.g., “...I feel like I am bad at the activities”), and relatedness (e.g., “...I feel excluded from the group I want to belong to”). The scale also presented acceptable psychometric properties for this study sample. For satisfaction: $\chi^2(51, n = 171) = 64.00$, $p < .11$; CFI = .94; TLI = .92; RMSEA = .04 (90% CI = .02 – .07), while for frustration: $\chi^2(51, n = 171) = 76.44$, $p < .001$; CFI = .93; TLI = .91; RMSEA = .05 (90% CI = .03 – .08). In addition, the reliability coefficients estimated via McDonald’s omega (ω) presented adequate values. For satisfaction, we obtained the following values: autonomy ($\omega = .70$), competence ($\omega = .60$), and relatedness ($\omega = .73$). For frustration, the values were as follows: autonomy ($\omega = .72$), competence ($\omega = .70$), and relatedness ($\omega = .71$).

Motivation in PE classes

Student motivation in PE class was measured via the Physical Education Motivation Questionnaire adapted for elementary education (CMEF; Leo et al., 2016). Completing the sentence “I participate in PE classes...,” the scale includes 20 items, four for each type of motivational regulation, with the exception of introjected, evaluating intrinsic regulation (e.g., “...because Physical Education is fun”), identified regulation (e.g., “...because I can learn skills that I might use in other areas of my life”), introjected regulation, (e.g., “...because I feel bad about myself if I skip class”), external regulation (e.g., “...because it is expected of me by my teacher and classmates”), and amotivation (e.g., “...but I actually feel like I am wasting my time in this class”). Based on the approaches in SDT and previous research on PE (Haerens et al., 2015), we calculated composite scores for autonomous motivation (averaging intrinsic motivation and identified regulation) and controlled motivation (averaging introjected and external regulation) to simplify the analysis. Responses were logged using a 5-point Likert scale (1 = “Strongly disagree,” 5 = “Strongly agree”). In this study, the confirmatory factor analysis (CFA) showed an acceptable fit for the three factor model: $\chi^2(132, n = 171) = 198.75$, $p < .001$, CFI = .95; TLI = .94; RMSEA = .05, 90% CI = .04 – .07). The reliability coefficients obtained via McDonald’s omega were adequate for autonomous motivation ($\omega = .82$), controlled motivation ($\omega = .81$), and amotivation ($\omega = .60$).

Intention to engage in PA

Student intention to engage in PA was measured using three items (e.g., “In the coming weeks, I intend to do sports or play in the afternoons”) from the Theory of Planned

Behavior Questionnaire (Hagger et al., 2009). Responses were logged using a 7-point Likert scale (1 = “Strongly disagree,” 7 = “Strongly agree”). The CFA conducted in this study indicated an adequate fit for a single factor model: $\chi^2(2, n = 171) = 9.63, p < .001$, CFI = .98; TLI = .98; RMSEA = .04, 90% CI = .01 – .05). McDonald’s omega coefficient indicated adequate reliability ($\omega = .68$).

Procedure

Before starting the study, the principal investigator contacted the school leadership teams to inform them about the aim of the research and to request collaboration. The family members or legal guardians were then asked to sign an informed consent form authorizing their children’s participation. The students themselves also filled out a written informed consent form. The questionnaires were administered collectively during classroom hours, taking approximately 25 minutes of class time. The PE teachers were not present in the classroom when the questionnaires were completed to minimize potential bias or influence in the students’ responses. This study was conducted in accordance with the ethical principles of the Declaration of Helsinki and received approval from the University of Extremadura ethics committee (Ref.: 240/2024).

Data Analysis

In the preliminary analyses, we calculated the descriptive statistics (mean and standard deviation), composite reliability (McDonald’s omega coefficient, ω), and latent correlations, among other variables. The available sample size ($n = 171$) was deemed adequate to estimate structural equation models with a moderate number of latent variables, guaranteeing the stability and reliability of the estimated parameters (Wang & Wang, 2012). For the primary analyses, we estimated a structural equation model using the weighted least squares mean and variance (WLSMV) adjusted estimator, which is adequate for ordinal Likert-like data and robust to non-normality (Muthén & Muthén, 2017). To estimate the indirect effects, we used a bootstrap procedure with 5,000 resamples, from which we obtained 95% confidence intervals based on the percentile method, due to its greater robustness against potential deviations in normality in the distribution of the indirect effects. In addition, we evaluated reliability using McDonald’s omega coefficient (ω), interpreted according to psychometric

recommendations that consider values between .60 and .70 as acceptable in short and multidimensional scales, particularly in children (Loewenthal & Lewis, 2020; Cicchetti, 1994; Hernaez, 2015). The predictive relationship of satisfaction and frustration of autonomy, competence, and relatedness with motivation (autonomous, controlled, and amotivation) and intention to engage in PA was analyzed using a two-step model proposed by Kline (2011). The first step examined the measurement model, including the relationships between all the latent variables. The second step evaluated the hypothesized structural relationships. The model fit was evaluated via the following indices: CFI and TLI values over .90 indicate a good fit, while values over .95 reflect an excellent fit. For the RMSEA, values $\leq .08$ were interpreted as adequate and $\leq .06$ as excellent (Marsh et al., 2004). The analysis was conducted using IBM SPSS (version 25.0) and Mplus (version 8.0) statistics software.

Results

Preliminary Results

The results presented in Table 1 show the descriptive statistics, the composite reliability, and the latent correlations between the analyzed variables. Likewise, the differences according to sex and school grade, respectively, can be seen in Tables 1 and 2. In terms of BPNs, the mean scores for satisfaction of autonomy, competence, and relatedness were above the midpoint of the scale, while the mean scores for frustration of said needs were situated below said value. In terms of the types of motivation, autonomous motivation presented a very high mean value, while both controlled motivation and amotivation presented means below the midpoint of the scale. Likewise, the mean for intention to engage in PA was considerably higher than the midpoint. The correlations between satisfaction of autonomy ($r = .28, p < .05$), competence ($r = .71, p < .01$), and relatedness ($r = .55, p < .01$) with autonomous motivation were positive and significant. Similarly, each of the BPNs showed positive and significant correlations with the intention to engage in PA ($r = .31, .44$ and $.46; p < .05$, respectively). On the other hand, competence frustration was significantly and negatively correlated with controlled motivation ($r = -.24; p < .05$), while relatedness frustration ($r = .19; p < .05$) was positively associated. As for amotivation, a significant and positive correlation was

observed with frustration of autonomy ($r = .43$; $p < .01$), competence ($r = .36$; $p < .01$), and relatedness ($r = .38$; $p < .01$). Lastly, frustration of autonomy ($r = -.26$; $p < .01$), competence ($r = -.37$; $p < .01$), and relatedness ($r = -.23$; $p < .01$) were significantly and negatively associated with the intention to engage in PA.

Primary Results

While some of the direct effects were not significant, the hypothesized models presented good fit indices in terms of the observed data: $\chi^2/df = 1.31$, $p < .001$; CFI = .90; TLI = .90; RMSEA = .04 (90% CI = .03 – .05). All the direct effects are presented in Table 2.

Table 1

Descriptive analysis, composite reliability, and latent correlations between the study variables

Variables	<i>M (SD)</i>	ω	1	2	3	4	5	6	7	8	9	10	11	12
1. Sex	4.17 (0.54)		-	.16*	-.01	-.06	-.02	.16*	.09	.09	-.16*	-.12	.05	-.25**
2. Grade	4.41 (0.53)			-	-.13	-.28**	-.43**	.15*	-.22*	.26**	-.42**	-.32**	-.04	-.25**
3. Autonomy satisfaction	4.59 (0.40)	.70			-	.36*	.44**	-.58**	-.22*	-.24*	.28*	-.14	-.27*	.31*
4. Competence satisfaction	1.84 (0.56)	.60				-	.38*	-.32*	-.65**	-.42**	.71**	.29**	-.25	.44**
5. Relatedness satisfaction	1.66 (0.57)	.73					-	-.27*	-.39**	-.79**	.55**	.13	-.22*	.46**
6. Autonomy frustration	1.67 (0.55)	.72						-	.40**	.39**	-.39**	.11	.43**	-.26*
7. Competence frustration	4.41 (0.48)	.70							-	.57**	-.49**	-.24*	.36**	-.37**
8. Relatedness frustration	2.87 (1.04)	.71								-	-.43**	.19*	.38**	-.23*
9. Autonomous motivation	1.26 (0.36)	.82									-	.27**	-.49**	.57**
10. Controlled motivation	6.33 (0.72)	.81										-	.33**	.11
11. Amotivation	28.8 % (15)	.60											-	-.43**
12. Physical activity intent	28.8 % (15)	.68												-

Note: The correlations were significant at levels where $p < .05^*$ and $p < .01^{**}$. Pearson correlations are shown, with the exception of the variable grade, for which Spearman's rank correlation coefficient was used.

Table 2

Direct effects of the satisfaction and frustration of BPNs on student motivation and intention to engage in PA

	β	SE	<i>p</i>	95% BCBCI
Direct effects on autonomous motivation				
Autonomy satisfaction	.06	.08	.44	(-.07, .20)
Competence satisfaction	.61**	.07	< .001	(.48, .74)
Relatedness satisfaction	.25*	.09	.01	(.10, .40)
Direct effects on controlled motivation				
Autonomy frustration	.34*	.10	.01	(.17, .51)
Competence frustration	-.41**	.11	< .001	(-.58, -.24)
Relatedness frustration	-.08	.11	.45	(-.26, .10)
Direct effects on amotivation				
Autonomy frustration	.30*	.12	.01	(.11, .50)
Competence frustration	.28*	.13	.03	(.06, .50)
Relatedness frustration	.10	.12	.40	(-.10, .31)
Direct effects on the intent to engage in PA				
Autonomous motivation	.51**	.09	< .001	(.36, .66)
Controlled motivation	.02	.10	.78	(-.13, .19)
Amotivation	-.23*	.11	.03	(-.41, -.05)

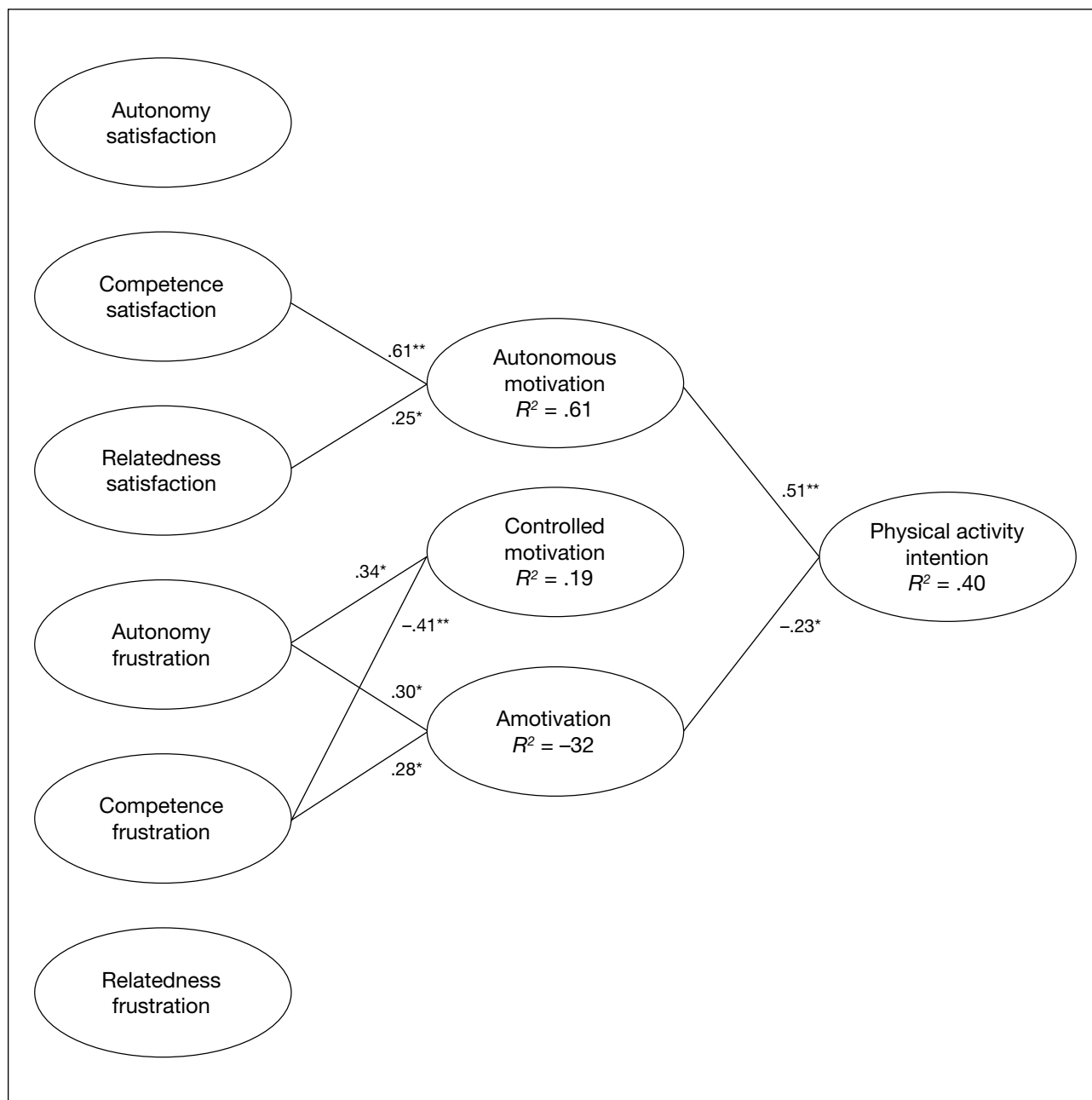
Note: β = standardized beta coefficient; SE = standard error; 95% BCBCI = bias-corrected bootstrap confidence interval. * $p < .05$, ** $p < .01$.

Figure 2 shows the direct effects of the satisfaction and frustration of the BPNs autonomy, competence, and relatedness, as well as the types of motivation for the intention to engage in PA. Competence and relatedness satisfaction were significantly and positively related to autonomous motivation. Autonomy

frustration was positively associated with controlled motivation and amotivation. Competence frustration was negatively related to controlled motivation and positively related to amotivation. Lastly, the intention to engage in PA was positively predicted by autonomous motivation and negatively by amotivation.

Figure 2

Structural Equation Model that shows the direct effects between satisfaction and frustration of BPNs, the different types of motivation, and intention to engage in PA



Note: All the relations shown in the figure were significant where $p < .05^*$ and $p < .01^{**}$.

Table 3 presents the indirect effects of the satisfaction and frustration of the needs for autonomy, competence, and relatedness on the intention to engage in PA, mediated by autonomous motivation, controlled motivation, and amotivation. In particular, competence and relatedness

satisfaction presented a positive indirect effect on intention to engage in PA through autonomous motivation. In contrast, autonomy frustration presented a negative indirect effect on intention to engage in PA, mediated by amotivation.

Table 3

Direct effects of the satisfaction and frustration of BPNs on student motivation and intention to engage in PA

	β	SE	p	95% BCBCI
Indirect effects of satisfaction of autonomy in PA intention				
Total indirect effect	.03	.04	.45	(-.04, .10)
Specific indirect effect via autonomous motivation	.03	.04	.45	(-.04, .10)
Indirect effects of satisfaction of competence in PA intention				
Total indirect effect	.31**	.06	< .001	(.20, .42)
Specific indirect effect via autonomous motivation	.31**	.06	< .001	(.20, .42)
Indirect effects of satisfaction of relatedness in PA intention				
Total indirect effect	.13*	.05	.01	(.04, .21)
Specific indirect effect via autonomous motivation	.13*	.05	.01	(.04, .21)
Indirect effects of frustration of autonomy in PA intention				
Total indirect effect	-.06	.04	.11	(-.13, .01)
Specific indirect effect via controlled motivation	.01	.03	.78	(-.04, .06)
Specific indirect effect via amotivation	-.07†	.04	.08	(-.14, -.01)
Indirect effects of frustration of competence in PA intention				
Total indirect effect	-.07	.07	.28	(-.19, .04)
Specific indirect effect via controlled motivation	-.01	.04	.78	(-.08, .05)
Specific indirect effect via amotivation	-.06	.04	.13	(-.13, .01)
Indirect effects of frustration of relatedness in PA intention				
Total indirect effect	-.02	.03	.43	(-.08, .03)
Specific indirect effect via controlled motivation	-.01	.01	.79	(-.01, .01)
Specific indirect effect via amotivation	-.02	.03	.44	(-.07, .02)

Note: β = standardized beta coefficient; SE = standard error; 95% BCBCI = bias-corrected bootstrap confidence interval

* $p < .05$, ** $p < .01$, † $p > .05$ but the 95% BCBCI does not contain 0.

Discussion

The aim of this study was to analyze the effects of BPNs satisfaction and frustration on the intention to engage in PA in elementary school students, exploring the mediating role of motivation according to SDT (Ryan & Deci, 2017). The main findings were: 1) satisfaction of the competence and relatedness needs was positively and indirectly related to the intention to engage in PA through autonomous motivation; 2) autonomy frustration was negatively and indirectly related to intention to engage in PA through amotivation; and 3) competence frustration was negatively related to controlled

motivation, which did not present a significant influence on student intention to engage in PA.

First, the fact that competence and relatedness satisfaction were positively and indirectly related to the intention to engage in PA through autonomous motivation partially supports the first hypothesis, highlighting the key role of these BPNs in developing motivation that is more self-determined and that has adaptive consequences in PE (Vasconcellos et al., 2020). By creating feelings of efficacy and mastery of skills, the perception of competence encourages personal interests, regulates behavior in a more internal manner, and

reinforces self-confidence and personal commitment (Ryan & Deci, 2017). This pattern has been confirmed in studies that identified competence as one of the needs that is most directly associated with students' intention to engage in PA (Fernández-Espínola et al., 2020). Specifically, in our study, competence emerged as the primary predictor of motivational quality in PE, a similar pattern to that reported by Vasconcellos et al. (2020) in their meta-analysis conducted in high school students.

In that case, feeling connected to others, particularly to a group of equals or to the teacher, contributes to creating positive affectional bonds with PA and developing an active identity (Leo et al., 2020). In elementary school, where social and emotional development is particularly important, these dimensions are especially relevant. The literature has shown that a positive relationship environment can promote enjoyment and the feeling of belonging, which in turn positively influences the intention to continue engaging in PA (Trigueros et al., 2019a). This pattern is also in line with that set forth in the trans-contextual model (Hagger et al., 2003), which highlights the role of autonomous motivation in transferring behavior intention to leisure time contexts.

Second, autonomy frustration is negatively and indirectly associated with the intention to engage in PA through increased amotivation, which supports our second hypothesis. This result is consistent with previous studies (Haerens et al., 2015; Vansteenkiste & Ryan, 2013), which indicate that educational settings that are overly controlling or that offer little participation may stir up feelings of pressure, obligation, or lack of freedom in students, thereby limiting their feeling of personal choice and causing less adaptive forms of regulation. In elementary school, when students are developing their self-concept and decision-making abilities, perceiving activities as imposed upon them or overly directed could cause disinterest, feelings of obligation, or rejection, thus diminishing autonomous motivation and increasing amotivation, in turn hindering the adoption of long-term behaviors and compromising future intention to engage in PA (Assor et al., 2005). This negative pattern has been associated with controlling teaching styles that limit involvement in PE (Trigueros et al., 2019b) and, according to the trans-contextual model, these frustrating experiences hinder motivational internalization and the transfer of intention to extracurricular activity (Ntouvolis et al., 2015).

Third, and unexpectedly, competence frustration was negatively associated with controlled motivation. Contrary to our expectations, as we had hypothesized that this frustration would promote less self-determined forms of

motivation, the findings suggest that students who perceive themselves as incompetent not only fail to develop greater autonomous motivation, but also fail to respond to external incentives. Though counterintuitive, this interpretation could be explained by the concept of "behavioral withdrawal" in SDT (Bartholomew et al., 2011), according to which extreme frustration of competence may lead students to experience emotions such as frustration, shame, or low self-esteem, possibly resulting in fully disconnecting from PA completely. Thus, feeling incapable may result in emotional overwhelm and disconnection, even when receiving rewards or praise (Franco et al., 2021), this being particularly relevant in elementary school, where self-regulatory mechanisms are only just emerging and repeated experiences of inefficacy could result in avoiding PA (Ntoumanis et al., 2021). This pattern has also been described in motivational profiles with elevated frustration, characterized by low levels of both autonomous motivation and controlled motivation (Warburton et al., 2020).

Lastly, neither autonomy satisfaction nor relatedness frustration were significantly associated with the intention to engage in PA. These results do not align with previous studies (Leyton-Román et al., 2020), where BPNs satisfaction predicted more autonomous motivation, which consequently promoted increased engagement in PA among students. Our hypothesis posits that, in elementary school, decision-making processes and social experiences may be contextual. In other words, children tend to follow norms and respond to social signals within the classroom without necessarily internalizing these experiences as motivations to engage in PA outside the educational setting (Chen et al., 2021; Reeve & Cheon, 2021). This hypothesis, as well as the results obtained by Manzano-Sánchez (2023), who showed that elementary school students already exhibit a more self-determined motivational profile towards PA compared to high school students, could contribute to explaining the discrepancies found in comparison to prior research. In terms of relatedness frustration, our hypothesis suggests that its lack of association with intention to engage in PA could be due to the weight of the teacher's role in this educational stage, since teachers that provide emotional support and promote cooperative dynamics may soften negative experiences between equals and promote safe and motivating environments (Moreno-Murcia et al., 2024; Trigueros et al., 2019a). What's more, the inherently playful and cooperative nature of PE may dilute the influence of negative social experiences by creating recurring opportunities to develop interpersonal relationships (Aracil-Alcocer & Alonso-Villodre, 2024).

Practical Applications

The results of this study, in line with those proposed in SDT, provide important implications for improving student motivation in PE classes during the elementary education years. Firstly, they highlight the need to design activities adapted to students' perceived competence level and offer individualized feedback targeted at progression and mastery of skills while avoiding social comparisons or focusing on end results, which could produce frustration and disengagement (Reeve et al., 2014). Likewise, encouraging positive social relationships through cooperative dynamics, group activities, and an emotionally safe environment reinforces students' feelings of belonging and connection (Fierro-Suero et al., 2024). In addition to promoting teaching behaviors that are supportive of BPNs, it is crucial to avoid practices that negatively impact motivation, such as excessively controlling styles, which can frustrate autonomy and competence and cause amotivation or rejection towards engaging in PA (Haerens et al., 2015). Therefore, training teachers in SDT-aligned motivational strategies is essential to creating inclusive, emotionally-sensitive environments aimed at developing sustainable active habits from a young age.

Study Limitations and Future Perspectives

Despite the contributions of this study, it presents some limitations and potential future lines of research that are important to highlight. First, the cross-sectional design prevents us from establishing causal relationships between the analyzed variables, so longitudinal or quasi-experimental studies could be useful to confirm the directionality of the relationships. Second, though our sample included students from 3rd to 6th grade from five different elementary schools, the small sample size limits our ability to generalize the results, so we recommend replicating the study with larger sample sizes. Third, the exclusive use of self-reporting questionnaires could be subject to social-desirability bias; supplementing this methodology with other qualitative processes, such as focus groups, could provide a more in-depth understanding of the topic at hand. Likewise, this study evaluated the intention to engage in PA, but not actual behavior. Future research should consider including direct or objective measures of PA that allows for a comparison of these results. Lastly, some dimensions of the instruments used showed relatively low omega values (such as competence satisfaction, amotivation, and the intention to engage in PA). However, these omega values can be deemed acceptable in short scales, multidimensional instruments, or studies in children, which tend to present a higher degree of response variability

(Loewenthal & Lewis, 2020; Cicchetti, 1994; Hernaez, 2015). From a contemporary perspective, reliability is not considered a dichotomous criterion based on strict cut-off points but rather a continuum in which what matters is providing sufficient evidence to support the internal consistency of the instrument. Consequently, the results provide sufficient evidence of the instruments' internal consistency for the purposes of this study. Future research could continue to optimize and validate these instruments in elementary education to improve their psychometric precision.

Conclusion

Collectively, the results allowed us to identify two different motivational trajectories in this group of elementary school students. On the one hand, competence and relatedness satisfaction are linked to more self-determined motivation, which encourages the intention to engage in PA outside the school environment. On the other hand, frustration of autonomy and competence are associated with higher amotivation, limiting students from adopting an active lifestyle.

These findings reinforce the importance of creating educational settings that promote the satisfaction of BPNs from an early age, as seen in SDT, thereby promoting more adaptive motivational processes that translate into better adherence to PA and the ongoing benefits to the students' physical and emotional well-being. It also emphasizes the need to train teachers in teaching strategies that are aligned with the principles of more self-determined motivation to promote the all-around well-being of students and to help consolidate active and healthy lifestyles in the long-term.

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Effects of Competitive and Non-Competitive HIIT on Psychological and Sleep-Related Variables in Adolescents

David Carbonell-Escalas^{1*} , Josep Vidal-Conti¹ & Aina Galmes-Panades^{1,2,3}

¹Physical Activity and Sport Sciences Research Group (GICAFE), Institute for Educational Research and Innovation (IRIE), University of the Balearic Islands, Palma (Spain).

²Nursing, Community Health and Global Health Research Group, Health Research Institute of the Balearic Islands (IdISBa), Palma (Spain).

³Biomedical Research Networking Center for Physiopathology of Obesity and Nutrition (CIBEROBN), Carlos III Health Institute, Madrid (Spain).

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***Corresponding author:**
David Carbonell-Escalas
david.carbonell@uib.es

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Abstract

Adolescence is a key stage for consolidating active habits and developing psychological variables related to well-being. In the school context, high-intensity interval training (HIIT) has been proposed as an efficient strategy for increasing physical activity; however, evidence regarding the influence of different pedagogical formats, such as competitive formats, on psychological variables and sleep quality and duration remains limited. The aim of this study was to analyze the effects of competitive and non-competitive HIIT programs on motivation toward physical activity, self-esteem, enjoyment, perceived stress, and sleep quality and duration in adolescents. A quasi-experimental pretest-posttest design with three parallel groups (competitive, non-competitive and control) was used. A total of 189 students aged 15 to 17 years from two schools participated, of whom 46.7% were female and 53.3% were male. The intervention lasted 10 weeks, with two weekly sessions integrated into physical education classes. The variables were assessed using validated questionnaires, and within-group analyses and between-group comparisons adjusted for sex were performed. The results showed significant between-group differences in identified regulation and self-esteem. The non-competitive group showed a significant increase in identified regulation, whereas the competitive group showed a significant decrease in self-esteem. No between-group differences were observed in the remaining variables, although the competitive group showed a significant reduction in sleep duration in the within-group analysis. Overall, the results indicated that the design of the HIIT program was a determining factor in the students' psychological responses.

Keywords: mental health, physical education, school-based physical activity, self-determined motivation, self-esteem

Introduction

Adolescence is a critical period for the overall development of individuals, during which lifestyle habits that influence present and future health are consolidated (Banati et al., 2025). Among these behaviors, regular physical activity plays a fundamental role, not only because of its benefits for physical fitness and disease prevention (Anderson & Durstine, 2019), but also because of its relationship with various psychological variables, such as self-esteem, motivation, enjoyment and perceived stress, as well as sleep-related variables, including sleep quality and duration (Fu et al., 2025). However, despite this evidence, most adolescents do not meet the recommended levels of physical activity (Guthold et al., 2020), highlighting the need to develop effective school-based interventions that provide sufficient opportunities for movement during school hours (Alalawi et al., 2023).

Psychosocial and well-being variables related to physical activity, such as sleep quality and duration, motivation toward physical activity, self-esteem, enjoyment and perceived stress, play a fundamental role in active behavior (Master et al., 2019; Yan et al., 2023). Sleep quality and duration are considered key indicators of physical and mental health (World Health Organization, 2019), and several studies have shown that they may be positively influenced by higher levels of physical activity (Carbonell-Escalas et al., 2025).

In the motivational domain, Self-Determination Theory proposes that sustained participation in physical exercise is promoted when young people experience autonomy, competence and positive relationships, thereby increasing their self-determined motivation and adherence (Barbosa-Cano & Gomez-Baya, 2025). Factors such as self-esteem, enjoyment and perceived stress play an important role in the exercise experience and have been associated with how adolescents respond emotionally to physical activity (Yan et al., 2023). Therefore, understanding how these psychological dimensions change in response to different exercise programs is essential for assessing the true effectiveness of school-based interventions aimed at improving psychological well-being and motivation toward physical activity in adolescents. In this respect, analyzing how different types of exercise influence psychological dimensions such as self-esteem, enjoyment and perceived stress is key to identifying which intervention formats promote greater adherence to physical activity and the development of active behaviors in the school context.

High-intensity interval training (HIIT) has become established as an efficient and feasible alternative for promoting physical activity among adolescents (Costigan et al., 2015). This type of training is characterized by short intervals of intense effort interspersed with brief recovery periods, allowing meaningful benefits to be achieved in a short amount of time (Ito, 2019). Its high time efficiency, lack of equipment requirements and easy adaptation to physical education classes make it a particularly suitable strategy for the school setting (Bento et al., 2022). Furthermore, HIIT has been shown to promote student engagement and participation (Duncombe et al., 2023).

One of the most common challenges when implementing HIIT programs with adolescents is the progressive decline in motivation and adherence over the course of the intervention, which may limit the benefits of the program (Bento et al., 2021). In response to this issue, incorporating competitive elements has been proposed as an extrinsic motivational strategy to increase students' effort, engagement and continued participation (Bento et al., 2021). The literature suggests that competition may act as a reinforcer that increases engagement and the intensity achieved (Guo et al., 2022). However, there is limited evidence directly assessing whether integrating competition into school-based HIIT programs improves students' psychological outcomes or subjective experience compared with non-competitive formats.

In addition, most previous studies have focused primarily on the effects of HIIT on physical fitness and physiological variables (Costigan et al., 2015), without addressing its effects on psychological variables such as motivation, enjoyment, self-esteem and perceived stress, or on sleep-related variables. This knowledge gap is particularly relevant in educational settings, where these dimensions may influence adherence to and the effectiveness of interventions in the medium and long term.

Therefore, the aim of the present study was to analyze the effects of two HIIT formats, competitive and non-competitive, on psychological variables (motivation toward physical activity, self-esteem, enjoyment and perceived stress) and sleep-related variables (sleep quality and duration) in adolescents, compared with a control group receiving regular physical education classes. It was hypothesized that non-competitive HIIT would promote more adaptive psychological responses, whereas the inclusion of competitive components based on rankings and peer comparison might be associated with a less favorable response in self-esteem.

Method

Study Design

A quasi-experimental study with a pretest–posttest design and parallel groups (control, non-competitive HIIT and competitive HIIT) was conducted. The study was conducted as part of the Burn2Learn Mallorca project (ClinicalTrials.gov: NCT06699862), a school-based intervention implemented in schools in Mallorca and based on the integration of brief HIIT sessions into physical education classes. The present study specifically compared competitive and non-competitive HIIT formats in terms of their effects on psychological and sleep-related variables in adolescents.

Participants

The sample comprised 189 students in the fourth year of compulsory secondary education from two public secondary schools in Mallorca, one urban and one rural. Of the total number of participants, 46.7% were female and 53.3% were male. The mean age was 15.1 ± 0.80 years, mean body weight was 62.1 ± 10.9 kg and mean height was 168.0 ± 8.70 cm. Among female and male participants, respectively, mean age was 15.0 ± 0.79 and 15.2 ± 0.81 years, mean body weight was 58.8 ± 9.68 and 64.7 ± 11.1 kg, and mean height was 162.0 ± 6.11 and 173.0 ± 6.74 cm.

A convenience sample was drawn from intact fourth-year compulsory secondary education classes at two public schools in Mallorca that agreed to participate in the project. This strategy was adopted for reasons of feasibility within the school setting and enabled the intervention to be implemented within the usual organization of physical education classes. The intervention lasted 10 weeks, with two weekly sessions integrated into the regular physical education schedule.

The inclusion criteria were: (a) being in the fourth year of compulsory secondary education at the beginning of the study, (b) providing their own informed consent and that of their legal guardian, (c) having no medical contraindications to performing high-intensity exercise and (d) attending at least 80% of the scheduled sessions. Participants were excluded if they had an injury or illness that prevented safe participation or if they did not complete the pre- or post-intervention assessments.

Students in the selected intact classes who did not meet the inclusion criteria, did not provide informed consent or did not complete the pretest and posttest assessments were not included in the analyses. However, as the interventions were

integrated into regular physical education activities, these students were able to participate in the sessions provided that there were no medical contraindications and at the teachers' discretion. The absence of medical contraindications to high-intensity physical exercise and the exclusion criterion relating to injuries or illnesses that prevented safe participation were verified using the information provided by families in the informed consent form, in which they were required to disclose any relevant conditions. The physical education teachers also informed the research team of any incidents that were known or identified during the intervention.

Procedure

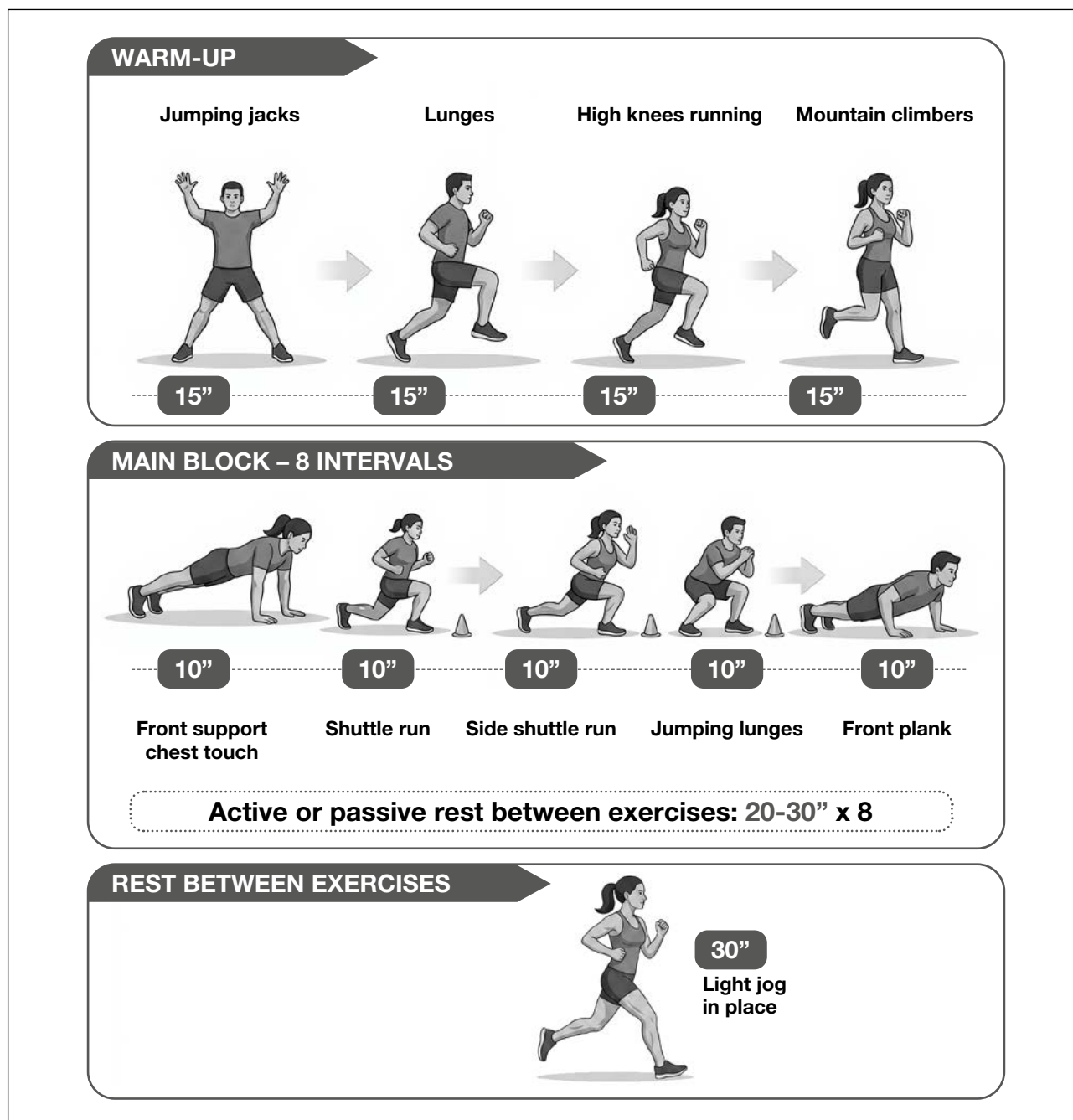
The study was approved by the Ethics Committee of the University of the Balearic Islands (Ref. 385CER23) and the Research Ethics Committee for Medicinal Products of the Balearic Islands (Ref. IB5511/24PI). All procedures were conducted in accordance with the ethical principles governing research involving human participants, and data confidentiality was ensured.

Participants were allocated to the study conditions by intact class, in accordance with the schools' usual organization. The classes were assigned to three conditions: control group, non-competitive HIIT and competitive HIIT. This decision was made for reasons of feasibility within the school setting and avoided reorganizing students individually, thereby preserving the usual dynamics of physical education classes. The participation of two schools, one urban and one rural, enabled the intervention to be implemented in different school contexts; however, school type was neither experimentally manipulated nor used as an allocation criterion.

Data were collected before and after the intervention using self-report questionnaires assessing sleep quality and duration, enjoyment, motivation toward physical activity, self-esteem and perceived stress. The assessments were conducted in groups during school hours and in the presence of the research team.

The intervention followed the same general structure as previous studies conducted as part of the Burn2Learn Mallorca project (Carbonell-Escalas et al., 2026). Each HIIT session lasted approximately 8–12 minutes and included aerobic and bodyweight strength exercises organized into stations and performed at high intensity. Figure 1 provides a schematic example of a session, including the exercise sequence, the duration of the work intervals and the recovery periods.

In the competitive group, the sessions were organized as a competition within each class and between classes.

Figure 1*Example of a HIIT session used in the intervention*

Heart rate was recorded during the sessions using Polar H10 heart-rate monitors and the color-coded intensity-zone system available on the Polar platform. The scoring system was based on the time accumulated in the high-intensity zones (orange and red zones) as an indicator of relative intensity. The score was calculated from the percentage of the session time that each participant spent in these zones; for example, if 8.5 minutes of a 10-minute session were accumulated in the orange and red zones, 85 points were awarded. The results were displayed on weekly individual and group leaderboards. The training structure was the same in the

non-competitive group, but without comparison or scoring. The control group continued with the regular physical education program designed by the school's teachers and did not receive HIIT sessions or use an intensity-based scoring system. The content of these classes was not prescribed by the research team and followed the physical education department's regular planning.

The teachers supervised the sessions and recorded attendance and the intensity achieved, while the researchers coordinated data collection and provided technical support throughout the process.

Instruments

The Pittsburgh Sleep Quality Index (PSQI) (Buysse et al., 1989), validated for use in a Spanish population (Royuela Rico & Macías Fernández, 1997), was used to assess sleep quality and duration. The PSQI is a self-report questionnaire that assesses sleep quality over the previous month using 19 items grouped into seven components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. Each component is scored from 0 to 3, and the sum provides a global score ranging from 0 to 21, with higher values indicating poorer sleep quality. Sleep duration, expressed in hours per night, was also analyzed separately. An example item is: “During the past month, how many hours of actual sleep did you get at night?”

Self-esteem was assessed using the Rosenberg Self-Esteem Scale (Rosenberg, 1965), adapted and validated for use in a Spanish population (Vázquez-Morejón et al., 2004). It consists of 10 items rated on a 4-point Likert scale (from “strongly agree” to “strongly disagree”). The total score reflects the perceived level of self-esteem, with higher values indicating a more positive self-evaluation. An example item is: “I feel that I am a person of worth, at least on an equal plane with others.”

Perceived stress was measured using the 10-item Perceived Stress Scale (PSS-10) (Cohen et al., 1983), adapted and validated for use in a Spanish population (Remor, 2006). It assesses the subjective perception of stress over the previous month, with responses ranging from 0 (“never”) to 4 (“very often”). The sum of the items provides a global score ranging from 0 to 40, with higher values indicating a higher level of perceived stress. An example item is: “In the last month, how often have you felt that you were unable to control the important things in your life?”

Enjoyment during physical activity was assessed using the Physical Activity Enjoyment Scale (PACES) (Kendzierski & DeCarlo, 1991), adapted and validated for Spanish adolescents (Fernández García et al., 2008). This scale consists of 16 items rated on a 5-point scale. Negatively worded items were reverse-scored so that higher scores reflected greater enjoyment of physical activity. An example item is: “I enjoy physical activity.”

Motivation toward physical activity was assessed using the Behavioral Regulation in Exercise Questionnaire-2

(BREQ-2) (Markland & Tobin, 2004), adapted and validated for use in a Spanish population (Murcia et al., 2007), which is based on Self-Determination Theory. The questionnaire includes 19 items (0 = “not true for me” to 4 = “very true for me”) distributed across five dimensions: amotivation, external regulation, introjected regulation, identified regulation and intrinsic regulation. The subscales were analyzed independently to explore the different types of motivational regulation. An example item for identified regulation is: “I value the benefits of exercise.”

Statistical Analysis

Descriptive statistics (mean and standard deviation) were calculated for all variables and stratified by group (competitive HIIT, non-competitive HIIT and control group) and sex to provide an initial characterization of the sample.

Paired-samples t-tests were performed to examine within-group changes between the pretest and posttest. Cohen’s *d* was also calculated as an estimate of effect size to assess the magnitude of within-group pretest–posttest changes beyond statistical significance.

Between-group differences in absolute changes (Post–Pre) were analyzed using ANCOVA, with sex included as a covariate, to determine whether there were significant differences between the groups. The *F* values, significance levels (*p* values) and effect sizes were reported. The results were presented in figures illustrating pretest–posttest changes in variables with and without significant differences.

Statistical analyses were performed using jamovi software (version 2.7.15), and the level of statistical significance was set at $p < .05$.

Results

Baseline descriptive statistics showed similar values across the three groups for the psychological and sleep-related variables. Regarding sleep, both sleep duration and sleep quality showed similar values across the three conditions. The competitive HIIT group had higher perceived stress, amotivation and self-esteem scores than the other groups, while enjoyment and the different types of motivation were similar across groups in both female and male participants.

Table 1
Baseline descriptive statistics for the study population

Variable	Control group (n = 70)						Non-competitive HIIT (n = 70)						Competitive HIIT (n = 49)					
	Total		Male		Female		Total		Male		Female		Total		Male		Female	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Perceived stress	24.01	7.88	22.49	7.28	26.44	8.32	24.74	7.26	23.44	7.16	26.12	7.21	29.04	7.42	26.71	8.02	30.79	6.56
Sleep duration	6.90	1.49	7.29	1.15	6.26	1.75	7.24	1.42	7.52	1.30	6.90	1.51	6.94	1.99	7.14	1.93	6.79	2.07
Sleep quality	6.43	4.37	5.77	3.88	7.48	4.96	6.04	4.45	5.61	4.08	6.50	4.83	6.88	3.31	6.67	3.75	7.04	3.00
Intrinsic regulation	3.97	1.03	4.09	0.96	3.79	1.12	3.92	0.98	4.06	0.95	3.76	1.00	3.67	1.00	4.10	0.86	3.34	0.98
Identified regulation	3.86	0.84	3.91	0.67	3.77	1.06	3.65	0.85	3.72	0.78	3.57	0.93	3.84	0.80	4.09	0.88	3.66	0.69
Introjected regulation	2.84	1.13	2.91	0.98	2.73	1.34	2.65	1.03	2.59	0.88	2.71	1.18	2.99	1.12	3.10	1.05	2.90	1.19
External regulation	1.91	0.81	1.96	0.70	1.83	0.97	1.91	0.98	1.90	1.00	1.91	0.97	2.22	0.97	2.02	0.89	2.38	1.01
Amotivation	1.69	0.84	1.74	0.86	1.63	0.82	1.82	0.98	1.92	0.99	1.70	0.97	2.31	0.70	2.38	0.66	2.25	0.74
PA enjoyment	62.91	11.07	62.52	12.39	63.54	8.72	64.03	10.20	65.00	11.15	63.00	9.14	60.16	9.39	62.33	9.62	58.54	9.04
Self-esteem	23.60	3.69	23.71	4.11	23.42	2.97	24.64	4.02	23.78	4.56	25.56	3.18	26.71	2.61	26.33	2.83	27.00	2.45

Note. SD = standard deviation, $\bar{x}$ = mean, n = sample size.

Table 2
Pre- and post-intervention changes in the study variables within each group (control, non-competitive HIIT and competitive HIIT)

	Control group (n = 70)				Non-competitive HIIT (n = 70)				Competitive HIIT (n = 49)			
	Pre		Effect size (d)	Sig.	Pre		Effect size (d)	Sig.	Pre		Effect size (d)	Sig.
	$\bar{x}$ (SD)	Post $\bar{x}$ (SD)			$\bar{x}$ (SD)	Post $\bar{x}$ (SD)			$\bar{x}$ (SD)	Post $\bar{x}$ (SD)		
Perceived stress	24.01 (7.88)	24.13 (8.05)	0.02	$t = 0.16$ $p = .877$	24.74 (7.26)	23.70 (7.82)	0.09	$t = 0.75$ $p = .456$	29.04 (7.24)	26.82 (8.63)	0.22	$t = 1.52$ $p = .135$
Sleep quality	6.43 (4.37)	7.13 (1.38)	-0.12	$t = -0.92$ $p = .361$	6.04 (4.45)	6.63 (1.36)	-0.12	$t = -1.04$ $p = .302$	6.88 (3.31)	6.67 (3.91)	0.04	$t = 0.31$ $p = .761$
Sleep duration	6.90 (1.49)	5.86 (3.58)	0.20	$t = 1.45$ $p = .197$	7.24 (1.42)	6.85 (2.67)	0.14	$t = 1.09$ $p = .279$	6.94 (1.99)	6.06 (1.73)	0.30	$t = 2.13$ $p = .038$
Intrinsic regulation	3.97 (1.03)	3.76 (0.74)	0.23	$t = 1.78$ $p = .080$	3.92 (0.98)	3.45 (1.02)	-0.16	$t = -1.36$ $p = .177$	3.67 (1.00)	3.45 (1.02)	0.17	$t = 1.20$ $p = .235$
Identified regulation	3.86 (0.84)	3.72 (0.82)	0.10	$t = 0.77$ $p = .446$	3.65 (0.85)	3.90 (0.65)	-0.27	$t = -2.25$ $p = .028$	3.84 (0.80)	3.51 (0.89)	0.30	$t = 2.09$ $p = .042$
Introjected regulation	2.84 (1.13)	2.88 (1.14)	-0.02	$t = -0.16$ $p = .875$	2.65 (1.03)	2.66 (1.12)	-0.01	$t = -0.08$ $p = .938$	2.99 (1.02)	2.99 (0.97)	0.00	$t = 0.01$ $p = .993$
External regulation	1.91 (0.81)	1.99 (0.89)	-0.02	$t = -0.14$ $p = .891$	1.91 (0.98)	2.25 (0.79)	-0.31	$t = -2.56$ $p = .013$	2.22 (0.97)	2.19 (0.96)	0.03	$t = 0.22$ $p = .829$
Amotivation	1.69 (0.84)	1.75 (0.92)	-0.13	$t = -0.99$ $p = .327$	1.82 (0.98)	1.91 (0.95)	-0.07	$t = -0.58$ $p = .566$	2.31 (0.70)	2.21 (0.75)	0.11	$t = 0.74$ $p = .463$
PA enjoyment	62.91 (11.07)	62.27 (12.59)	0.03	$t = 0.20$ $p = .839$	64.03 (10.20)	62.53 (8.92)	0.13	$t = 1.05$ $p = .296$	60.16 (9.39)	60.06 (10.12)	0.01	$t = 0.06$ $p = .954$
Self-esteem	23.60 (3.69)	26.05 (3.82)	-0.57	$t = -4.28$ $p < .001$	24.64 (4.02)	26.56 (6.38)	-0.25	$t = -2.13$ $p = .037$	26.71 (2.61)	23.18 (2.89)	0.78	$t = 5.47$ $p < .001$

Note. SD = standard deviation, $\bar{x}$ = mean, d = Cohen's effect size, Sig. = p value from the paired-samples t-test, n = sample size. p values < .05 are shown in bold.

The pretest–posttest analyses revealed significant changes depending on the intervention group (Table 2). The competitive HIIT group showed a significant decrease in sleep duration ($p = .038$), as well as decreases in identified regulation ($p = .042$) and self-esteem ($p < .001$). By contrast, the non-competitive HIIT group showed significant increases in identified regulation ($p = .028$), external regulation

($p = .013$) and self-esteem ($p = .037$). In the control group, only self-esteem increased significantly ($p < .001$).

No statistically significant changes were detected in any group for the remaining variables. Perceived stress showed a slight reduction in the competitive HIIT group, although this did not reach statistical significance, while sleep quality and intrinsic regulation remained stable across all three groups.

Likewise, introjected regulation, amotivation and enjoyment of physical activity showed no significant changes following the intervention.

Mean pre–post changes (Post–Pre) in the psychological and sleep-related variables according to intervention group are shown in Figures 2 and 3. Between-group comparisons of pretest–posttest changes were performed using analyses of covariance (ANCOVA) adjusted for sex, in order to examine potential differences attributable to the type of intervention.

Variables With Significant Between-Group Differences

The ANCOVA analyses revealed significant differences in identified regulation and self-esteem, the changes in which are shown in Figure 2. For identified regulation, a significant main effect of group was observed ($F(2, 173) = 5.93, p = .003$). Post hoc comparisons with Bonferroni correction indicated that the non-competitive HIIT group experienced a significantly greater increase in this variable than the competitive HIIT group ($p = .003; d = 0.63$), with

no significant differences between the control group and either intervention group.

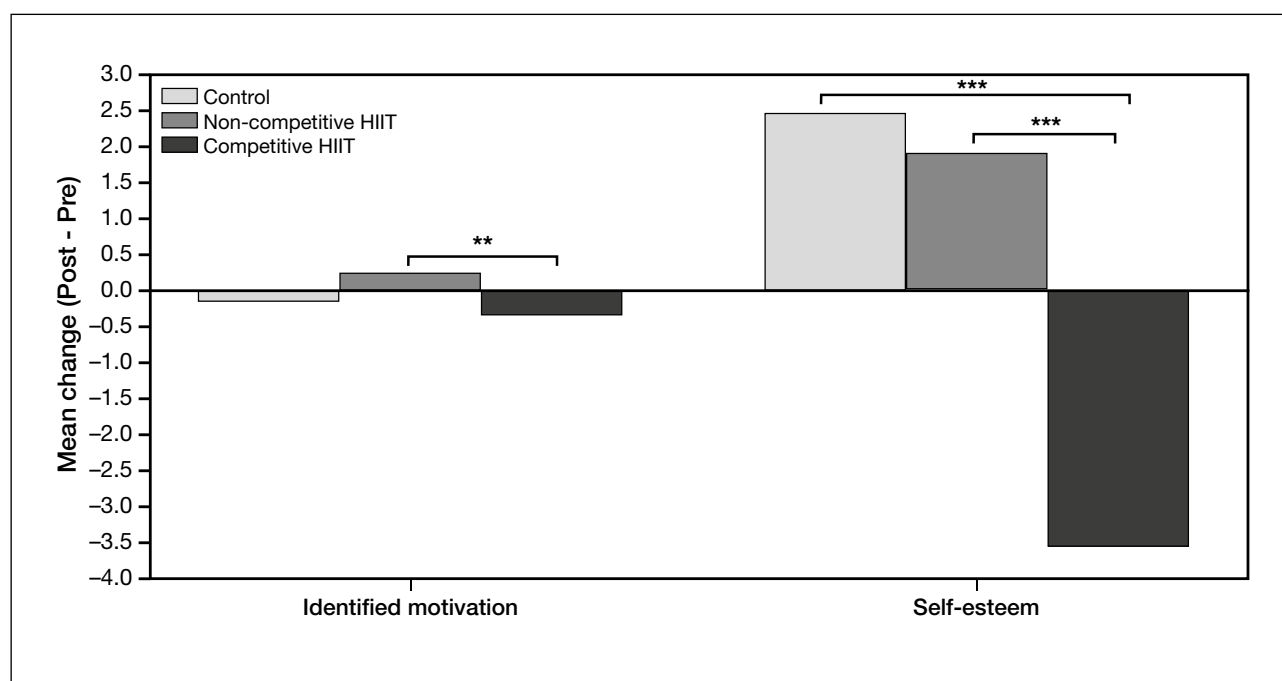
For self-esteem, a highly significant main effect of group was identified ($F(2, 172) = 15.86, p < .001$). Bonferroni-adjusted post hoc analyses showed that the competitive HIIT group experienced a significantly greater decrease in self-esteem than both the control group ($p < .001; d = 1.02$) and the non-competitive HIIT group ($p < .001; d = 0.89$), while no significant differences were observed between the control group and the non-competitive HIIT group.

Variables Without Significant Between-Group Differences

By contrast, no statistically significant between-group differences were observed in the pre–post changes in perceived stress, sleep quality, sleep duration, intrinsic regulation, introjected regulation, external regulation, amotivation or enjoyment of physical activity after adjustment for sex ($p > .05$ in all cases). The mean changes observed in these variables are presented descriptively in Figure 3.

Figure 2

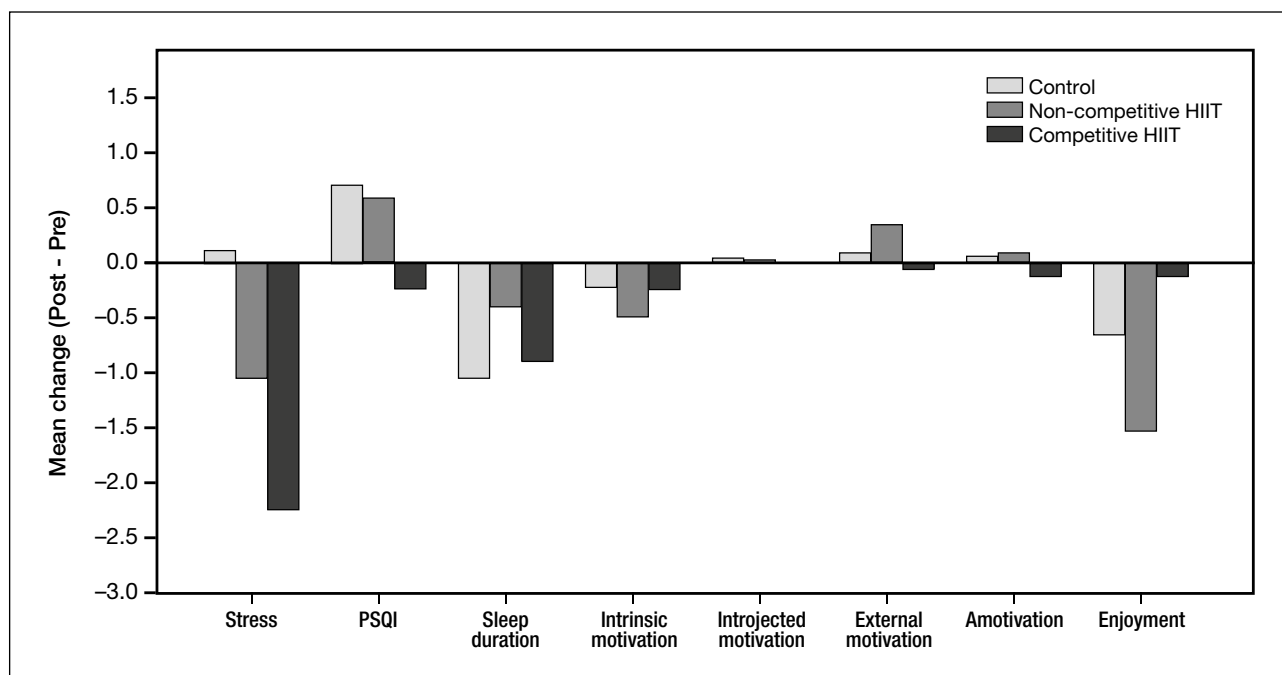
Between-group changes (Post–Pre) in variables showing statistically significant differences according to intervention group



Note. The bars represent sex-adjusted mean pre–post changes (Post–Pre) obtained using analysis of covariance (ANCOVA). The brackets indicate significant post hoc between-group comparisons following Bonferroni correction (** $p < .01$; *** $p < .001$).

Figure 3

Between-group changes in the pre-post values (Post-Pre) of psychological and sleep-related variables without statistically significant differences



Note. The bars represent sex-adjusted mean pre-post changes (Post-Pre) obtained using analysis of covariance (ANCOVA). No statistically significant between-group differences were observed after adjustment for sex.

Discussion

The aim of the present study was to analyze the effects of two HIIT formats, competitive and non-competitive, on psychological and sleep-related variables in adolescents in a school setting. Unlike previous research focused on physical fitness or general comparisons with control groups (Duncombe et al., 2022), this study included a comparison between intervention formats, making it possible to explore the role of the competitive component in students' psychological responses. The results showed significant between-group changes in self-esteem and identified regulation: the competitive format was associated with a decrease in self-esteem, whereas non-competitive HIIT promoted an increase in identified regulation, with no relevant differences in the remaining variables.

Self-esteem emerged as the psychological variable most sensitive to the intervention format, showing clear between-group differences according to the competitive component of HIIT. Specifically, the competitive HIIT group showed a significant decrease in self-esteem compared with both the control group and the non-competitive HIIT group, whereas the latter did not differ from the control group. This finding is particularly relevant in adolescents, a population characterized by greater vulnerability to social comparison and external evaluation processes, factors closely linked to the development of self-concept and self-esteem (Gibbons & Buunk, 1999; Liu et

al., 2025). In educational settings, where physical performance and the public display of abilities carry considerable symbolic weight, the introduction of structured competitive dynamics may intensify the social comparison processes inherent in physical education, with potential implications for students' sensitive psychological variables (Spray et al., 2023). This result is consistent with previous studies conducted in competitive educational settings, which have indicated that performance-oriented and social comparison climates may be associated with more negative perceptions of self-concept and self-esteem in adolescents (Fülöp et al., 2025; Melguizo-Ibáñez et al., 2025).

From a theoretical perspective, these results can be interpreted through Self-Determination Theory, which proposes that environments oriented toward outcomes and social comparison may undermine the satisfaction of basic psychological needs, particularly perceived competence, when there are marked individual differences in ability or physical fitness (Ryan & Deci, 2000; Valero-Valenzuela et al., 2021). In this respect, the competitive format used in the present study, based on rankings and explicit comparisons, may have reinforced perceptions of relative incompetence among some students, thereby negatively affecting their self-esteem. By contrast, the absence of differences between non-competitive HIIT and the control group suggests that high-intensity programs can be implemented in school settings without compromising

self-esteem, provided that the pedagogical design prioritizes participation, individual effort and personal improvement over comparative performance (Vasconcellos et al., 2020).

Regarding identified regulation, the results showed that the non-competitive HIIT format was associated with a significantly greater increase in this form of motivational regulation than competitive HIIT, with no relevant differences compared with the control group. This finding is particularly relevant from an educational perspective, as identified regulation reflects a process through which the personal and functional value of physical activity is internalized, even when the activity itself is not intrinsically enjoyable. Against this background, non-competitive HIIT may have created a context that was more conducive to perceptions of autonomy and the personal meaningfulness of the task by reducing the pressure associated with social comparison and relative performance. This interpretation is consistent with previous studies highlighting the importance of task-oriented motivational climates in physical education for promoting more adaptive internalization processes (Milton et al., 2025). Conversely, the competitive format, which focused on rankings and outcomes, may have shifted the motivational focus toward more controlled forms of regulation, thereby limiting the development of more self-determined forms of motivation (Wu et al., 2021). Overall, these results reinforce the idea that the pedagogical design of HIIT is a key element in promoting not only participation but also the motivational quality of students' experiences in school physical education.

With regard to sleep, the results should be interpreted from an exploratory perspective, given the limited body of previous evidence on the relationship between school-based HIIT interventions and sleep-related variables in adolescents, particularly with respect to comparisons between competitive and non-competitive formats. The stability observed in sleep quality across the three groups suggests that the intervention had no relevant impact on the subjective perception of rest. However, the reduction in sleep duration observed only in the competitive HIIT group suggests possible differences in responses to different exercise formats, although this finding should be interpreted with caution. One possible explanation is that weekly exposure to rankings, public scores and peer comparison may have increased psychological arousal or concerns about performance, at least among some students, which could have interfered with their sleep habits. This interpretation should nonetheless be regarded as exploratory, as perceived stress showed no significant between-group differences and specific variables such as competitive anxiety, pre-sleep arousal or anticipatory worry were not assessed.

In addition, contextual factors inherent to the school setting, such as the stage of the academic year or assessment demands, may also have influenced this variable (Carbonell-Escalas et al., 2025). Overall, these results provide preliminary insight into sleep outcomes in school-based HIIT interventions and highlight the need for future research incorporating longitudinal designs and objective measures of sleep.

Beyond the effects observed on self-esteem and identified regulation, perceived stress, enjoyment, the remaining forms of motivational regulation and sleep quality showed no significant between-group changes. The absence of changes in these variables may be explained, on the one hand, by the high temporal stability of some psychological constructs (Röglin et al., 2023), particularly in short-term interventions, and, on the other, by the fact that the intervention was conducted in a real school setting and integrated into the regular physical education curriculum, which may have helped maintain stable levels of psychological well-being across all groups (Lubans et al., 2021). In the case of perceived stress, although no statistically significant between-group differences were observed, the competitive HIIT format showed the greatest reduction in this variable.

The within-group analyses showed patterns of change consistent with the observed between-group effects, with increases in self-esteem and more self-determined forms of motivation in the non-competitive HIIT group, and decreases in variables such as identified regulation and self-esteem in the competitive format, reinforcing the relevance of the pedagogical design of the intervention. Taken together, these results suggest that certain psychological aspects may require longer or more specific interventions in order for detectable changes to emerge in adolescents.

The results of the present study have relevant implications for the design of HIIT interventions in school physical education. The findings suggest that the pedagogical format of HIIT is a key element beyond exercise intensity, as different approaches may generate different psychological responses among students. In this respect, non-competitive HIIT emerges as a particularly suitable alternative in educational settings, as it promotes more self-determined forms of motivation without compromising sensitive psychological variables such as self-esteem. By contrast, the inclusion of competitive components based on rankings and explicit comparisons requires careful planning, particularly in adolescents, among whom individual differences in ability and physical fitness may amplify social comparison processes. From an educational perspective, these results reinforce the need to prioritize approaches that promote participation, personal improvement and the meaningfulness

of physical activity, aligning interventions with the educational aims of physical education and the promotion of healthy active habits in the long term.

Regarding the control group, the results show that participation in regular physical education classes was not associated with a deterioration in the psychological variables assessed over the 10-week intervention period. However, as the specific content of these classes was neither prescribed by the research team nor systematically recorded, these results should be interpreted with caution. Therefore, the changes observed in the control group cannot be attributed to any specific characteristics of regular physical education and can only be described as the pattern observed in this group during the study period.

Limitations and Future Research Directions

This study has several limitations that should be considered when interpreting the results. First, the duration of the intervention and its integration into the school schedule may have limited the magnitude of the changes observed in some psychological and sleep-related variables. As the intervention was conducted during regular physical education classes, it was constrained by the actual duration of the sessions, school organization, the academic calendar, student attendance and the time available to implement the HIIT protocol, which may have reduced effective exposure to the program. Furthermore, although the effect of sex was controlled for, no information was available on other relevant contextual variables, such as socioeconomic status, extracurricular sport participation or the participants' sporting background. In this context, no detailed information was collected on previous sporting experience, competitive level, familiarity with high-intensity exercise or participation in organized sport, variables that may have influenced the intensity achieved during the sessions, as well as motivation and perceived enjoyment after the activity. Likewise, the exact content and internal load of the regular physical education classes attended by the control group were not systematically recorded, as these classes followed the teachers' regular program. This issue should be considered when interpreting comparisons between the control group and the HIIT groups. Another limitation is the use of self-report measures to assess psychological and sleep-related variables, which may introduce perceptual bias. In this respect, future research should incorporate longer interventions, longitudinal designs and objective measures, particularly in relation to sleep, an area that remains underexplored in school-based HIIT interventions. It would also be useful to analyze

different competitive designs in order to optimize physical and psychological benefits in educational settings, comparing, for example, formats based on individual rankings, cooperative team competition, challenges based on personal progress, private or public feedback, and scoring systems focused on personal improvement rather than direct peer comparison.

Conclusions

The findings of this study show that the competitive HIIT format was associated with a significant decrease in self-esteem compared with the control group and non-competitive HIIT, whereas the latter produced a greater increase in identified regulation. These results confirm that the pedagogical component of HIIT modulates its psychological impact on adolescents, with the non-competitive approach being more suitable in educational settings. Although no significant effects were observed for the sleep-related variables, their inclusion represents a novel contribution to an area that remains underexplored and opens up a promising avenue for future research. The conclusions were drawn after controlling for the effect of sex in the analyses.

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The Power of Inclusion Dynamics in Physical Education: An Analysis of Social Interaction Patterns

Vanessa Sastre^{1*}, Oleguer Camerino² and Marta Castañer²

¹ University of Lleida, Lleida (Spain).

² National Institute of Physical Education – Lleida, University of Lleida, Lleida (Spain).

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***Corresponding author:**
Vanessa Sastre
vanessa.sastre@udl.cat

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Abstract

The aim of this study was to identify the types of motor skills interactions that occur during physical education classes, exploring how they occur between students of different cultural backgrounds according to activity type and gender. To that end, we used a mixed methods design combining different analyses of the results based on the data extracted from the systematic observational methodology. The sample was made up of 87 students (39 females and 48 males) aged between 10 and 11 years ($M = 10.49$; $SD = 0.50$) from two schools with different socio-economic contexts. We designed an ad hoc observational instrument based on motor action theory to record cooperative and oppositional behavior between non-immigrant and immigrant students, using LINCE PLUS software. We supplemented the analyses by combining temporal pattern detection (T-patterns) using the program THEME and Welch's ANOVA statistical analysis with a linear regression analysis and an exploratory factor analysis. The results reveal different motor interaction patterns according to the school concerned and student gender. From a quantitative approach, the results show that the type of activity proposed and the number of times it is performed directly impact how students interact during class. These findings suggest that inclusion or exclusion dynamics depend on the school environment and how the activities are designed, with the resulting recommendation that physical education be based on educational projects that promote equitable participation among students.

Keywords: detection of T-patterns, domestic student, foreign student, inclusion-exclusion, observational methodology, physical education

Introduction

In the early decades of the 21st century, international migration flows have increased substantially, particularly throughout the European continent. In 2023, more than 3.7 million people legally migrated to Europe, mainly for work- or family-related reasons, while only a small fraction entered irregularly (European Parliament [Parlamento Europeo], 2023). That same year, the United Nations' refugee agency reported that 19.5 million people were forcibly displaced in Europe, of which close to 13 million were refugees and around 4.9 million were internally displaced, and some 1.4 million were new asylum-seekers (UNHCR, 2024). Despite these numbers, non-EU citizens represent only 6% of the European population.

In response to this growing migratory pressure, multiple EU policies have been drafted. In April 2024, the European Commission presented the Pact on Migration and Asylum with the aim of establishing a common system that guarantees both the safety and dignity of individuals requesting international protection, as well as catering to the concerns of Member States in terms of their management capacity (European Commission [Comisión Europea], 2024).

In Spain, immigration has had a particularly significant impact. In January 2025, the Spanish population reached 49,077,984 inhabitants, with this growth mainly due to the rising number of individuals from other countries. Likewise, the immigrant population surpassed 9.3 million, and many of those new residents have already obtained Spanish citizenship (INE [Instituto Nacional de Estadística], 2025). Thus, in a short period of time, Spain has transformed from a country of emigration to a country that receives immigrants from multiple locations.

This socio-economic and demographic transformation has produced social, economic, and educational changes. With this new sociological context, pedagogical responses must adapt to promote integration, social harmony, and respect for diversity (Economic and Social Council [Consejo Económico y Social], 2019).

In this setting of social transformation and reception, physical education and sports (PES) at school can be an excellent tool for social inclusion, creating and encouraging spaces for direct interaction and building social bonds between the key players: teachers and students. The experiential and motor dimensions of PES offer unique opportunities to promote values such as equality, cooperation, mutual respect, and empathy, all of which are essential in culturally diverse contexts (Espinola González et al., 2024; Jiménez-Parra et al., 2022; Shao et al., 2025; UNESCO, 2015). Beyond its value in terms of physical development, sports and PE are agents for socialization that can actively contribute to social cohesion and strengthen feelings of belonging, both in a school environment and within the community at large (Ferrari et al., 2025; Monjas et al., 2015; Mundet et al., 2021; Ríos, 2017; Sandoval-Iniesta & Alonso-Roque, 2023; Sherlock, 2024).

The scientific evidence on PES as a potential channel for communication, based on pedagogical innovation that promotes student participation, supports this vision of it as an agent of socialization (Camerino et al., 2019, 2023; García-Castejón et al., 2021; Hellison, 1995; Prat et al., 2019; Valero-Valenzuela et al., 2020). Likewise, inclusive approaches such as the cooperation inherent in physical education (Boke et al., 2025; Graça et al., 2024; Burgueño et al., 2020; Sánchez-Alcaraz et al., 2019) have shown their efficacy not only in terms of motor skills acquisition, but also in developing executive functions (Belando et al., 2024a, 2024b; Martín-Rodríguez et al., 2024) and social and emotional skills (Belando et al., 2012, 2024a; García-García et al., 2023; Jiménez-Parra et al., 2022; Sánchez-Alcaraz et al., 2019). These methodological proposals promote equity, student prominence, and the transfer of learning to other areas of life.

Some studies present evidence showing that participation in shared physical activities between non-immigrant and immigrant students can foster positive intercultural relationships, reduce stereotypes, and improve the classroom climate (Evangelio et al., 2018; Carter et al., 2021). In that regard, PES offers an ideal setting for addressing the topics of social justice, global citizenship, and educational inclusion through an active and participatory approach (García López & Abellán, 2024; Gerdin, 2025; Greco et al., 2024).

This study offers empirical evidence of the inclusion-exclusion potential of PES classes and aims to explore how motor skills interactions unfold between participants from different cultural backgrounds during different class sessions. As such, the aim of this study was to analyze motor skills interactions among students from different cultural backgrounds during physical education classes, taking into consideration the schools, motor skills mastery, and the gender of the participants.

Method

Study Design and Approach

For this study, we used a systematic observational methodology (Anguera et al., 2020), framed within a mixed-method approach (Camerino et al., 2012; Anguera et al., 2018), which enabled us to answer complex social research questions (Greene, 2015) and understand social and human behavior during PES sessions (Hernández-Mendo et al., 2010). We used direct, nonparticipant observation, using continuous weekly intrasession recordings, allowing us to conduct intersession monitoring of the participants. The observational design was nomothetic, as it included a diverse variety of students, and multidimensional, as it considered various criteria that make up the observation tool used.

This methodology allowed us to capture spontaneous and

meaningful behavior in authentic physical activity contexts, providing an in-depth view of the actual role that sport plays in the integration of immigrant students. It also allowed us to identify relational patterns that often go unnoticed in traditional approaches, thus contributing scientific evidence to the debate around the transformative potential of PES in diverse school environments.

Participants

The sample was made up of 87 students (39 females and 48 males) aged between 10 and 11 years ($M = 10.49$; $DE = 0.50$). Students from the equivalent of 6th grade of Spanish elementary school were selected from two schools in the city of Lleida. Both schools had two classes per grade (A and B). These schools represent different socioeconomic contexts and were specifically chosen for their contrasts: one state-subsidized private school located in the neighborhood with the highest income level in the city, and one public school located in an area with a high level of economic vulnerability.

Four students were observed in each session (two male and two female), ensuring at all times the representation of one non-immigrant student and one immigrant student. A total of eight sessions were recorded, with the participation of 32 students.

Table 1
Distribution of participants according to school, grade, gender, and origin

School	Grade	Gender	Non-immigrant	Immigrant
School 1	6th grade, group A	Female	3	7
School 1	6th grade, group A	Male	4	8
School 1	6th grade, group B	Female	3	5
School 1	6th grade, group B	Male	4	7
School 2	6th grade, group A	Female	10	2
School 2	6th grade, group A	Male	10	2
School 2	6th grade, group B	Female	8	1
School 2	6th grade, group B	Male	11	2

Nota. The participants were grouped by school (1 and 2), grade (6th grade, the last year of Spanish elementary education), gender (female and male), and origin (non-immigrant or immigrant).

Instruments

An ad hoc observation instrument was designed based on the theory of motor action or motor action science (Parlebas, 1986, 2001). This theory identifies socio-motricity as the combination of leisure experiences in which participants interact with their classmates or peers (cooperation), with their opponents (opposition), or both (cooperation-opposition) (Lagardera & Lavega, 2003).

The theory of motor action, developed in the 1970s, laid the foundations of motor praxeology as a new scientific discipline (Parlebas, 1981, 2001). Since then, this discipline has produced evidence for a field of knowledge that was previously unexplored: motor action (Lagardera & Lavega, 2003).

From this theoretical perspective, the instrument considers three domains of motor action that have been transformed into dimensions and criteria:

- Cooperation: activities based on positive interactions between classmates, such as dancing or building human towers.
- Opposition: situations in which an individual uses motor skills to interact with an opponent, such as in judo or singles tennis.
- Cooperation-opposition: scenarios that combine cooperation with classmates and opposition against opponents, such as soccer, basketball, volleyball, or doubles tennis.

To ensure the content validity of the instrument, we created a panel of experts made up of researchers specializing in social relationships in sports, observational methodology professionals, and PES professionals. The validation process focused on a review of the observation categories and criteria: initially, we presented the experts with a preliminary instrument, and they evaluated the suitability, clarity, and relevance of each category and criterion in relation to the study objectives and the sports-related context. Based on their comments, we removed categories deemed redundant or that offered little information, changed ambiguous criteria, and added new categories or subcategories that better reflected the observable behaviors of cooperation, opposition, and cooperation-opposition. The modified instrument then underwent a second review by the panel, ensuring that the changes had improved the precision, coherence, and completeness of the observation system. This process allowed the final instrument to have clear, relevant categories and criteria that were appropriate to the context and the study objectives.

Observation Instrument

Based on the validated categories and criteria, we created an instrument designed to record interactive behavior and reveal behavior patterns among the participants according to gender, immigrant background, and school. The instrument

was made up of an observation system with five criteria (see Table 2), combining a field format with a category system, allowing us to collect precise, systematic data to analyze the motor skills interactions.

Table 2
Observational instrument

Criterion or dimension	Categories	Codes	Descriptions
Situation	Start of situation	SS	Situation in which the teacher starts the class
	End of situation	SE	Situation in which the teacher ends the class
	Start of cooperative activity	SCA	Situation in which the students start engaging in a joint exercise to achieve a common goal
	End of cooperative activity	ECA	Situation in which the students finish engaging in a joint exercise to achieve a common goal
	Start of opposition activity	SOA	Situation in which the students start engaging in an exercise involving competition or confrontation
	End of opposition activity	EOA	Situation in which the students finish engaging in an exercise involving competition or confrontation
	Start of cooperation-opposition activity	SCO	Situation in which the students start engaging in an exercise involving opposition and collaboration
	End of cooperation-opposition activity	ECO	Situation in which the students finish engaging in an exercise involving opposition and collaboration
	Opposition activity	OA	Situation in which the participants compete against each other, trying to beat their opponents
	Cooperation activity	CA	Situation in which the participants work together to achieve a common goal
Type of space	Gymnasium	GYM	Covered space equipped for physical activities
	Playground	PLA	Outdoor space intended for physical activities
Cooperation motor interaction	Cooperation motor interaction 1: Passing/throwing a moving object	CMIP	Action in which a participant passes a moving object to a classmate to ensure continuity of the activity
	Cooperation motor interaction 2: High five	CMIH	Action in which a participant intervenes to prevent another classmate from being trapped or eliminated, ensuring continuity of the game or activity
	Cooperation motor interaction 3: Hugging/supporting each other	CMIE	Physical contact in which a participant encircles another with their arms or leans against them, typically to maintain balance or reinforce cohesion during the task
	Cooperation motor interaction 4: Helping someone get up	CMIA	Action in which a classmate helps another to stand back up after falling or losing their balance
	Cooperation motor interaction 5: Rescuing	CMIS	Action in which a classmate saves or frees another so they can continue participating in the activity
	Cooperation motor interaction 6: Carrying a teammate	CMIC	Action in which a classmate supports or carries another in order to help them or move them during the exercise
	Cooperation motor interaction 7: Receiving the moving object	CMIR	Action of receiving or catching a moving object from a classmate with the aim of continuing with the game sequence
	Cooperation motor interaction 8: Grasping	CMIG	Action in which a participant holds or grabs a classmate to help them balance or help them complete the exercise

Table 2 (Continued)
Observational instrument

Criterion or dimension	Categories	Codes	Descriptions
Opposition motor interaction	Opposition motor interaction 1: Throwing a moving object	OMIT	Action in which a participant throws a moving object with the aim of challenging their opponent or fulfilling an objective in the game
	Opposition motor interaction 2: Blocking/stopping a moving object	OMIB	Attempt to stop, intercept, or block an object thrown by an opponent
	Opposition motor interaction 3: Capturing	OMIC	Action in which a participant captures or traps another player within the game, either by touching, grabbing, or marking them in some manner.
	Opposition motor interaction 4: Chasing	OMICH	Intentional movement toward another player to catch them or limit their movement within the game
	Opposition motor interaction 5: Eliminating	OMIE	Action in which a participant removes another player from the game through an established interaction permitted by the game
	Opposition motor interaction 6: Pushing	OMIP	Use of force against an opponent to push them off balance
	Opposition motor interaction 7: Intercepting a moving object	OMII	Action in which a player blocks or interrupts the trajectory of a moving object to prevent it from reaching its recipient/destination
Objective of the behavior/ recipient	To non-immigrant student	NIS	The motor interaction is directed toward a non-immigrant classmate
	To immigrant student	IS	The motor interaction is directed toward an immigrant classmate
	To the teacher	T	The motor interaction is directed toward the teacher

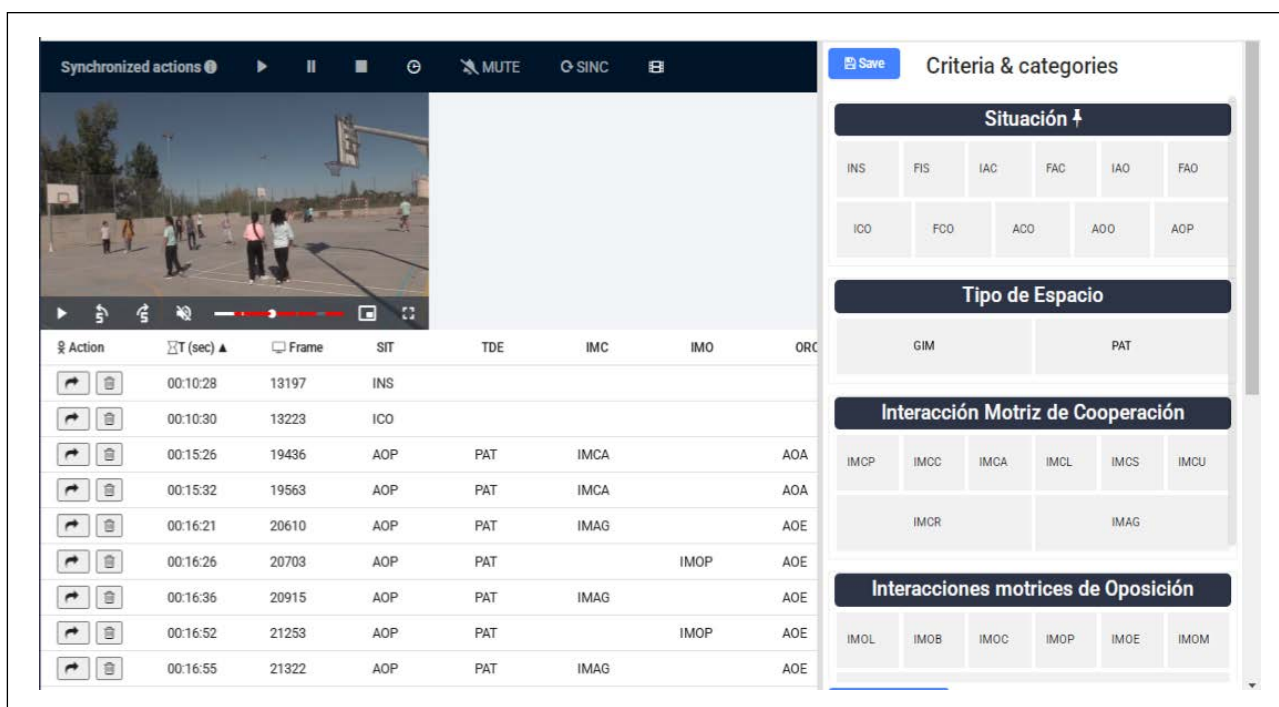
Recording Instrument

We used the LINC PLUS software to record the behavior documented in the observation system (Soto et al., 2019, 2022). The software offers multiple functions, such as collaborative work, since it can be used with simultaneous videos and multiple observers; the behaviors are presented

within the application in real time and can be selected there, allowing users to directly view the frames where they occur. Figure 1 shows the interactive screen with the session video, the observational instrument categories, and the codes for the behaviors that occur as the researcher selects them in the tool.

Figure 1

LINC PLUS screen showing the video of the session, the instrument categories, and the observer's coding (Soto et al., 2022)



Procedure

The sessions analyzed were held in October 2024. The classes were recorded after receiving prior authorization from the management teams of both schools and the teachers involved, and after obtaining signed informed consent forms from the parents. The study also received approval from the University of Lleida Ethics Committee (reference number: CERT172).

Before starting fieldwork, we held informational meetings with the management teams from both schools and the teachers responsible for teaching the physical education classes. Our aim was to explain the study goals and obtain consent to record the classes.

We then held various meetings with experts in the field of physical education and social relationships in order to define and reach an agreement regarding the observation tool to be used during the study.

The recordings were taken over the course of one week during regular physical education classes and included classes held on the playground as well as those that coincided with recess periods. We used an elevated, fixed camera placed in a corner, allowing us to record a panoramic shot of everything that occurred during the motor action activities.

Being able to record in the students' regular school environment helps minimize possible reactivity bias or changes in behavior due to the presence of a camera (Behar & Riba, 1993).

Data Analysis

Detection of T-patterns using THEME software

The temporal pattern analysis (T-patterns) was carried out using THEME 6.0 software (Magnusson, 2000), a specialized tool for identifying hidden temporal structures in observational data through the detection of T-patterns. These patterns correspond to recurring sequences of behavior that repeat with a significant temporal structure (Anguera et al., 2011; Magnusson, 2000).

To ensure the validity and relevance of the obtained results, the following parameters were defined:

- *Minimum Occurrence*: 3, to detect relevant patterns without excluding less frequent patterns with interpretive value (Anguera et al., 2011).
- *Maximum dI*: 5000, allowing us to identify consistent relationships between events far apart in time.
- *Burst Detection*: activated with a significance level of .05 and a minimum of 5 occurrences per burst, filtering relevant events and avoiding noise (Magnusson, 2000).
- *Packet Detection*: deactivated, as it was not relevant to this study.

The analysis was carried out using the data previously coded in the LINCE PLUS program and exported in a format compatible with THEME, following the methodological recommendations inherent to the systematic observational approach (Anguera et al., 2011; Portell et al., 2015).

Generalizability

We conducted multiple additional analyses to assess the internal validity of the instrument and the possibility of generalizing the results to samples with similar characteristics.

We evaluated the internal reliability using Cronbach's alpha coefficient and detected the need to recode one of the variables (*times*), resulting in the variable *times_recode*. Likewise, due to the lack of homogeneity of variances in multiple variables (according to Levene's test), we decided to use Welch's ANOVA instead of the traditional ANOVA.

Additionally, we applied a multiple linear regression model and exploratory factor analysis with oblique rotation (Oblimin) to explore the predictive power of the included variables and the dimensional structure of the instrument.

The results from these analyses are presented in the Results section.

ANOVA

We used the SPSS program (version 30.0) for the statistical data analysis. We worked with a database comprising 387 valid cases, with no missing data, allowing for robust information management.

We initially calculated descriptive statistics for the study variables (*activity*, *interaction*, *recipient* and *times*) and applied a traditional ANOVA to identify significant differences between groups. This analysis revealed statistically significant effects on the *activity* and *times* variables, while *interaction* and *recipient* showed no significant differences.

During the analysis, we detected violations of homogeneity of variance in the variables *activity*, *recipient* and *times_recode*, according to Levene's test. For that reason, we decided to use Welch's ANOVA, which is more appropriate under conditions of heteroscedasticity. This analysis was conducted individually for each variable, allowing us to identify significant differences between groups with greater methodological precision.

It must also be pointed out that, after detecting inverse coding in the variable *times*, we created a new variable, *times_recode*, which showed more consistent behavior in the subsequent analyses.

Table 3*Kappa value and consideration according to Landis and Koch (1977, p. 165)*

Line A	Line B
Female student with immigrant background = .84	Female student with immigrant background = 1
Female student with non-immigrant background = .95	Female student with non-immigrant background = .91
Male student with immigrant background = .93	Male student with immigrant background = .88
Male student with non-immigrant background = .78	Male student with non-immigrant background = .92

Data Quality Control

The two study authors recorded the data: one researcher with observational methodology experience and one physical education teacher with experience in education. The researcher recorded 100% of the sessions, while the teacher acted as a second observer to calculate interobserver reliability.

Both observers received specific training based on the methodological principles proposed by Anguera (2003), focused on the criteria of the observation system used.

To ensure data quality and reliability, we calculated interobserver agreement via Cohen's kappa coefficient (Cohen, 1960, 1968), using the LINCE PLUS software (Soto et al., 2022). This procedure was developed according to the methodological recommendations of Bakeman and Quera (1996, 2001).

The second observer analyzed two sessions from two different schools, coding the behavior of eight randomly chosen students (two male and two female non-immigrant students and two male and two female immigrant students from each school).

These values reflect a high level of agreement in the coding of the observed behaviors, which supports the reliability of the recording instrument used.

Results

Generalizability

The internal reliability analysis initially presented a negative Cronbach's alpha value ($\alpha = -.288$), revealing consistency problems in the scale. After recoding the variable *times* (*times_recode*), the value improved, although it did not reach optimal levels. Therefore, we analyzed the variables individually as different dimensions.

Welch's ANOVA, which we used due to the heterogeneity of variances, revealed significant differences between the groups in the *activity* and *times_recode* variables, yet no

differences were observed in *interaction* or *recipient*.

The multiple linear regression model was significant ($F(4, 382) = 39.875, p < .001$), with an adjusted R^2 of .287. Of the predictors, the variables *activity*, *times_recode*, and *recipient* showed significant effects, while *interaction* did not reach statistical significance. No problems of collinearity were detected ($VIF < 1.1$).

Lastly, the exploratory factor analysis identified a two-dimensional structure that explained the 55.13% of the total variance. The commonalities were adequate in all the variables, which supports the internal validity of the instrument, although not as a unified scale.

Detection of T-patterns Using THEME Software

The results obtained with the THEME software revealed different motor interaction patterns based on school, student gender, and type of behavior (cooperation or opposition). At school 1 and for opposition activities, non-immigrant female students showed a greater tendency to interact with non-immigrant male students; however, they engaged in opposition interactions, choosing to eliminate them to break the continuity of the game, while immigrant female students tended to interact by cooperating with immigrant male students in opposition activities, engaging in behavior such as holding or supporting them to maintain balance or prevent their elimination from the game (see Figure 2).

In the case of non-immigrant male students at school 1, they demonstrated opposition behaviors toward other non-immigrant students in cooperation-opposition activities, with elimination being the most frequent behavior; however, they showed cooperation with immigrant students, with holding onto others to steady them or facilitate completion of the exercise being the most frequent behavior (see Figure 3). Nevertheless, the immigrant male students displayed a pattern of cooperation with immigrant students in cooperation-opposition activities (see Figure 3), with the most significant behaviors being embrace/lean and holding to steady or

Figure 2
T-Pattern of the interactions exhibited by the female students at school 1

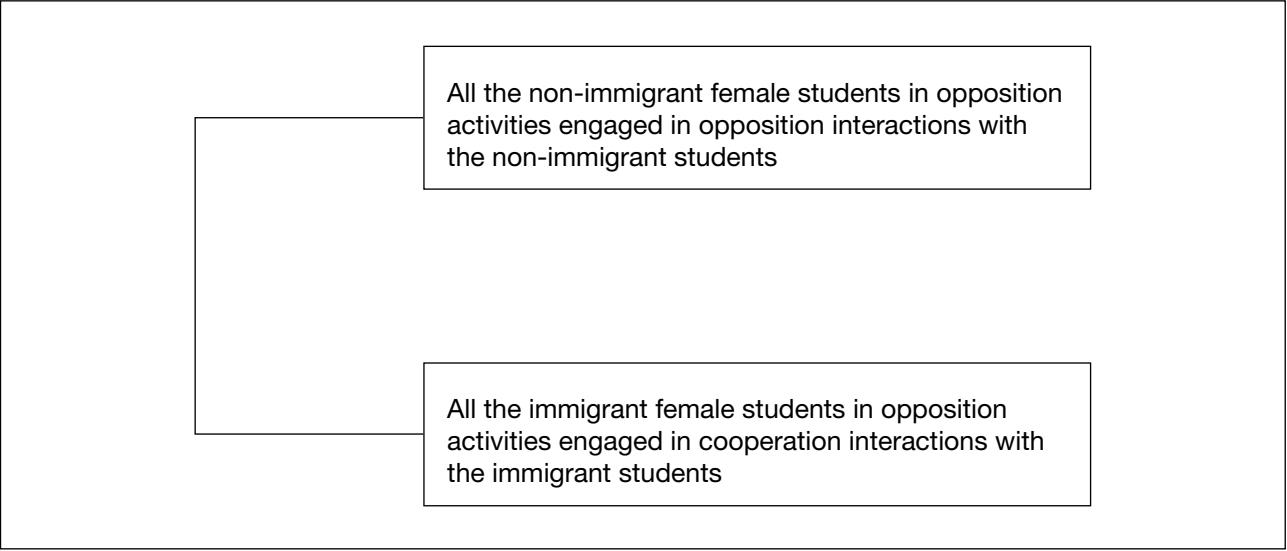


Figure 3
T-Pattern of the interactions exhibited by the male students at school 1

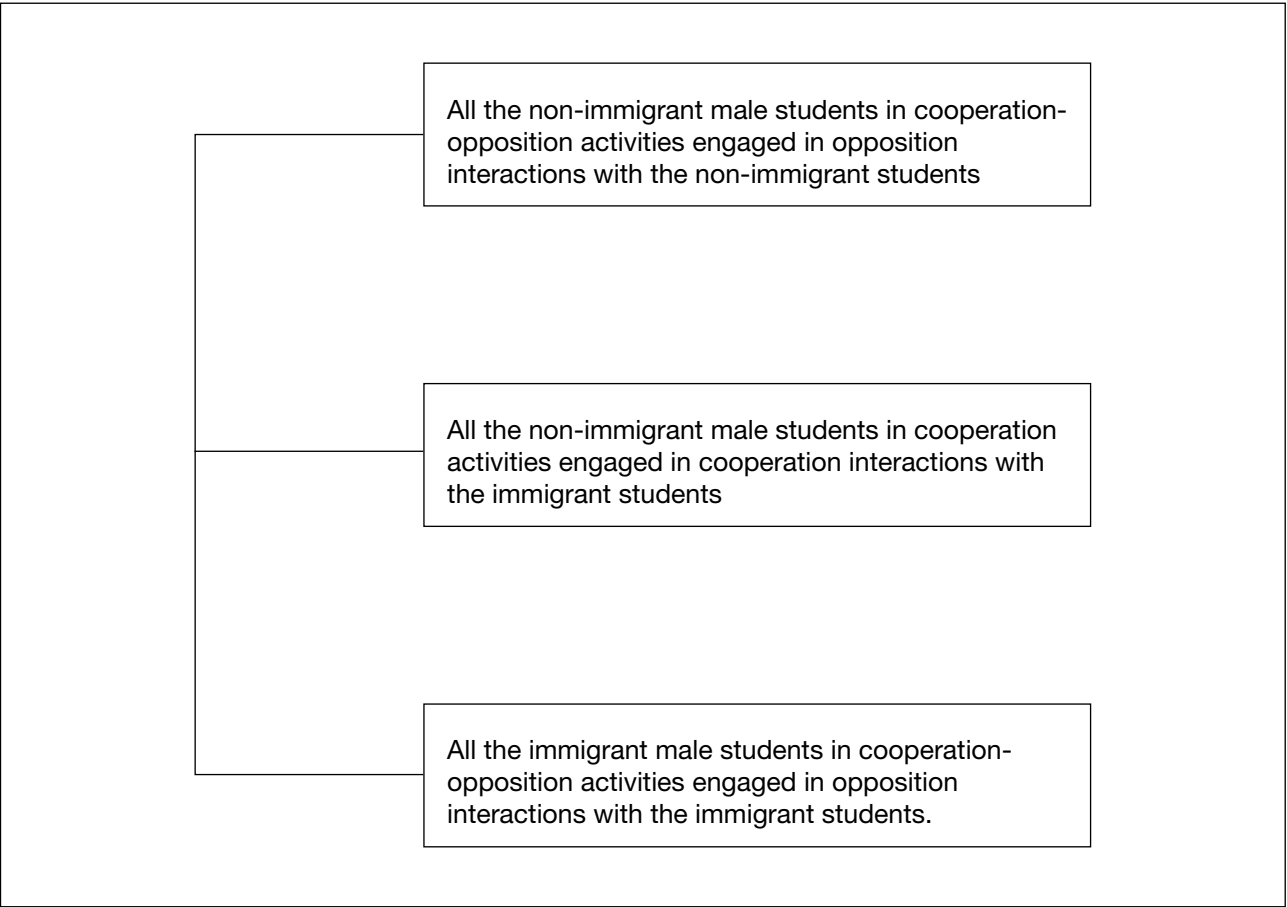
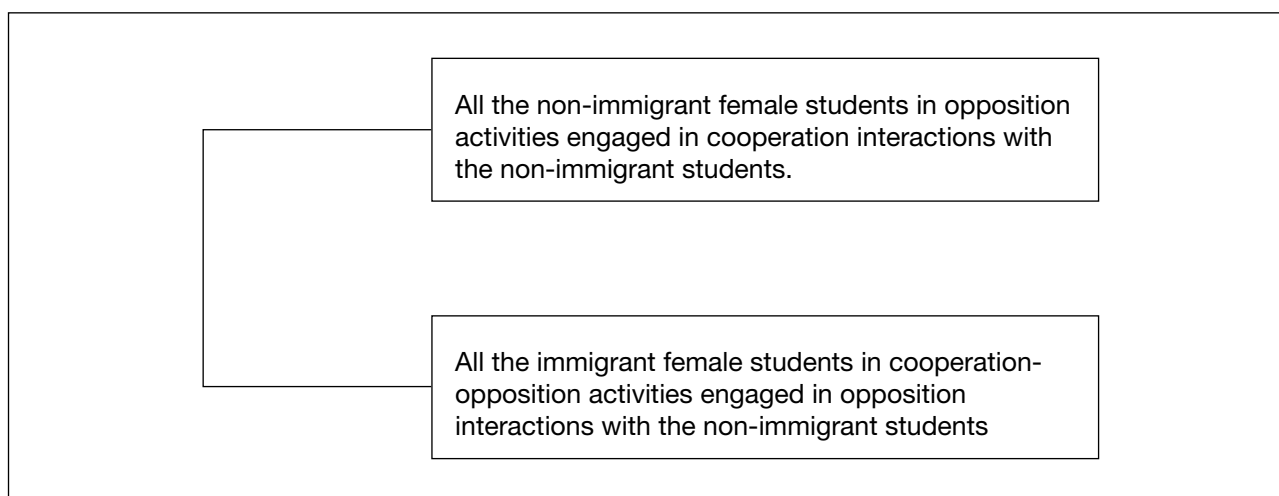
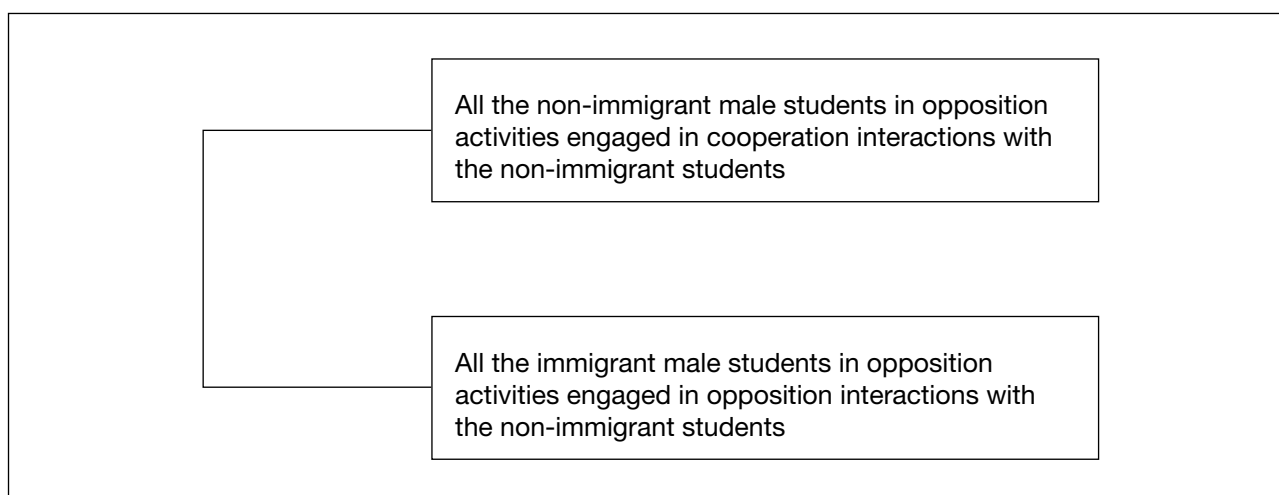


Figure 4*T-Pattern of the interactions exhibited by the female students at school 2***Figure 5***T-Pattern of the interactions exhibited by the male students at school 2*

reinforce cohesion during the task.

Nevertheless, in opposition activities, the non-immigrant female students at school 2, mostly engaged in cooperation interactions with the non-immigrant students, with the behavior of holding onto classmates to maintain their stability and, therefore, continuity in the game being particularly relevant. The immigrant female students presented an inverse pattern in this type of activity, as they interacted in opposition to the non-immigrant students, with behaviors such as chasing them in order to catch them or limiting their movements within the game (see Figure 4).

As for the non-immigrant male students from school 2, we identified patterns of cooperation, such as holding onto one another to maintain balance during the game and ensure continuity during opposition activities with non-immigrant students (see Figure 5). On the other hand, in the same type of activity, the immigrant students showed a greater tendency

toward opposition to the non-immigrant students, engaging in more capturing behavior to prevent these students from continuing to play (see Figure 5).

ANOVA

To determine whether there were significant differences between the groups in the observed dimensions, we used Welch's ANOVA for the *activity*, *interaction*, *recipient*, and *times_recode* variables. We considered this test more appropriate than the traditional ANOVA because Levene's test indicated violations of the assumption of homogeneity of variances for multiple variables (*activity*, *recipient*, and *times*).

The *times* variable was previously recoded (*times_recode*), as its original coding was inverse to that of the other variables, which negatively affected the internal reliability

of the instrument.

The results showed statistically significant differences in the *activity* and *times_recode* variables. Specifically, for *activity*, the traditional ANOVA resulted in a value of $F = 10.634$, $p < .001$, although Welch's ANOVA could not be calculated due to the existence of zero variances in some groups. For *times_recode*, Welch's ANOVA was significant: $F(31, 100.053) = 3.585$, $p < .001$.

On the other hand, no significant differences were observed in *interaction* (Welch's $F = 1.031$, $df = 31, 100.253$, $p = .438$) or *recipient*, for which, once again, we could not calculate Welch's ANOVA due to the presence of zero variances.

In summary, these results suggest that the group significantly affects the type of activity and the frequency with which it occurs but does not influence the nature of the interaction or the person to whom it is directed.

Discussion

The study results allowed us to better understand how social-motor dynamics in physical education not only reflect current social relations but also help shape them. Based on the T-pattern analysis, we observed that interactions between non-immigrant and immigrant students do not follow a uniform pattern but are structured differently according to school context, gender, and type of motor action situation.

At school 1, the results show a clear tendency among students to group together based on their background, particularly in opposition situations. In the case of female students, a clearly distinct pattern can be observed based on origin. While the non-immigrant female students engaged in oppositional behaviors directed toward their own group, the immigrant female students showed a tendency to cooperate with other immigrant female students even during opposition situations, engaging in behaviors such as holding onto others or steadying one another. This result reinforces the existence of grouping based on background, in which intragroup cooperation acts as a cohesion and support mechanism that promotes continuity of the activity.

As for the male students from the same school, we observed more complex dynamics. The non-immigrant male students combined oppositional behavior toward their own group with cooperative behavior toward the immigrant students, while the immigrant male students tended to cooperate primarily with classmates from their same background. These results highlight that cooperation-opposition situations generate more flexible spaces for interaction in which relationships are not exclusively structured around cultural background. In line with motor action praxeology (Parlebas, 2001), these types of motor action domains promote changeable interactions,

requiring students to alternate between collaboration and confrontation, which can expand opportunities for interaction and relationships.

However, these spaces do not, in and of themselves, guarantee inclusive dynamics. While we observed cross-cultural interactions between students of different backgrounds, these were not distributed equitably, signaling the presence of partial or selective inclusion dynamics. This supports the idea that the inclusive potential of physical education depends not only on the type of activity but also on how tasks are structured and pedagogically designed.

On the other hand, at school 2, we identified clearly distinct patterns, with greater polarization according to cultural background. In this case, non-immigrant female students displayed cooperative behaviors within their own group, while immigrant female students displayed oppositional behaviors toward non-immigrant students. The same pattern occurred among male students, with non-immigrant students cooperating within their own group and immigrant male students showing a tendency toward opposition to the non-immigrant students.

These results can be interpreted from a social identity perspective, which posits that individuals tend to strengthen their bonds with their own group and distinguish themselves from others, particularly when they are in the minority. In this sense, the immigrant students' opposition toward the majority group could be understood as a form of identity affirmation within the social-motor context and beyond the rationale of the actual game. Likewise, this cooperation among mainly non-immigrant students suggests the possible existence of internal cohesion dynamics that do not always extend to the class group as a whole.

The differences observed between the two schools highlight the decisive role of the social-educational context. At school 1, where immigrant students constituted the majority, interactions were more diverse and there was less polarization. By contrast, at school 2, where immigrant students were the minority, more pronounced patterns of differentiation emerged between groups. This finding aligns with previous studies showing that the proportion of students from different backgrounds conditions opportunities for interaction and the development of social relationships in the classroom.

From a quantitative point of view, Welch's ANOVA results indicate that variables such as type of activity and activity frequency significantly influence interaction dynamics. However, the lack of differences in the *interaction* and *recipient* variables may suggest an apparent homogeneity that is nuanced by the T-pattern analysis. This analysis reveals that interactions are not random but are organized into complex temporal structures, with distinct patterns emerging based on the context and student profile.

Taken as a whole, these results support the idea that, in physical education, inclusion does not automatically occur due to the mere existence of a diverse student body but rather depends greatly on the creation of motor action situations and teachers' pedagogical intentions. Cooperation, when directed in a balanced manner, can encourage social cohesion; however, in the absence of deliberate planning, other dynamics can arise, such as grouping together, exclusion, or confrontation between groups.

This highlights the need to promote pedagogical approaches that foster equitable interaction between students from different backgrounds, integrating models based on cooperation and social and personal responsibility. Only through deliberate educational design will it be possible to transform physical education into a true space for social cohesion and inclusion.

Study Limitations

This study presents certain limitations that must be considered when interpreting the results. First, the sample included a small number of directly observed students, which could limit the generalizability of the findings to other educational settings. Likewise, the study focused on two schools in the same city, with differing socioeconomic situations, but did not consider other geographic or cultural settings. Another limitation is the brief time frame for data collection, which did not allow us to analyze the evolution of interactions over the course of the school year. Lastly, no individual variables were included, such as level of motor competence, prior inclusion experience, or attitudes toward diversity, all of which could enrich our interpretation of the detected relational patterns.

Practical Implications and Future Lines of Research

The obtained results underscore the importance of physical education teachers' development of activities that foster equitable interaction between students from distinct cultural backgrounds. Methodological strategies based on cooperation and hybrid pedagogical models for inclusion can help minimize exclusion dynamics and encourage group cohesion. For teachers, this entails planning activities that strike a balance between cooperation and opposition, ensuring the active participation of all students and creating a classroom climate that promotes empathy and mutual respect.

In terms of future research, it could be interesting to expand the sample to other social-educational contexts,

including different school ages, and conduct a longitudinal analysis of the evolution of motor interactions over time. Similarly, it would be interesting to include individual variables (motor competence, prior level of integration, motivation) that can provide a deeper understanding of the factors that influence the development of inclusive relationships in physical education.

Conclusions

Intercultural inclusion in physical education is not a natural consequence of classroom diversity but rather the result of deliberate teaching choices. For this space to truly contribute to fostering harmony and mutual respect, teachers must design activities that promote equitable interaction among all students, regardless of their cultural background. Only through well-planned, context-sensitive, and cooperation-oriented teaching approaches is it possible to transform physical education into a true driving force for inclusion and social cohesion in the school environment.

This study has shown that inclusion does not occur automatically but rather depends on factors such as activity type, school context, and student gender. While we identified opportunities for cooperation to promote integration, we also observed exclusion dynamics in certain scenarios. Therefore, it is essential that physical education activities extend beyond technical goals to encourage the creation of inclusive and equitable social bonds. Physical education, understood as a space for social-motor interaction, can be a driver of social cohesion provided that learning and activities are designed in a deliberate and diversity-conscious manner.

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Characterization of an Intervention Program for Physical Education and School Sport in Primary Education Through Document Analysis of Planned Tasks

Ibon Echeazarra^{1*} , Iñigo Sasiain¹ and Oidui Usabiaga¹

¹ Physical Education and Sport, University of the Basque Country, Vitoria (Spain).



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Department of Sports
Institut Nacional d'Educació
Física de Catalunya (INEFC)

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***Corresponding author:**
Ibon Echeazarra
ibon.etxeazarra@ehu.eus

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Abstract

Motor activity plays a key role in holistic development during childhood, with physical education (PE) and school sport (SS) constituting two of the main regulated settings for motor activity among school-age children. This study aimed to characterize the pedagogical approach of a motor intervention program designed in a coordinated manner for both settings. To this end, a document analysis was conducted of the tasks included in the PE and SS program plans, using an ad hoc observational tool that enabled the activities to be categorized according to their structural characteristics. A total of 3 890 tasks were analyzed and classified according to variables related to the management of practice time and the internal logic of motor situations. The results revealed a program with a high level of motor engagement, characterized by a high proportion of motor tasks, high participation density, and a balanced distribution across the different motor action domains. A predominantly noncompetitive orientation and a diversity of practice settings that foster balanced development of students' motor competence were also observed. Overall, the program plans analyzed reflected an innovative pedagogical approach with educational potential for integrating PE and SS in a complementary manner. The structural analysis of tasks was also confirmed as a useful strategy for the pedagogical evaluation of motor intervention programs in school settings.

Keywords: evaluation, internal logic, motor competence, sport instruction

Introduction

The physical and motor dimension is essential for the holistic and balanced development of individuals, particularly at an early age. According to Piaget (1985), motor activity plays a decisive role in maturation and learning during childhood by enabling children to discover and interact with their environment, thus acquiring particular relevance at this stage of life. However, the current sociocultural context, characterized by sedentary behavior, occupational demands, and the proliferation of technology-based leisure, has led to a progressive disconnection from motor experiences, particularly among younger populations (Devís, 2018).

Against this backdrop, promoting practice settings that foster physical and motor development is particularly important. Motor practice settings are understood as social contexts in which motor situations are carried out with a common purpose among participants and can range widely, from free play to competitive training (Martínez-Santos, 2007). Among these, regulated settings such as physical education (PE) and school sport (SS) are governed by legal frameworks and pursue educational objectives, whether in curricular or extracurricular contexts.

In many education systems, PE and SS are complementary settings aimed at promoting students' holistic development through motor practice. In the context of this study, in the Basque Autonomous Community, both settings are governed by specific regulatory frameworks (Decree 77/2023 for PE and Decree 125/2008 for SS) that promote the development of motor competence from a holistic perspective and encourage physical and sports activity as a means of fostering educational development and the acquisition of healthy lifestyle habits.

Pedagogical content is a key component in achieving these educational goals. In PE, this is articulated through the development of motor competence (Ruiz, 1995), which, in connection with the notion of motor conduct (Parlebas, 2001), encompasses physical, cognitive, social, and emotional dimensions and translates into contextualized learning. Although SS does not always explicitly incorporate this concept into its organizational frameworks, various educational approaches share objectives aligned with it, such as improving physical fitness and knowledge of sports disciplines; accordingly, several authors support adopting motor competence as a core educational focus in nonformal contexts as well (Fort-Vanmeerhaeghe et al., 2017).

The motor task constitutes the main methodological and assessment resource in physical activity teaching (Torrents et al., 2011; Marqués & Martínez-Santos, 2015), and its structural characteristics shape learning opportunities and

should be aligned with educational objectives (Adé et al., 2022; Posso-Pacheco et al., 2022). From the perspective of motor praxeology, practices are classified according to their internal logic (type of social interaction and environmental uncertainty) into motor action domains, understood as families of tasks that foster the development of different competencies (Parlebas, 2021). Six main domains are identified in school settings: individual, cooperation, opposition, cooperation-opposition, adaptation to the environment, and expression (Larraz, 2004).

Consistent with this conceptual framework, various PE curricula have adopted motor action domains as an organizing principle for content, as they help structure planning and foster a greater diversity of learning experiences (López-Pastor et al., 2016). This perspective, which is also present in the curriculum of the setting examined in this study (the Basque Country), is applicable to SS, where diversifying tasks according to these domains can enrich the educational offering and promote a more balanced motor experience from an educational perspective (Larraz, 2009).

Nevertheless, despite the intentions expressed in regulatory frameworks, actual practice appears to diverge from these approaches. With regard to PE teaching, a performance-centered logic focused on only a few sports persists, restricting motor learning and reducing the educational potential of the subject (Beltrán & Devís, 2019). In SS, competitive approaches predominate, reproducing standardized adult-oriented motor models centered on technical instruction. This situation has prompted the development of alternative motor intervention programs aimed at integrating curricular and extracurricular settings according to principles consistent with regulatory frameworks (Martínez et al., 2019).

Despite the educational relevance of both practice settings, few studies have structurally analyzed the pedagogical approaches underlying PE and SS programs, particularly when both contexts are designed in a coordinated manner. In this regard, analyzing the motor tasks that make up the program plans provides insight into the practice settings offered to students and enables their educational potential to be assessed.

Considering the above, this study aimed to characterize the pedagogical approach of a motor intervention program designed for coordinated implementation in PE and SS within the same educational setting. To this end, within the framework of observational methodology, an indirect observation strategy based on document analysis of the tasks included in the program plans was adopted to identify the structural characteristics of the proposed motor situations. The analysis was conducted both jointly,

assessing the motor experience offered to students as a whole, and separately by setting, with the aim of exploring the potential pedagogical complementarity between the two practice contexts.

Method

Context

This study analyzed two motor intervention programs for primary education students that are implemented in a coordinated manner in the PE and SS settings. Both programs are implemented at a school located in the municipality of Usurbil (Gipuzkoa, Spain): the PE program at Udarregi Ikastola and the SS program known as Zirimara (Martínez et al., 2019). The programs were selected through purposive sampling because they constitute a joint initiative integrating curricular and extracurricular contexts and have been implemented continuously since the 2018–2019 school year. As an indicator of program consolidation, during the 2024–2025 school year, a total of 103 students (68 boys and 35 girls) from the first two cycles of primary education (41 from the first cycle and 62 from the second) participated in the joint PE and SS initiative, representing 67% of the school's students.

With regard to SS, the Zirimara program was designed in 2016 following a process of reflection and assessment carried out by stakeholders from the education and sports sectors (Martínez et al., 2019), with the aim of promoting school sport oriented toward students' holistic development. In this regard, the program moves away from models focused exclusively on competition and seeks to foster both student autonomy and contact with the natural environment.

The instructional proposal analyzed in this study takes the form of an overall program plan for grades one through four of primary education, designed in coordination with the school's own PE program plan. This ensures a coherent and complementary approach across the formal (PE) and nonformal (SS) contexts. For the analysis of the content examined in this study, the 3 890 activities included in the two program plans were coded: 1,948 tasks in PE and 1,942 tasks in SS.

Ethical Considerations

The study did not involve the direct participation of students, nor did it involve the observation or intervention of the

motor tasks implemented. The unit of analysis consisted of the planned tasks included in physical education and school sport curricula, considered as theoretical proposals for tasks to be implemented. Consequently, no data were collected directly from participants, nor was any intervention carried out involving individuals. Therefore, the study was not submitted for review by an ethics committee.

Coding Tool and Procedure

The study was conducted within the framework of observational methodology applied to document analysis, using an indirect observation strategy focused on the tasks included in the instructional program plans. The units of analysis were the planned tasks, which were considered representative of the program's pedagogical approach. This approach makes it possible to analyze the educational potential of the proposal based on the structural characteristics of the motor situations, thus providing a useful tool for evaluating motor intervention programs.

To analyze the activities included in the program plan, an ad hoc taxonomic tool was developed, structured as a combination of field formats and a category system (Anguera, 1992), which made it possible to simultaneously record different structural characteristics of the tasks included in the program plans. On the one hand, it enabled the analysis of practice time management by distinguishing between motor and nonmotor tasks, their density (Echeazarra, 2016), and their distribution throughout the session. On the other hand, it facilitated the identification of characteristics of the internal logic that are relevant from an instructional perspective (López de Sosoaga, 2010), such as action domains, memory, and equipment. Table 1 presents the criteria and categories used to categorize the tasks.

Using the taxonomic tool described above, all activities included in the annual PE and SS program plans were then analyzed. Prior to coding, an interobserver agreement test was conducted between two observers to verify the reliability of those coding criteria that were not explicitly stated in the program plans but could be derived from the structural characteristics of the tasks described in them. Both observers recorded and classified 50 tasks, comparing their results with the final categorization. Cohen's kappa coefficient (Cohen, 1960) and the interpretation scale proposed by Landis and Koch (1977) were used to assess the degree of agreement. Satisfactory values were obtained for all criteria, ranging from .87 to 1.00 (see Table 2).

Table 1*Brief description of the criteria and categories used to code the tasks*

	Criteria	Categories	Description
Contextualization	Context	PE and SS	Context in which the activity takes place
	Grade level	PE1. PE2. PE3. PE4.	Grade for which the activity is intended
	Instructional unit	Name of the unit	Instructional unit corresponding to this activity
	Session No.	Session number	Number of sessions per grade level
	Exercise No.	Exercise number	Number of exercises per grade level
	Exercise	Name of the activity	Name of the activity in the program plan
	Duration	Activity duration	Duration of each activity in minutes
Practice time management	Type of practice	Motor	Motor task
		Nonmotor	Task with no motor involvement
	Density index	Full	≥ 75% of students participate in the activity
		Partial	< 75% of students participate in the activity
	Session phase	Opening	Initial phase for welcoming students and providing explanations
		Main phase	Central phase devoted to learning
		Closing	Final phase for reflection and closing
Characteristics of motor practice	Motor action domains	Psychomotor (P)	Individual actions in a stable space, with no interaction
		Opposition (O)	One-on-one (1:1). Includes all-against-all and one-against-all situations (1:X)
		Cooperation (C)	Motor situation involving cooperation among participants in the absence of opposition
		Cooperation-opposition (CO)	Motor situations in which participants interact simultaneously through cooperative relationships with teammates and oppositional relationships against opponents
		Expressive (E)	Activities with a strongly artistic and expressive nature
		Environmental uncertainty (EU)	Activities involving uncertainty in the environment
	Equipment	Standard	Standard equipment is used
		Alternative	Equipment other than standard equipment is used
		No equipment	No equipment is used
	Memory	With memory	The task identifies the winner(s) upon completion
		Without memory	The task does not determine a winner

Table 2*Results of the interobserver agreement test. Cohen's kappa statistic*

Criteria	Interobserver agreement
Density	.87
Action domain	.98
Equipment	.96
Memory	1

Statistical Analysis

Results were expressed as mean and standard deviation, using relative data to facilitate comparisons between PE and SS, given the differences in planned practice time. Normality and homoscedasticity were assessed using the Shapiro–Wilk and Levene tests, and, based on the results, nonparametric statistics were used.

For the between-context analysis, the Kruskal–Wallis test was applied, followed by Dunn’s post hoc test with Bonferroni correction. For the within-context analyses, the Mann–Whitney *U* test was used for variables with two levels, and the Kruskal–Wallis test with Dunn’s post hoc test was used for variables with more than two levels. The same procedure was used to analyze differences between the two PE cycles. In addition, effect sizes (ES) were calculated using Cohen’s *d* (Cohen, 1988), along with their 95% confidence intervals, and their magnitude was classified as trivial (< .2), small (.2–.5), moderate (.5–.8), or large (> .8) (Cohen, 1988). The analysis was performed using JASP v0.14, with differences considered significant at $p < .05$.

Results

Practice Time Management

With regard to the temporal management of practice, motor

engagement (type of nonmotor and motor practice together with the density of motor practice) is presented on the one hand, and the organization of practice time according to session phase (opening, main phase, and closing), which was in turn categorized as nonmotor or motor, on the other. Table 3 presents data for the practice settings studied, PE and SS, both separately and jointly (Combined), while Table 4 presents the corresponding data for the two PE cycles (PEcycle1 and PEcycle2).

In the comparison between contexts, PE showed significantly higher values than SS for motor practice (0.90 [0.74; 1.06], large) as well as for full-density motor practice (0.41 [0.26; 0.56], small). Regarding session structure, PE showed significantly higher values in the opening (0.15 [–0.03; 0.34], trivial) and closing (0.66 [0.47; 0.84], moderate) phases than SS, whereas SS showed significantly higher values in the main phase (0.84 [0.65; 1.03], large). Finally, SS showed significantly higher values for nonmotor practice during the opening phase than PE (1.85 [2.07; 1.63], large).

In the comparison between PE cycles, PEcycle1 showed significantly higher values than PEcycle2 for motor practice (0.23 [0.06; 0.39], small) and for full-density motor practice (0.50 [0.34; 0.67], moderate). Regarding session structure, the only significant difference was found for motor practice during the opening phase, which was significantly higher in PEcycle1 (0.15 [–0.03; 0.34], trivial).

Table 3

Type of practice (motor and nonmotor, and partial and full density for motor practice) and session phase (motor and nonmotor practice) in the PE and SS contexts

Type of practice						Session structure			
PE	Nonmotor	Motor		Opening		Main phase		Closing	
	20.3 ± 17.2	79.7 ± 17.2 ^b		24.2 ± 9.4 ^b		59.2 ± 9.8		16.6 ± 4.2 ^b	
		Partial d.	Full d.	Nonmotor	Motor	Nonmotor	Motor	Nonmotor	Motor
		11.9 ± 25.0	88.1 ± 25.0 ^b	53.6 ± 31.5	46.4 ± 31.5 ^b	3.3 ± 12.7	96.7 ± 12.7	100.0 ± 0.0	0.0 ± 0.00
SS	Nonmotor	Motor		Opening		Main phase		Closing	
	34.0 ± 12.6 ^a	66.0 ± 12.6		23.1 ± 3.7		65.6 ± 4.1 ^a		11.3 ± 11.2	
		Partial d.	Full d.	Nonmotor	Motor	Nonmotor	Motor	Nonmotor	Motor
		22.9 ± 28.4 ^a	77.1 ± 28.4	97.1 ± 9.4 ^a	2.9 ± 9.4	3.4 ± 14.3	96.6 ± 14.3	100.0 ± 0.0	0.0 ± 0.00
Combined	Nonmotor	Motor		Opening		Main phase		Closing	
	25.9 ± 16.8	74.1 ± 16.8		23.6 ± 7.2		62.4 ± 8.2		14.0 ± 4.1	
		Partial d.	Full d.	Nonmotor	Motor	Nonmotor	Motor	Nonmotor	Motor
		16.5 ± 27.0	83.5 ± 27.0	75.3 ± 31.8	24.7 ± 31.8	3.3 ± 13.5	96.7 ± 13.5	100.0 ± 0.0	0.0 ± 0.0

Note. Significant differences at $p < .05$: a > PE, b > SS; Partial d. = partial density, Full d. = full density.

Table 4

Type of practice (motor and nonmotor, and partial and full density for motor practice) and session phase (motor and nonmotor practice) in the PEcycle1 and PEcycle2 contexts

Type of practice					Session structure										
PEcycle1	Nonmotor		Motor		Opening		Main phase		Closing						
	18.4 ± 17.4		81.6 ± 17.4 ^b		23.2 ± 10.1		60.5 ± 10.7		16.3 ± 4.0						
	Partial d.		Full d.		Nonmotor		Motor		Nonmotor		Motor				
	6.1 ± 17.5		93.9 ± 17.5 ^b		51.1 ± 34.1		48.9 ± 34.1 ^b		4.0 ± 13.8		96.0 ± 13.8		100.0 ± 0.0		0.0 ± 0.0
PEcycle2	Nonmotor		Motor		Opening		Main phase		Closing						
	22.3 ± 16.7 ^a		77.7 ± 16.7		25.0 ± 8.6		58.0 ± 8.7		17.0 ± 4.4						
	Partial d.		Full d.		Nonmotor		Motor		Nonmotor		Motor				
	18.5 ± 30.1 ^a		81.5 ± 30.1		56.0 ± 28.6 ^a		44.0 ± 28.6		2.6 ± 11.5		97.4 ± 11.5		100.0 ± 0.0		0.0 ± 0.0

Note. Significant differences at $p < .05$: a > PEcycle1, b > PEcycle2; Partial d. = partial density, Full d. = full density.

Structural Characteristics of Motor Practice

This second section presents the variables related to the structural characteristics that define the motor tasks included in the PE and SS program plans, categorized according to their motor action domain, whether or not they have

memory, and the type of equipment used. As in the previous section, data are presented for the comparison between PE and SS (Table 5), on the one hand, and between PEcycle1 and PEcycle2 (Table 6), on the other. Effect size values are also presented for the comparisons between PE and SS (Figure 1) and between PEcycle1 and PEcycle2 (Figure 2).

Table 5

Classification of motor practice according to action domains, memory, and equipment in the PE and SS contexts

	Action domains						Memory		Equipment		
	P	C	O	CO	EU	E	No	Yes	No	Standard	Alternative
PE	16.7 ± 32.4 ³	20.9 ± 38.2 ^{b35}	6.8 ± 19.9	15.6 ± 30.6 ³	14.2 ± 34.3	25.8 ± 42.4 ^{b35}	85.3 ± 29.2 ^{b2}	14.7 ± 29.2	35.3 ± 42.8 ^{b3}	61.9 ± 43.2 ¹³	2.8 ± 13.5
SS	19.6 ± 28.7 ^{a256}	12.0 ± 21.1	17.1 ± 26.3 ^{a56}	24.3 ± 30.4 ^{a256}	12.2 ± 30.2	14.9 ± 34.0	63.8 ± 33.5 ²	36.2 ± 33.5 ^a	21.4 ± 29.6 ³	73.4 ± 31.6 ^{a13}	5.2 ± 14.6 ^a
Combined	17.9 ± 30.8 ⁵	17.2 ± 32.5 ⁵	11.0 ± 23.3	19.2 ± 30.8 ³⁵	13.4 ± 32.6	23.3 ± 39.5 ⁵	76.5 ± 32.8 ²	23.5 ± 32.8	29.5 ± 38.5 ³	66.7 ± 39.2 ¹³	3.8 ± 14.0

Note. a > PE, b > SS, 1 > P, 2 > C, 3 > O, 4 > CO, 5 > EU, 6 > E, 1 > No, 2 > Yes, 1 > No, 2 > Standard, 3 > Alternative, P = psychomotor, C = cooperation, O = opposition, CO = cooperation-opposition, EU = environmental uncertainty, E = expressive activity.

Table 6

Classification of motor practice according to action domains, memory, and equipment in the PEcycle1 and PEcycle2 contexts

	Action domains						Memory		Equipment		
	P	C	O	CO	EU	E	No	Yes	No	Standard	Alternative
PEcycle1	7.8 ± 20.7	24.5 ± 41.6 ¹³	7.4 ± 21.1	17.0 ± 31.2 ¹³	18.1 ± 38.3	25.2 ± 42.2 ¹³	90.8 ± 22.4 ^{b2}	9.2 ± 22.4	38.0 ± 42.8 ³	58.8 ± 43.3 ¹³	3.3 ± 15.2
PEcycle2	26.6 ± 39.6 ^{a345}	16.9 ± 33.6 ³	6.1 ± 18.5	14.0 ± 29.9	9.9 ± 28.6	26.4 ± 42.7 ²³⁵	79.2 ± 34.3 ²	20.8 ± 34.3 ^a	32.2 ± 42.8 ³	65.5 ± 43.0 ¹³	2.3 ± 11.5

Note. a > PEcycle1, b > PEcycle2, 1 > P, 2 > C, 3 > O, 4 > CO, 5 > EU, 6 > E, 1 > No, 2 > Yes, 1 > No, 2 > Standard, 3 > Alternative, P = psychomotor, C = cooperation, O = opposition, CO = cooperation-opposition, EU = environmental uncertainty, E = expressive activity.

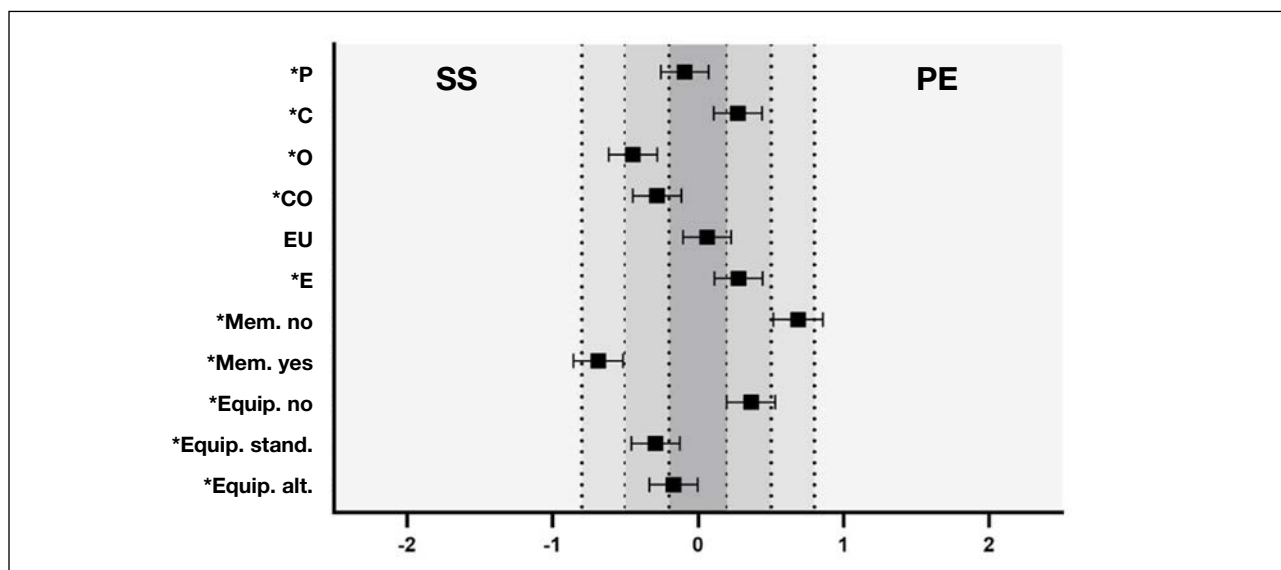
In the comparison between PE and SS, all variables except the EU domain differed significantly between contexts. Specifically, PE showed significantly higher values than SS for C, E, without memory, and no equipment (small, small, moderate, and small ES, respectively). By contrast, P, O, CO, with memory, standard equipment, and alternative equipment showed significantly higher values

in SS than in PE (trivial, small, small, moderate, small, and trivial ES, respectively).

The approaches in PEcycle1 and PEcycle2 appeared more similar, with significant differences in three of the 11 variables. Thus, P and with memory were significantly higher in PEcycle2 (moderate and small ES, respectively), whereas without memory was significantly higher in PEcycle1 (small ES).

Figure 1

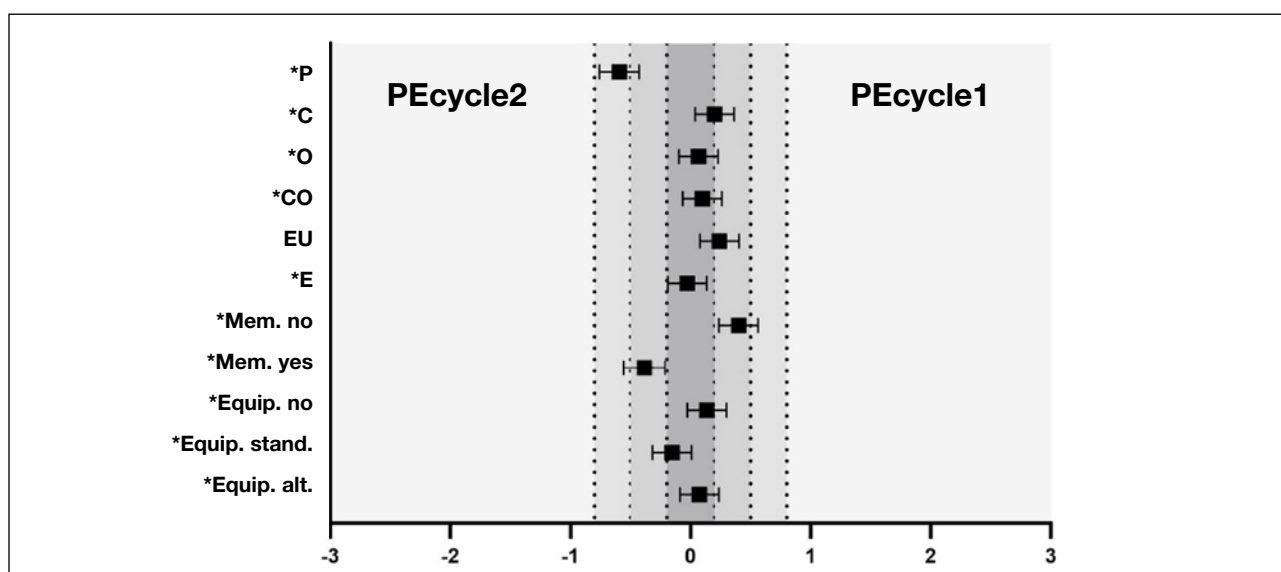
Effect size of the comparison between the PE and SS contexts for each structural task variable



Note. P = psychomotor, C = cooperation, O = opposition, CO = cooperation-opposition, EU = environmental uncertainty, E = expressive activity, Mem. no = activity without memory, Mem. yes = activity with memory, Equip. no = activity without equipment, Equip. stand. = activity with standard equipment, Equip. alt. = activity with alternative equipment.

Figure 2

Effect size of the comparison between the PEcycle1 and PEcycle2 contexts for each structural task variable



Note. P = psychomotor, C = cooperation, O = opposition, CO = cooperation-opposition, EU = environmental uncertainty, E = expressive activity, Mem. no = activity without memory, Mem. yes = activity with memory, Equip. no = activity without equipment, Equip. stand. = activity with standard equipment, Equip. alt. = activity with alternative equipment.

To characterize the approaches in each of the contexts studied in greater detail, mean values for the 11 structural variables were compared within each context, separately for PE and SS. In addition, an integrated analysis of the activities planned for PE and SS (Combined) was also conducted to assess, from an overall perspective, the approach offered to students who participate in both practice contexts.

Beginning with the comparison between action domains, significant differences were found, with a distinct distribution depending on the context analyzed. In PE, the P, C, CO, and E domains showed significantly higher values than O (0.37 [0.21; 0.52], small; 0.46 [0.31; 0.61], small; 0.34 [0.19; 0.49], small; and 0.57 [0.42; 0.72], moderate, respectively), while C and E showed significantly higher values than EU (0.18 [0.03; 0.33], trivial; and 0.30 [0.15; 0.45], small, respectively). In SS, the P, O, and CO domains showed significantly higher values than EU (0.25 [0.06; 0.43], small; 0.17 [0.01; 0.36], small; and 0.40 [0.21; 0.58], small, respectively) and E (0.15 [0.04; 0.33], trivial; 0.07 [-0.11; 0.26], small; and 0.29 [0.10; 0.47], small, respectively), whereas P and CO showed significantly higher values than C (0.30 [0.11; 0.48], small; and 0.47 [0.28; 0.65], small, respectively). Finally, the Combined approach showed fewer significant differences between domains: P, C, CO, and E showed significantly higher values than EU (0.14 [0.03; 0.26], trivial; 0.12 [0.00; 0.23], trivial; 0.18 [0.07; 0.30], trivial; and 0.27 [0.16; 0.39], small, respectively), while CO showed significantly higher values than O (0.30 [0.18; 0.41], small).

Regarding the memory variable, in all three contexts—PE, SS, and Combined—values for tasks without memory were significantly higher than those for tasks with memory (2.39 [2.20; 2.59], large; 0.82 [0.62; 1.01], large; and 1.60 [1.47; 1.73], large, respectively). Finally, in all three contexts (PE, SS, and Combined), values for tasks using standard equipment were significantly higher than those for tasks without equipment (0.61 [0.46; 0.77], moderate; 1.68 [1.47; 1.90], large; and 0.95 [0.83; 1.07], large, respectively) and those using alternative equipment (1.83 [1.65; 2.01], large; 2.74 [2.49; 3.00], large; and 2.12 [1.97; 2.26], large, respectively), while values for tasks without equipment were significantly higher than those for tasks using alternative equipment (1.01 [0.86; 1.17], large; 0.69 [0.50; 0.88], moderate; and 0.88 [0.76; 1.00], large, respectively).

Regarding the approach in each PE cycle, in PEcycle1 the C, CO, and E domains showed significantly higher values than P (0.50 [0.34; 0.67], moderate; 0.34 [0.18; 0.50], small; and 0.52 [0.36; 0.68], moderate, respectively) and O (0.51 [0.35; 0.68], moderate; 0.36 [0.20; 0.52], small; and 0.53 [0.37; 0.69], moderate, respectively). In PEcycle2, P, C, and E showed significantly higher values than O (0.66 [0.49; 0.83], moderate; 0.39 [0.23; 0.56], small; and 0.61 [0.44;

0.78], moderate, respectively), P and E showed significantly higher values than EU (0.48 [0.31; 0.65], small; and 0.45 [0.28; 0.62], small, respectively), P was higher than CO (0.36 [0.19; 0.52], small), and E was higher than C (0.25 [0.08; 0.41], small). As in the other contexts, values for tasks without memory were significantly higher than those for tasks with memory (3.61 [3.35; 3.87], large; and 1.68 [1.49; 1.88], large, respectively), while values for tasks using standard equipment were significantly higher than those for tasks without equipment (0.48 [0.32; 0.64], small; 0.77 [0.60; 0.94], moderate) and those using alternative equipment (1.69 [1.51; 1.88], large; and 1.98 [1.79; 2.19], large, respectively), and values for tasks without equipment were significantly higher than those for tasks using alternative equipment (1.07 [0.90; 1.24], large; and 0.95 [0.77; 1.12], large, respectively).

Discussion

From a methodological perspective, this study provides an indirect observation-based approach to the evaluation of motor intervention programs, using the structural analysis of planned tasks as the unit of analysis. This approach makes it possible to characterize the pedagogical potential of educational proposals without directly observing their implementation, providing a useful tool for the assessment and improvement of educational programs in school settings. The analysis, which examines the overall coherence and complementarity between the settings of a program integrating PE and SS, considers indicators of motor practice time (proportion of motor and nonmotor tasks, density, and temporal distribution) and the structural characteristics of the tasks, including action domains, equipment use, and memory.

Regarding practice time management, the combined analysis reveals an approach that promotes a high level of motor engagement. Three-quarters of the total planned time is devoted to motor practice, amounting to approximately 45 minutes of practice in 60-minute sessions. Given the limited instructional time devoted to motor development, this approach has considerable pedagogical value, as motor practice is fundamental to motor development (Parlebas, 2021). Previous studies have highlighted the low amount of effective practice time in PE, with values below 30% (Yanci et al., 2016). In this study, motor practice time reaches 80% in PE, significantly higher than the 66% observed in SS.

This does not imply that the entire session should consist of motor practice, thereby avoiding the “the more, the better” logic typical of performance-oriented models. An educational approach requires periods of explanation, analysis, and reflection, which are essential for learning (Tinning, 1996). It is therefore necessary to strike a balance that ensures

sufficient practice time without sacrificing nonactive periods that support learning. The program plans analyzed include 25% nonmotor tasks, located mainly in the opening and closing phases, leaving the main phase for motor practice. This organization moves beyond the technical view of “warm-up” and “cool-down,” turning these periods into meaningful pedagogical spaces that together account for 40% of the session.

In the comparison between contexts, PE devotes more time to these phases, possibly because of its curricular nature, although SS also allocates a substantial proportion of time to them, close to one-third of the total. The opening phase in SS is essentially nonmotor, whereas in PE it alternates between motor and nonmotor activities. Particularly in SS, it may be beneficial to incorporate strategies that increase motor engagement from the beginning of the session without compromising the pedagogical approach.

Density is another key variable for ensuring effective practice time, although it is not always taken into account (Echeazarra, 2016). It refers to the participation opportunities afforded by a task: if a task involves waiting or taking turns, it is considered low-density and limits learning. Full-density tasks, which allow simultaneous participation, are therefore more desirable. The program plans analyzed show that more than 80% of the tasks are full-density. PE reaches 88%, compared with 77% in SS, although the effect size is small. Activities such as target games, technical exercises, or relays, which are associated with traditional models (Tinning, 1996), are more common in SS, which explains its lower density.

Regarding motor action domains, the combined approach shows diversity and a balanced distribution, with all domains accounting for at least 10% of the tasks. This is consistent with current motor learning theories, which advocate varied practice to foster balanced development of motor competence (Ruiz, 2020; Parlebas, 2001). Each domain represents a different learning environment, involving different types of interaction with the environment and different motor demands, thereby enriching students' experiences (López-Pastor et al., 2016). The least represented domains are opposition and environmental uncertainty, despite their value in developing motor intelligence (Parlebas, 2001). Opposition tasks foster sociomotor intelligence and the management of rivalry, whereas environmental uncertainty tasks promote more adaptive and flexible motor responses. The latter, which are often associated with activities in natural environments, can also address cross-curricular learning outcomes such as respect for the environment (Sáez-Padilla et al., 2011; Martínez-Santos, 2007), although their implementation is often limited by contextual factors or perceptions of risk (Peñarrubia et al., 2016). Strengthening pedagogical confidence and teacher training may help overcome these barriers.

Although the combined analysis of PE and SS does not show major differences in the distribution of domains, comparisons within each context reveal variations: five of the six domains show significant differences, although most have small or trivial effects. This suggests that the two contexts may be regarded as complementary, thereby enriching students' experiences. PE shows higher percentages of expressive and cooperation tasks, whereas SS places greater emphasis on opposition and cooperation-opposition tasks. The former are well aligned with the PE curriculum, in which body expression is a compulsory component. Devoting one-quarter of the time to these types of tasks therefore appears appropriate. Although they are not compulsory in SS, regulations recommend using PE as a reference. Approaches such as those proposed by Romero-Martín and Arribas (2020), based on cooperative learning, may be useful in both contexts.

Cooperation tasks are key to promoting social values such as cooperation, tolerance, and inclusion (Lavega et al., 2014), and have become increasingly prominent in PE through models such as cooperative learning (Fernández-Río & Méndez-Giménez, 2016). Their inclusion in SS may be equally valuable. However, SS is characterized by a greater emphasis on opposition and cooperation-opposition tasks, which are associated with its more traditional motor culture (Etxebeste, 2013). Even so, more than half of the tasks in SS are noncompetitive, which is particularly relevant for promoting inclusive environments.

Regarding the memory and equipment variables, tasks without memory and tasks using standard equipment predominate. Tasks with memory identify winners and losers, reinforcing the competitive component, whereas tasks without memory encourage participation without pressure associated with making mistakes (Etxebeste et al., 2014). More than 75% of the tasks analyzed are without memory, with a higher proportion in PE (85%) than in SS (64%). This suggests that although SS has a somewhat more competitive orientation, its logic is not centered exclusively on competition, in line with the regulations (Decree 125/2008).

Regarding equipment use, seven out of every 10 minutes of practice involve equipment, predominantly standard equipment. PE includes more tasks without equipment (35% vs. 21% in SS), favoring more expressive and body-centered forms of practice. Alternative or self-constructed equipment is rarely used (5%), although these types of approaches may enrich both PE and SS (Méndez-Giménez et al., 2017).

Finally, the comparison between PE cycles showed no significant differences in most variables. The main difference was found in the second cycle, where psychomotor tasks were more frequent. This is because the first cycle retains psychomotor approaches inspired by early childhood

education, whereas the second introduces activities more focused on motor control, such as manipulation, aiming, and balance.

Conclusions

The structural analysis of planned tasks emerges as a key evaluation strategy for assessing the coherence of the pedagogical approach and the complementarity between PE and SS. The main conclusion of the assessment is the characterization of an innovative coordinated motor intervention approach for the PE and SS settings. When analyzed both jointly and separately, the two program plans constitute a pedagogically relevant project for promoting physical and sports activity and the holistic development of motor competence. They are characterized by: 1) promoting high levels of participation and motor engagement; 2) providing variety and balance across practice settings, fostering both motor and cross-curricular learning; 3) moving away from competitive dynamics while promoting educational attitudes and values; and 4) maintaining alignment and complementarity between PE (more cooperative and expressive) and SS (more sport-oriented and tactical). Understanding the pedagogical effects of planned tasks enables teachers to better align their interventions with educational objectives, and further assessments are needed to deepen the analysis of school-based motor development programs.

The study also has limitations and identifies directions for future research. First, because it focuses on what is planned rather than what is implemented, discrepancies may arise. Teacher training in recording what is actually implemented is proposed to reduce reliance on external observers. Second, the taxonomic system should be enriched with additional variables to improve precision. Third, other indicators should be incorporated, such as the assessment of communication styles using validated tools, together with qualitative techniques (interviews or focus groups) to obtain more in-depth information. In addition, the analysis should be extended to more schools and grade levels to assess the extent to which practices align with the regulatory framework. Finally, future research could complement this approach with direct observation studies to analyze the actual implementation of tasks in practice settings.

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Detection of the Electromyographic Threshold in Finger Flexor Muscles Using Intermittent Isometric Contraction Tests

Lluc Bilbao-Figuerola¹, Aribau Portillo¹, Blai Ferrer-Uris^{1*}  and Albert Busquets¹  

¹ National Institute of Physical Education of Catalonia (INEFC), University of Barcelona (UB), Barcelona (Spain).

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*Corresponding author:
Blai Ferrer Uris
bferrer@gencat.cat

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Abstract

The electromyographic threshold (EMGT) is the relative exercise intensity at which a nonlinear increase in electromyographic (EMG) activity is observed. It has only been detected in monoarticular and biarticular muscles of the lower limbs, but not in multiarticular muscles. Intermittent isometric contraction tests (IICTs) may facilitate EMGT detection; however, the short inter-set rest intervals used in these protocols may affect its detection. Our objectives were (1) to explore EMGT detection in multiarticular upper-limb muscles, such as the flexor digitorum profundus (FDP) and flexor digitorum superficialis (FDS), using an IICT with a short inter-set rest interval of 30 s (SR-IICT), and (2) to compare the SR-IICT results with those obtained using a protocol with long inter-set rest intervals of 120 s (LR-IICT). Ten participants (24.49 ± 4.04 years) completed both protocols, while EMG activity in the FDP and FDS and force output were recorded. The EMGT was determined in both tests for both muscles, as were the intensity and force levels reached at the end of each test. The LR-IICT facilitated EMGT detection in more participants (6 out of 10). Additionally, the LR-IICT enabled participants to finish the test while exerting greater absolute force and completing more sets. Our results show that detecting the EMGT in the FDS and FDP using IICT protocols is challenging, but also indicate that extending inter-set rest intervals may facilitate its detection, possibly by allowing greater force to be exerted during the final set.

Keywords: adults, electromyographic activity, intermittent incremental test, isometric force, multiarticular muscles

Introduction

Physiological threshold detection makes it possible to identify changes in the pattern of the body's biological responses. They have therefore become a fundamental tool for planning and monitoring physical training. Traditionally, physiological threshold detection has focused on systemic or metabolic aspects, whereas few studies have sought to identify thresholds related to muscle electromyographic (EMG) activity (Ertl et al., 2016).

EMG activity during incremental tests has been suggested to follow an exponential growth pattern (Iannetta et al., 2017), in which the nonlinear increase would correspond to increased recruitment of high-threshold motor units (MUs) (Ertl et al., 2016; Hug et al., 2006b; Lucía et al., 1999; Moritani & DeVries, 1978). According to the "size principle" (Henneman et al., 1965), the type of muscle fibers recruited depends on muscle contraction intensity (force output). At low muscle contraction intensities, recruitment predominantly involves type I fibers (smaller MUs with lower activation thresholds), whereas at higher intensities, type II fibers (larger MUs with higher activation thresholds) are also recruited to meet force demands (Cornett et al., 2000). Following this reasoning, the electromyographic threshold (EMGT) was defined as the relative exercise intensity at which a nonlinear increase in EMG activity is observed (an increase in the slope of an exponential growth curve) (Lucía et al., 1999). EMGT detection would therefore make it possible to identify the force magnitude at which an individual begins to recruit type II muscle fibers to a meaningful extent.

When estimating the EMGT, it should nevertheless be considered that its identification may be influenced by several physiological factors, including muscle fatigue (Woods et al., 2019), which may cause adjustments in the muscle activation signal, reduce force-generating capacity, and consequently affect neuromuscular activation patterns throughout exercise (Enoka & Duchateau, 2016). Although the EMGT has been successfully identified in lower-limb muscles during continuous incremental cycle ergometer tests, for example, in the vastus lateralis (Moritani & DeVries, 1978; Viitasalo et al., 1985), the fatigue accumulated during a continuous incremental test may prevent participants from reaching force levels at

which type II fiber recruitment increases sufficiently or may alter the rate of increase in type II fiber recruitment, thereby hindering the emergence of the EMGT. To address this issue, the use of an intermittent isometric contraction test (IICT) has been proposed (Woods et al., 2019). In previous studies, this protocol enabled participants to reach higher relative force output values than continuous incremental protocols (Long et al., 2017; Pitt et al., 2015), thereby facilitating EMGT detection (Woods et al., 2019).

Despite the advantages of IICTs for EMGT detection, they have only been applied to monoarticular and biarticular muscles of the lower limbs (De Ruiter et al., 2016; Woods et al., 2019, 2020), and their ability to detect the EMGT in upper-limb and/or multiarticular muscles therefore remains unknown. Moreover, the usual inter-set rest interval in an IICT, typically 30 s, may be insufficient, and some authors have suggested that extending it could improve the sensitivity of threshold detection (De Ruiter et al., 2016; Woods et al., 2019).

Improving EMGT detection procedures and exploring their potential application to upper-limb muscles could advance the study of electromyographic thresholds, particularly in the muscles involved in handgrip, as handgrip is a highly reproducible task that is easy to implement experimentally and widely used in clinical settings. These advances could also enhance the practical applications of the EMGT. In clinical settings, it could be used to diagnose neuromuscular disorders, as the early occurrence of the EMGT during an IICT could reflect an earlier need to recruit type II fibers, which could indicate impaired neuromuscular efficiency (Voet et al., 2022). In physical training, the EMGT could also be used to prescribe training intensities and identify neuromuscular adaptations, providing a functional marker complementary to traditional metabolic thresholds (Voet et al., 2022).

Accordingly, the objectives of this exploratory methodological study were: (1) to apply the IICT protocol to detect the EMGT in multiarticular upper-limb muscles, specifically the flexor digitorum profundus (FDP) and flexor digitorum superficialis (FDS); and (2) to compare the ability to detect the EMGT in the FDS and FDP using an IICT with 30-s inter-set rest intervals (short-rest IICT, SR-IICT) and an IICT with 120-s inter-set rest intervals (long-rest IICT, LR-IICT).

Method

Participants

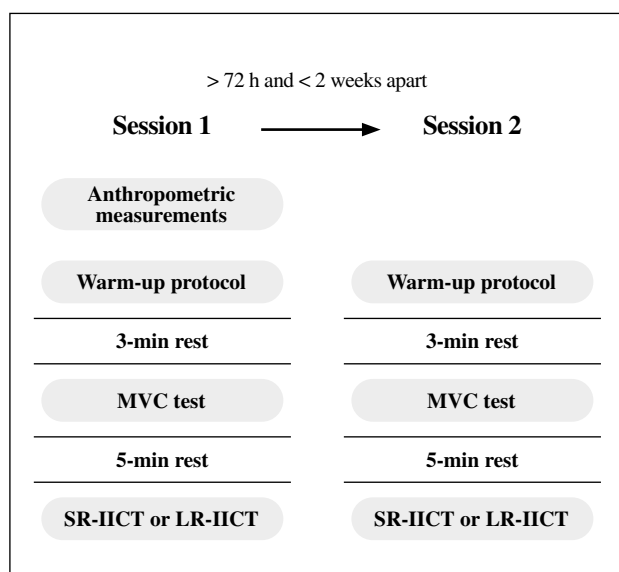
Ten healthy, physically active male participants took part in the study (age = 24.49 ± 4.04 years; height = 175.09 ± 5.22 cm; body mass = 74.16 ± 7.06 kg). The study was approved by the Clinical Research Ethics Committee of the Consell Català de l'Esport (02/CEICGC/2021). All participants received detailed information about the study objectives, procedures, risks, and benefits before providing written informed consent.

Experimental Protocol

Each participant completed two different experimental sessions in randomized order, without counterbalancing. The sessions were separated by a minimum of 72 h and a maximum of two weeks to ensure sufficient muscle recovery (Figure 1). One session was designed to assess the EMGT using the SR-IICT, whereas the other assessed the EMGT using the LR-IICT. Each session began with a standardized warm-up and a maximum voluntary contraction (MVC) test. In addition, each participant's height and body mass were recorded during the first session. Participants were asked to refrain from consuming coffee or caffeinated products on the day of testing and to avoid training during the preceding 24 h.

Figure 1

Diagram of the experimental protocol



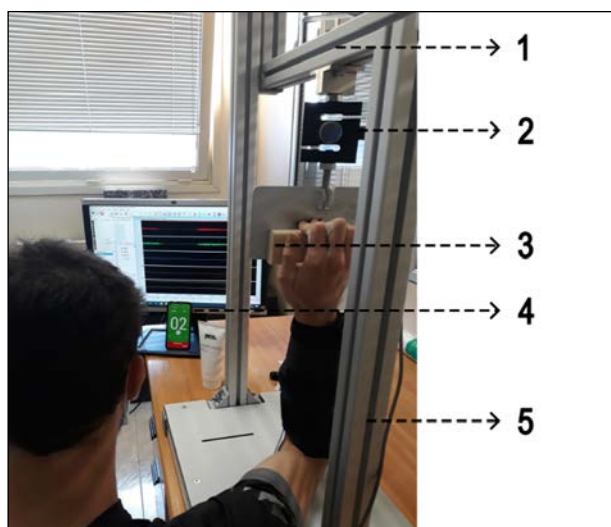
Note. MVC = maximum voluntary contraction, SR-IICT = intermittent isometric contraction test with short 30-s inter-set rest intervals, LR-IICT = intermittent isometric contraction test with long 120-s inter-set rest intervals.

Exercise Protocols

All protocols involved isometric finger-flexor contractions and used an ergometer specifically designed for this study, with a structure similar to that used by Philippe et al. (2012) (Figure 2). Before testing, participants sat sideways beside the ergometer, and the height of the hold was adjusted to standardize their position, approximately as follows: 90° of glenohumeral abduction and 60° of horizontal shoulder adduction, with 90° of elbow flexion (Figure 2). The dominant hand, as self-reported by the participant (Scharoun & Bryden, 2014), gripped the hold using a specific grip commonly referred to as a half-crimp or crimp (Ferrer-Uris et al., 2023): the proximal interphalangeal joint was flexed to 90°, the distal interphalangeal joint was extended or hyperextended, the metacarpophalangeal joint was in a neutral or slightly flexed position, and the thumb was not involved. The non-tested arm was positioned beneath the table on which the ergometer was placed. Verbal encouragement was provided to participants during all protocols (McNair et al., 1996).

Figure 2

Ergometer used and participant body position



Note. 1 = adjustable aluminum frame, 2 = strain gauge, 3 = wooden hold, 4 = timer, 5 = vertical aluminum support structure.

Maximum voluntary contraction test

All participants completed two MVC test attempts with a 2-min rest interval. During each attempt, participants were asked to exert the greatest possible finger-flexion force without losing the prescribed position, progressively increasing force and maintaining their maximum force for 5 s. The highest value on the smoothed force curve (see the “Data Reduction and EMGT Determination” subsection) was considered representative of the maximum isometric force for that session ($MVC_{SR-IICT}$ and $MVC_{LR-IICT}$) and was used to calculate the relative intensities in the SR-IICT and LR-IICT.

Short- and long-rest intermittent isometric contraction tests

The IICT protocol described by Woods et al. (2019) provided the basis for the design of the SR-IICT and LR-IICT. Both tests consisted of sets of five 5-s isometric contractions, with a 3-s rest interval between contractions. Both protocols began at an intensity of 25% of $MVC_{SR-IICT}$ and $MVC_{LR-IICT}$, respectively, and the target force was increased by 3% in each set. The difference between the two tests was the inter-set rest interval: 30 s for the SR-IICT and 120 s for the LR-IICT. The test ended when the participant failed to reach the target force in three of the five contractions in a set. During the rest intervals between contractions within the same set, participants were instructed to maintain their position on the hold without exerting force. During inter-set rest intervals, participants were asked to rest their arm on their thighs with the palm facing upward. Participants received real-time visual feedback on the force exerted, as well as visual and auditory feedback on contraction and rest times during both protocols.

Data Acquisition

The force exerted during each contraction was recorded throughout all tests using a strain gauge (SB1000, Biometrics Ltd, Newport, UK). Surface electromyography (EMG) was recorded simultaneously using bipolar Ag-AgCl surface electrodes (10-mm diameter, 20-mm center-to-center distance) (SX230, Biometrics Ltd, Newport, UK). The electrodes were attached over the flexor digitorum profundus (FDP) and flexor digitorum superficialis (FDS) muscles following the electrode placement procedure described by Ferrer-Uris et al. (2023).

Force and EMG data were recorded synchronously at a sampling frequency of 1000 Hz using the same data acquisition system (DataLink DLK 900, Biometrics Ltd, Newport, UK).

Data Reduction and EMGT Determination

The raw force and EMG signals were filtered using a fourth-order low-pass Butterworth filter with a cutoff frequency of 20 Hz and a fourth-order band-pass Butterworth filter with a range of 20–450 Hz, respectively.

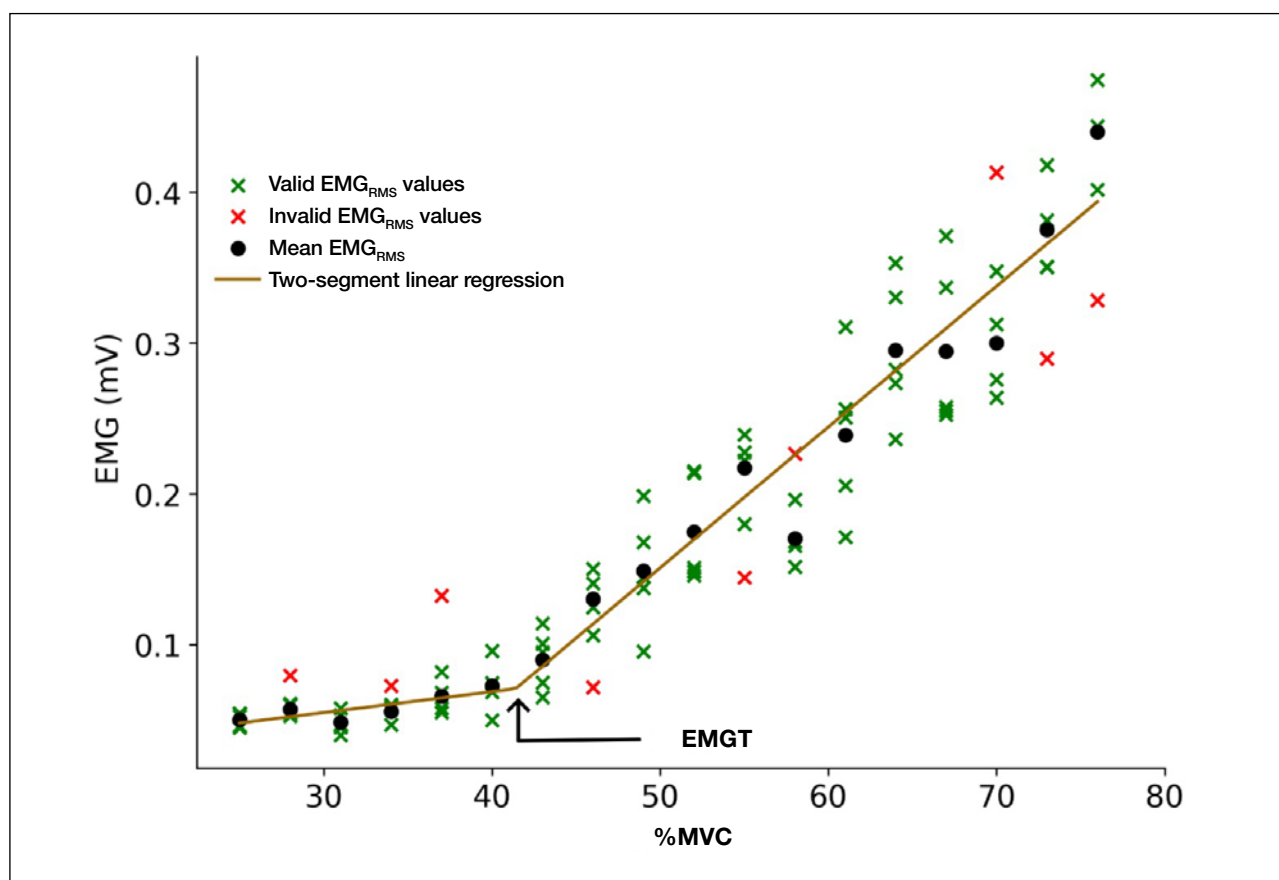
After filtering, the force data obtained during each MVC attempt were smoothed using a 500-ms recursive moving

average. The highest value from the two attempts in each session was considered the maximum value ($MVC_{SR-IICT}$ and $MVC_{LR-IICT}$). For the SR-IICT and LR-IICT, the filtered force signal was used to identify the onset and end of each contraction and to verify that the participant exerted the target force. The onset of each contraction was defined as the point at which force exceeded 12.5% of maximum force ($MVC_{SR-IICT}$ and $MVC_{LR-IICT}$), whereas its end was defined as the point at which force output fell below this 12.5% threshold. Contractions that did not meet these onset and end criteria were excluded from subsequent analyses. Only completed sets were used to determine the EMGT (at least three contractions had to reach and maintain the required percentage of MVC for 3 s in each set). In addition, the following variables were calculated from the final completed set in each protocol (SR-IICT and LR-IICT): (1) the percentage of MVC reached ($\%MVC_{SR-IICT}$ and $\%MVC_{LR-IICT}$) and (2) the arithmetic mean of the force exerted during the valid contractions, a variable termed “final force” ($\bar{x}_{FF_{SR-IICT}}$ and $\bar{x}_{FF_{LR-IICT}}$).

For the analysis of each muscle’s EMG activity during both IICTs, signal amplitude was calculated from the filtered signal as the root mean square (EMG_{RMS}) of each contraction. Specifically, EMG_{RMS} was calculated for each contraction within a 2-s window corresponding to the time interval during which the mean contraction force was closest to the target force intensity. The five contractions within each set were then checked to ensure that they showed similar EMG_{RMS} levels. To do so, the number of standard deviations (SDs) by which the EMG_{RMS} value of each contraction differed from the mean of the other four contractions in the set was calculated. Contractions whose EMGRMS values deviated by more than 3 SD from the mean were excluded. The mean EMGRMS of the retained contractions in each set ($\bar{x}_{EMGRMS}$) was then calculated (Woods et al., 2019).

Finally, to identify the EMGT of the FDS and FDP for each participant and protocol ($FDS-EMGT_{SR-IICT}$, $FDP-EMGT_{SR-IICT}$, $FDS-EMGT_{LR-IICT}$, and $FDP-EMGT_{LR-IICT}$) (Figure 3), a scatterplot was created relating $\bar{x}_{EMG_{RMS}}$ values to exercise intensity (the required percentage of maximum force). A two-segment linear regression model was applied to these data (Hug et al., 2006a; Lucía et al., 1999; Woods et al., 2019). The EMGT was defined as the percentage of MVC (x-coordinate) at which the two linear regression lines intersected. Because the intersection point in a two-segment model is always mathematically calculated

Figur 3
Procedure for determining the electromyographic threshold (EMGT)



Note. The EMGT was defined as the intersection of the two linear regressions obtained from the relationship between the relative intensity of the target force (expressed as a percentage of maximum voluntary contraction, %MVC) and muscle electromyographic (EMG) activity (expressed as the root mean square EMG_{RMS}). In this illustrative example of a participant's data, the crosses represent the EMG_{RMS} values for each contraction, with valid values shown in green and invalid values in red (values were considered invalid when the EMG_{RMS} deviated by more than 3 SD from the mean of the contractions performed at the same relative force intensity). Each black point, $\bar{x}_{EMG_{RMS}}$, corresponds to the mean EMG_{RMS} of all contractions performed at the same relative intensity.

and does not necessarily coincide with a measured value, an EMGT value was only accepted when at least one measured value belonging to the second regression line, which also had a positive but steeper slope, exceeded the extrapolated line of the first regression by +3 SD (Woods et al., 2019). When this condition was not met or the data did not show an adequate fit to a two-segment function, EMGT identification was considered unsuccessful.

Statistical Analysis

First, $MVC_{SR-IICT}$ and $MVC_{LR-IICT}$ were compared using a paired-samples *t*-test to verify that the initial force conditions were similar between the two sessions. The $\%MVC_{SR-IICT}$ and $\%MVC_{LR-IICT}$ variables, as well as $\bar{x}_{FF_{SR-IICT}}$ and $\bar{x}_{FF_{LR-IICT}}$, were also compared using a

paired-samples *t*-test to determine the overall effect of the inter-set recovery time on the intensity and absolute force reached at the end of the tests. EMGT detection was then compared for each muscle and protocol. Due to the low detection rate, a descriptive comparison was made between the EMGT values obtained in the SR-IICT and LR-IICT. When the EMGT was not detected, a qualitative analysis of the profile obtained using the two-segment linear regression model was performed to identify the possible reasons for the lack of detection. Before conducting any paired-samples *t*-test, data normality was examined using the Shapiro–Wilk test and Q–Q plots. A significance level of $p < .05$ was set for all comparisons, and the effect size for the *t*-tests was calculated using Cohen's *d* (Cohen, 2013). All statistical analyses were performed using JASP version 0.19.3 (JASP Team, 2025).

Results

Force results

The maximum force values obtained at the beginning of the sessions, $MVC_{SR-IICT}$ and $MVC_{LR-IICT}$, did not differ significantly ($t(9) = -0.139$; $p = .892$), suggesting that there was no learning effect or significant change in the participants' finger-flexor contractile capacity during the time

between sessions. A comparison of the values reached at the end of the two protocols showed that the LR-IICT enabled participants to reach higher relative intensities and force-output levels: $\%MVC_{SR-IICT}$ compared with $\%MVC_{LR-IICT}$ ($t_{(9)} = -3.025$; $p = .014$; $CI = (-11.535) - (-1.665)$; $d = 0.957$) and $\bar{x}_{FF_{SR-IICT}}$ compared with $\bar{x}_{FF_{LR-IICT}}$ ($t_{(9)} = -2.741$; $p = .023$; $CI = [-55.277, -5.287]$; $d = -0.867$) (Table 1 and Figure 4).

Table 1

Number of electromyographic thresholds (EMGTs) detected by protocol and muscle, and means and standard deviations for the EMGT, session maximum voluntary contraction (MVC), and force values reached in the final set of the test

	SR-IICT		LR-IICT	
	FDS	FDP	FDS	FDP
EMGT detection	$n = 2$ (20 %)	-	$n = 4$ (40 %)	$n = 2$ (20 %)
EMGT detection (%MVC)	45.4 ± 12.7	-	38.4 ± 5.8	35.2 ± 1.0
MVC (N)	384.2 ± 93.4		385.8 ± 92.8	
Final set expressed as %MVC	64.3 ± 8.7		$70.9 \pm 9.8^*$	
$\bar{x}_{FF}$ (N)	248.7 ± 76.3		$278.99 \pm 100.3^*$	

Note. CSR-IICT = intermittent isometric contraction test with short inter-set rest intervals (30 s); LR-IICT = intermittent isometric contraction test with long inter-set rest intervals (120 s); FDS = flexor digitorum superficialis; FDP = flexor digitorum profundus; EMGT = electromyographic threshold; MVC = maximum voluntary contraction; %MVC = percentage of maximum voluntary contraction reached in the final set of the test; $\bar{x}_{FF}$ = mean force output in the final set.

* = significant difference between protocols based on a paired-samples t -test ($p < .05$).

Figure 4

Individual values (colored markers and lines) and sample mean and standard deviation (bar and error bar) for the relative maximum voluntary contraction value (%MVC) in the final set of the intermittent isometric contraction protocol with short inter-set rest intervals (30 s; SR-IICT) and long inter-set rest intervals (120 s; LR-IICT)

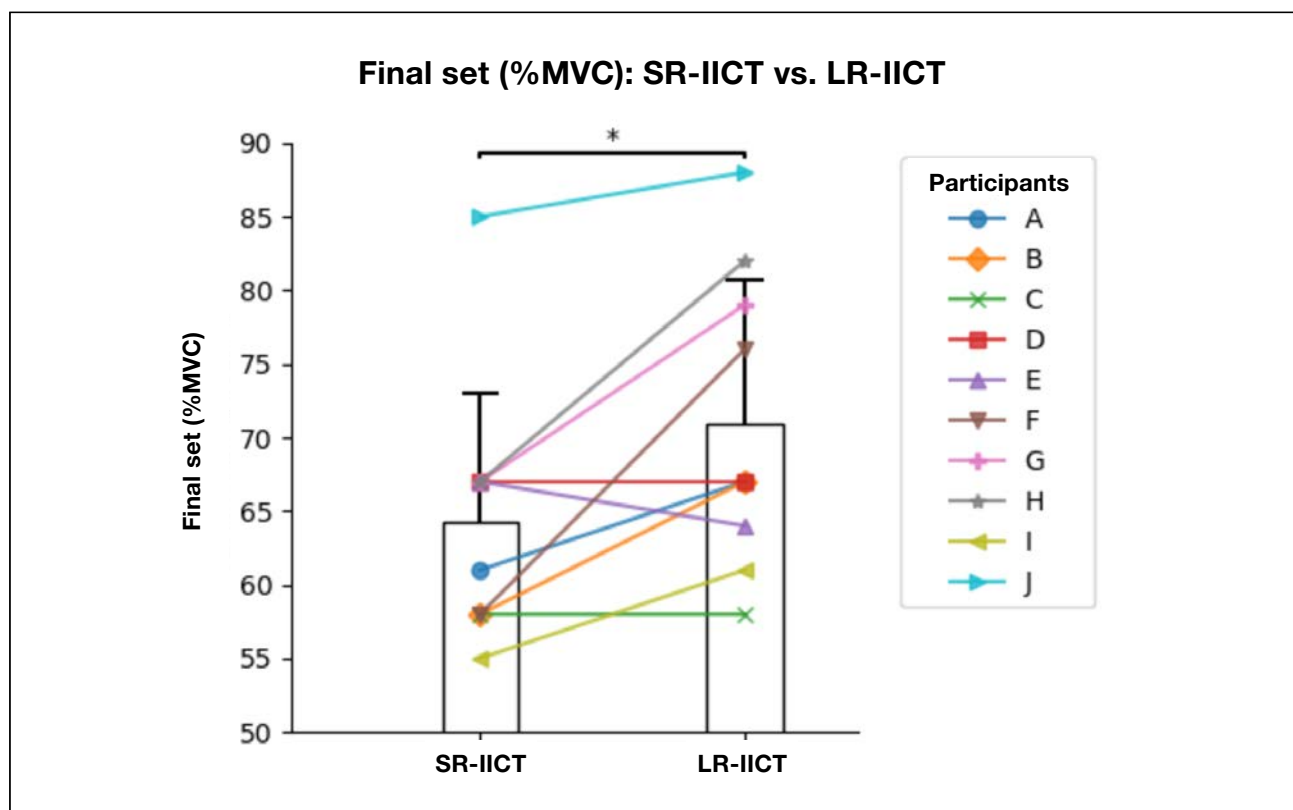


Table 2

Electromyographic threshold (EMGT) values for the participants in whom it was detected, expressed as a percentage of maximum voluntary contraction, and detection protocol

	FDS-EMGT _{SR-IICT}	FDS-EMGT _{LR-IICT}	FDP-EMGT _{SR-IICT}	FDP-EMGT _{LR-IICT}
Participant A	-	-	-	34.54
Participant B	-	-	-	35.92
Participant C	-	39.01	-	-
Participant D	-	42.89	-	-
Participant E	45.41	40.41	-	-
Participant F	32.80	41.42	-	-

Note. FDS-EMGT_{SR-IICT} = electromyographic threshold of the flexor digitorum superficialis during the intermittent isometric contraction test with short inter-set rest intervals (30 s); FDS-EMGT_{LR-IICT} = electromyographic threshold of the flexor digitorum superficialis during the intermittent isometric contraction test with long inter-set rest intervals (120 s); FDP-EMGT_{SR-IICT} = electromyographic threshold of the flexor digitorum profundus during the intermittent isometric contraction test with short inter-set rest intervals (30 s); FDP-EMGT_{LR-IICT} = electromyographic threshold of the flexor digitorum profundus during the intermittent isometric contraction test with long inter-set rest intervals (120 s).

EMGT results

During the detection of the different EMGTs, 9.4% of the contractions performed were excluded because they did not meet the previously established inclusion criteria. The SR-IICT only enabled the FDS-EMGT_{SR-IICT} to be identified in 2 participants, whereas the LR-IICT enabled the FDS-EMGT_{LR-IICT} and FDP-EMGT_{LR-IICT} to be detected in 4 and 2 participants, respectively (Table 1). In both cases in which the FDS-EMGT_{SR-IICT} was detected, the FDS-EMGT_{LR-IICT} was also identified, with similar EMGT values obtained in the two protocols (Table 2).

In the SR-IICT, when the linear regression profiles of the FDP and FDS in which no EMGT was detected were considered together, 50% showed a breakpoint at the end of the test, after which the slope changed from positive to negative, with no point on the descending second regression falling more than 3 SD below the extrapolated line of the first regression. By contrast, in the LR-IICT, when the linear regression profiles of the FDP and FDS in which no EMGT was detected were considered together, 43% showed a breakpoint at which the slope of the second regression was steeper than that of the first; however, no point on the second regression exceeded the extrapolated line of the first regression by more than 3 SD (the second regression had a steeper slope, but the increase was not sufficiently pronounced).

Discussion

Our study results demonstrated the difficulty of detecting the EMGT in the finger flexor muscles using intermittent isometric contraction protocols. This finding calls into

question the generalizability of previous findings on the EMGT across different muscles and tasks, highlighting the need to continue exploring methodological approaches to detecting this threshold. Nevertheless, the protocol with longer inter-set rest intervals showed a higher EMGT detection rate (6 of 10 participants) than the short-rest protocol (2 of 10 participants), indicating that methodological modifications may improve the threshold detection rate.

SR-IICT protocol

Although some authors have noted that the EMGT is not always detectable in the agonist muscles studied (Jürimäe et al., 2007; Taylor & Bronks, 1995), the detection rate observed with the SR-IICT contrasts markedly with the rates reported in previous studies using similar protocols, which reached approximately 90% in lower-limb muscles (Ertl et al., 2016). EMGT detection mainly depends on the methodological criteria used for its determination, which must be rigorous and highly precise (Ertl et al., 2016). In our study, we chose to determine the EMGT mathematically, thereby eliminating evaluator subjectivity. An EMGT was only considered to be present when the breakpoint calculated using two-segment regression included at least one point from the second regression that exceeded the extrapolation of the first regression by +3 SD. The studies by Woods et al. (2019, 2020) are the only ones that have also applied this criterion when using an intermittent isometric contraction protocol with short inter-set rest intervals. However, they implemented an additional readjustment procedure when the EMGT was not detected. This procedure involved transferring $\bar{x}_{EMG_{RMS}}$ points used in one of the two regressions to the other if

doing so improved the model fit. Had it been applied, this strategy might have contributed to a higher EMGT detection rate in our study, but at the cost of some objectivity and simplicity in the detection process. Consequently, our results show that EMGT determination is highly complex in multiarticular upper-limb muscles when an objective and conservative methodology is used.

In addition to the methodological criteria used, other biomechanical, physiological, and motor-control factors may influence EMGT detection. Although these factors were not directly assessed in our study, they may help explain our findings. First, selecting a movement involving several agonist muscles that cross multiple joints and have several terminal tendons (one for each finger) may have affected our results, as compensation between muscles has been suggested to be one of the main factors affecting the EMG signal when detecting thresholds (Hug, 2010; Kouzaki et al., 2002). Second, previous evidence appears to indicate that the percentage of type IIb fibers in the FDS and FDP is lower than that in lower-limb muscles (Meznaric & Čarni, 2020). Because the EMGT has been associated with increased recruitment of high-threshold MUs (type II) (Ertl et al., 2016; Hug et al., 2006b; Lucía et al., 1999; Moritani & DeVries, 1978), a low proportion of type II fibers may limit the emergence of the EMGT (Jansson, 1996). Finally, differences in the type of isometric action used in the present study, in which we used a pushing isometric muscle action (PIMA), compared with the studies by Woods et al. (2019, 2020), in which a holding isometric muscle action (HIMA) was used, may also have affected EMG amplitude and EMGT detection (Oranchuk et al., 2024).

Thus, although assessing their influence was not an objective of the present study, changes in muscle involvement throughout the test, a low proportion of type IIb fibers in the muscles analyzed, and the type of isometric action used may help explain the difficulty we encountered in detecting the EMGT. In particular, these factors may help explain the cases in which the breakpoint of the two-segment model occurred in the final sets and was followed by a change to a negative slope in 50% of the cases in which the EMGT was not detected using the short-rest protocol. This pattern may be related to a linear increase in EMG activity caused by these factors, with this linearity only being disrupted by the onset of fatigue, which was probably induced by the short rest intervals in the SR-IICT. Even so, the influence of these factors should be addressed in future research.

Comparison of the SR-IICT and LR-IICT protocols

The protocol with long inter-set rest intervals showed a higher EMGT detection rate in both the FDS and FDP than the short-rest protocol. The protocol with long inter-set rest intervals enabled participants to complete more sets and resulted in a higher percentage of maximum force and greater force output in the final set than the short-rest protocol and resulted in a higher percentage of MVC and greater force output in the final set than the short-rest protocol, possibly allowing participants to reach intensities sufficient for EMGT detection through greater recruitment of high-threshold MUs (type II). (Ertl et al., 2016; Hug et al., 2006b; Lucía et al., 1999; Moritani & DeVries, 1978). This argument is supported by the fact that, among the EMGTs not detected using the long-rest protocol, only 14.3% of cases showed a breakpoint across the sets together with a negative slope in the second linear regression, compared with 50% under the short-rest protocol. In addition, 43% of the EMGTs not detected using the long-rest protocol showed a profile with a breakpoint after which the second linear regression had a positive slope, but without meeting the EMGT validation criterion. This may suggest that high-threshold MU recruitment is less abrupt in some individuals than in others and that the EMGT detection methodology should be refined to accommodate different recruitment patterns.

Regardless of the protocol used, more EMGTs were detected in the FDS than in the FDP in our study, which may be attributable to the importance of the FDS in the task performed. Similarly, previous studies conducted in different muscles and primarily using cycle ergometry (see the review by Ertl et al., 2016) reported higher EMGT detection rates in the vastus lateralis, as the main agonist, than in muscles with less prominent involvement (e.g., gastrocnemius, tibialis anterior). For the task performed in our study, both the FDP and FDS have been considered the main agonists (Philippe et al., 2012; Schweizer & Hudek, 2011). Recent research, however, indicates that this type of grip promotes greater FDS activation through active flexion of the proximal interphalangeal joint, whereas the FDP acts as a stabilizer of the distal interphalangeal joint together with the finger extensor muscles (Ferrer-Uris et al., 2023; Schweizer & Hudek, 2011).

Taken together, our results indicate that EMGT detection in multiarticular upper-limb muscles using IICT protocols is limited when objective and conservative methodological criteria are applied. Nevertheless, extending the inter-set rest interval increased the detection rate, probably by enabling higher contraction intensities, promoting greater recruitment

of type II MUs, and mitigating the confounding effects of fatigue. Despite the difficulties in determining the EMGT in the selected muscles, future methodological approaches may therefore improve our ability to detect the EMGT objectively in multiarticular muscles.

It is important to emphasize that the results of the present study should be interpreted with caution because this was an exploratory methodological study, which limits the confirmatory scope of the findings. Furthermore, the sample was relatively small, consisted exclusively of men, and had heterogeneous training levels. Although no learning effect was identified between the two sessions (i.e., no improvement in MVC), it should also be noted that the participants had limited familiarity with the specific task. The results are also not generalizable to the contralateral (non-dominant) limb or to other muscles. Finally, these findings should be extrapolated to populations of other ages with caution, as the location of these thresholds has been reported to shift throughout the lifespan. Thus, in addition to exploring methodological issues in EMGT determination, future studies should assess the implications of using monoarticular and multiarticular muscles to evaluate the EMGT and should include larger and more diverse samples.

Conclusions

Our study showed that detecting the EMGT in multiarticular upper-limb muscles (finger flexors) using intermittent isometric contraction protocols is challenging. Nevertheless, a higher EMGT detection rate was observed with long inter-set rest intervals (120 s) than with shorter rest intervals (30 s). Longer inter-set rest intervals may facilitate EMGT detection, possibly by enabling higher levels of contractile force to be reached, thereby promoting the recruitment of high-threshold (type II) motor units and attenuating the confounding effects of fatigue.

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Department of Sports
Institut Nacional d'Educació
Física de Catalunya (INEFC)

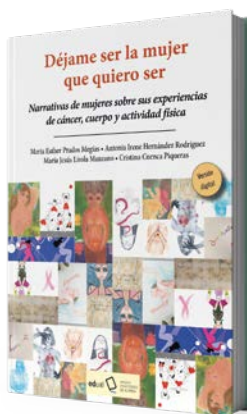
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Déjame ser la mujer que quiero ser
Narrativas de mujeres sobre sus
experiencias de cáncer, cuerpo y
actividad física

María Esther Prados-Megías, Antonia Irene
Hernández-Rodríguez, María Jesús Lirola-
Manzano, y Cristina Cuenca-Piqueras
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Judit Martínez Abajo¹

¹ Department of Didactics of Music, Visual Arts, and Movement Education, Faculty of Education and Sport, Vitoria-Gasteiz Campus, University of the Basque Country (EHU), Vitoria-Gasteiz (Spain).

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Déjame ser la mujer que quiero ser. Narrativas de mujeres sobre sus experiencias de cáncer, cuerpo y actividad física is a research-based work that offers valuable insight into how women participating in a physical exercise program for breast cancer survivors (Eficán) cope with the disease with the invaluable support of their social networks.

The book is grounded in the Eficán project, which examines how a strength-training program contributes to improving the physical health of women who have survived cancer. In its second phase, the project was expanded through a qualitative study using a biographical-narrative approach (Denzin & Lincoln, 2015; Prados-Megías & Rivas, 2017). The researchers employed techniques such as biographical narratives, in-depth interviews—which the participants preferred to call *narrative encounters* (Sánchez & Prados-Megías, 2023)—and focus group interviews, or *group narrative encounters*. Through these narratives, participants express their concerns, doubts, and forms of resistance as they navigate the experience of illness. The biographical-narrative approach provides a more personal and intimate perspective, one that encourages conversation, reflection, and dialogue with breast cancer survivors. In doing so, it advances a humanizing form of research that makes it possible to understand people's lived experiences while critically examining dominant discourses and practices.

The researchers listened carefully to the survivors' voices, seeking to co-construct knowledge, as Clandinin (2013) advocates. During the more than five months they spent together at the CorpoEDuca-M Laboratory, they became aware of additional concerns that emerged throughout the process. Although the physical training was essential for improving the participants' physical health, the women also needed to share how the experience of cancer had affected their bodies and their lives—from healthcare and medical treatment to their fears and anxieties. The analysis of the data gave rise to a series of emergent categories, which are explored in the book's four chapters: the first, *Afrontar la enfermedad (Coping with the Disease)*; the second, *La atención médico-sanitaria (Healthcare)*; the third, *Redes de apoyo (Support Networks)*; and the fourth, *Sobre el proyecto Eficán (About the Eficán Project)*.

The first chapter examines how cancer survivors cope with the disease. It addresses every stage of the experience, from receiving the diagnosis and navigating medical protocols and decision-making to coming to terms with the diagnosis itself. The women emphasize the need for healthcare protocols that provide not only clinical guidance but also emotional and psychological support. They underscore the importance of empathy and of healthcare professionals who know how to listen and place

themselves in their patients' shoes. At critical moments such as a biopsy, they need accurate, detailed information as well as sufficient time to process it. They also stress the importance of personalized care, in which they are clearly informed about what to expect throughout their treatment, the procedures they are likely to undergo, the side effects of treatment, and the ways in which hair loss or mastectomy may affect their sense of bodily identity. They must learn to accept their changed bodies while hoping that others will accept them as well. The participants also reflect on socially imposed ideals of beauty associated with femininity and sexuality. They explain that physical activity has helped them come to terms with their bodies, while criticizing the stereotypical ways in which cancer continues to be portrayed. As the authors conclude, "Their testimonies speak of learning to be a woman, and to do so, the socially imposed image of the superwoman must first be erased" (p. 74).

The second chapter focuses on healthcare, specifically the relationship between patients and healthcare professionals. At the time of diagnosis, the women interviewed describe a lack of humanity and empathy on the part of healthcare providers, who often deliver information in a detached manner. At a time of profound uncertainty, they experience this emotional distance acutely. They spend a lot of time waiting but little time being attended by healthcare professionals, and they report receiving limited information about their treatment options. They call for more welcoming environments where they can express their vulnerability, fear, and loneliness with greater comfort and dignity. Once chemotherapy has ended, many of the women describe feeling abandoned, as they receive little follow-up support during a stage often marked by lasting physical and emotional consequences. While they acknowledge the professionalism of healthcare staff, they also advocate for increased staffing in oncology and for multidisciplinary teams that include complementary therapies, psychological and social support, vocational guidance, and specialists in physical activity, physiotherapy, and nutrition. Studies such as Ramírez et al. (2017) have demonstrated the benefits of physical exercise in the recovery of breast cancer survivors. The women interviewed emphasize the importance of having access to qualified professionals who can guide them in improving their health through physical activity, stressing that simply handing patients a brochure with recommended exercises is not enough.

The value of support networks is explored in the third chapter. For the women interviewed, these networks consist primarily of their partners, parents, and children. At times, these relationships provide support; at others, they become

overprotective, and this dynamic works in both directions. The women acknowledge that they try to shield their families from suffering and that they become more flexible and permissive with their children. Yet support also comes from beyond the family. As one participant explains, "Friendships are important because you find out who you can really count on" (p. 99). Others note that cancer has made them more selective: "I don't want anyone in my life who drains me" (p. 99). They describe having to endure insensitive comments from others: "Suddenly, everyone seems to know more about cancer than you do—even though you're the one living through it firsthand. People often say things that hurt: 'You'll see, you'll recover; medicine has come such a long way these days (...)' or 'Don't worry, everything will be fine.' The truth is that no one knows that for sure—least of all you, the person living through it. Those people drain me; I don't want them by my side" (p. 100).

In the final chapter, the women reflect on the Eficac project and recognize that "the value of the program stems from listening carefully to what the women have experienced" (p. 108). The benefits they describe extend well beyond physical improvements, although they also suggest that "the program should offer a broader range of activities, not only upper-body strength-training exercises but also other forms of movement and physical training" (p. 112). The program has played a significant role in their recovery, helping them establish self-care routines while also fostering support networks among women facing similar experiences. Altogether, the participants' accounts suggest a process of empowerment, through which they advocate for improvements such as higher-quality psychosocial care. This research has been carried out with patience, care, and deep commitment, qualities that are evident in the participants' reflections. They express surprise that the researchers considered their stories worth listening to and describe feeling genuinely understood and valued.

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