Psychology of Sport & Exercise 80 (2025) 102905

Contents lists available at ScienceDirect

Psychology of Sport & Exercise

journal homepage: www.elsevier.com/locate/psychsport

Understanding motivational dynamics: Longitudinal associations between motivation and physical activity in children

Miguel Ángel López-Gajardo [a], Miguel Ángel Tapia-Serrano [a,*], Rafael Burgueño [b,c], Ángel Abós [b], Francisco M. Leo [a], Pedro Antonio Sánchez-Miguel [a], Luis García-González [b]

[a] Departamento de Didáctica de la Expresión Musical, Plástica y Corporal, Facultad de Formación del Profesorado, Universidad de Extremadura, Cáceres, España
[b] Department of Didactics of Musical, Plastic and Corporal Expression, Faculty of Health and Sports Science, University of Zaragoza, Zaragoza, Spain
[c] Department of Didactics of Language, Art and Sport, University of Malaga, Malaga, Spain

ARTICLE INFO

Keywords:
Autonomous motivation
Longitudinal design
Reciprocal relationship
Primary school

ABSTRACT

This study aims to test the longitudinal and reciprocal associations between autonomous and controlled motivation with physical activity (PA) behavior in children. These relationships were also inspected separately between boys and girls. A three-wave longitudinal study involving 502 children from primary school aged 9–11 years (M_{age} = 11.12; SD = 1.19; 160 boys [M_{age} = 10.53; SD = .53] and 131 girls [M_{age} = 10.49; SD = .53]), taking measures of each variable at three different times during nine months, was employed. Results indicated that boys' and girls' autonomous motivation was positively associated with higher PA behaviors over time. Furthermore, boys' and girls' controlled motivation was positively related with PA only at Time 2 (T2); however, it was negatively related only in girls at Time 3 (T3). Also, higher PA behaviors perceived by boys and girls at Time 1 (T1) showed a positive relationship with autonomous motivation at T2, as well as PA (only perceived with boys) at T2 and autonomous motivation at T3. Only PA at T1 showed a positive and significant relationship with controlled motivation at T2 in boys. To conclude, children who are autonomously motivated tend to sustain their participation in PA longitudinally, and vice versa; those children motivated by controlled factors are promoted to exhibit diminished interest in such activities over time.

1. Introduction

Physical activity (PA) is associated with numerous physical, psychosocial, and cognitive benefits in children and adolescents (García-Hermoso et al., 2021; World Health Organization, 2020). To achieve these benefits, the World Health Organization (Bull et al., 2020) recommends that children and adolescents, aged 5–17 years, should engage in at least 60 min per day of moderate-to-vigorous PA (Bull et al., 2020). However, the most recent global prevalence report showed that 78 % of boys and 85 % of girls were insufficiently physically active (Guthold et al., 2020). Specifically, European children and adolescents spend 65–70 % of their school hours being sedentary (Verloigne et al., 2016) and between 65 and 80 % in the case of Spain (Grao-Cruces et al., 2020). Consequently, PA promotion among children and adolescents has become a priority for Public Administrations (World Health Organization, 2020).

Motivation has been consistently identified as an important correlate and determinant of PA behavior in youth people (Owen et al., 2014). To understand PA behaviors, Self-Determination Theory (SDT: Deci & Ryan, 2000; Ryan & Deci, 2017) is a prominent psychological theory for studying motivation. SDT distinguishes between autonomous and controlled motivation from amotivation (i.e., the absence of motivation). Rather than focusing on the amount of motivation, SDT emphasizes the importance of its type, as different forms of motivation lead to different behavioral outcomes. The importance of considering the role of autonomous and controlled motivation in explaining PA behavior has become a prominent research focus over the past years. Cross-sectional studies have showed consistent and positive relationships between autonomous motivation and PA, albeit they revealed unclear and short-term associations from controlled motivation with PA behavior and ignored the potential reciprocal effects of PA behavior on motivation itself (Owen et al., 2014). Thus, there is a need for longitudinal research to shed light not only on the interplays between autonomous and controlled motivation and PA behavior, but also on the reciprocal effects that PA may have on motivation. This information could be of great value, as it could contribute to promoting PA in children.

* Corresponding author.
E-mail address: matapiase@unex.es (M.Á. Tapia-Serrano).

https://doi.org/10.1016/j.psychsport.2025.102905
Received 4 November 2024; Received in revised form 29 May 2025; Accepted 29 May 2025
Available online 30 May 2025

Therefore, the present study based on SDT aims to analyze the possible reciprocal relationship between autonomous and controlled motivation and PA behavior over time.

1.1. A self-determined lens for motivation

SDT (Deci & Ryan, 2000; Ryan & Deci, 2017) is a macro-theory that outlines a wide structure for studying motivation, which has often been used to gain a deeper insight into the reasons underlying human behavior, including the reasons young people engage in PA. SDT distinguishes between autonomous and controlled motivation and amotivation (i.e., the absence of motivation (Deci & Ryan, 2000; Ryan & Deci, 2017). Rather than focusing on how much motivation an individual has, SDT emphasizes the type of motivation, as different forms lead to different behavioral outcomes. Given their distinct nature, autonomous motivation is driven by intrinsic enjoyment and personal values, while controlled motivation relies on external pressures and contingencies. Autonomous motivation involves the regulation of behavior through experiences of enjoyment, curiosity, and search for new optimal horizons (intrinsic motivation), its alignment with the person's system of needs, values and goals (integrated regulation), as well as the endorsement of personal value, and the recognition of the benefits that the behavior itself brings (i.e., identified regulation). Controlled motivation, in contrast, involves the regulation of behavior through experiences driven both by self-imposed pressures and demands to gain self-esteem, or to prevent feelings of shame and guilt (introjected regulation), and by social pressures and external demands, either to obtain rewards or to avoid punishments (external regulation).

1.2. Relationships between motivation and PA

Previous SDT-based research has shown that the reasons people engage in a behavior are crucial for its initiation and maintenance over time. In the PA context, Owen et al.'s (2014) systematic review and meta-analysis research revealed cross-sectional, consistent relationships between children's and adolescents' motivational forms for PA and their PA behavior depending on the type of motivation (autonomous or controlled motivation). More particularly, there was a positive and moderate association between autonomous motivation and PA, while some studies have suggested thwart the relationship between controlled motivation and PA may be more complex and context dependent. Owen et al. (2014) found that introjected regulation was positively related to PA, whereas external regulation was not significantly associated with PA behavior. However, Costa et al. (2021) reported that controlled motivation was positively related to PA negative affect but did not examine direct associations with PA behavior. These findings highlight the need for further investigation into the differential roles of introjected and external regulation in PA engagement over time.

Although Owen et al.'s (2014) study gathered solid evidence on the cross-sectional relationships between autonomous and controlled motivation for PA with PA behavior in children and adolescents, there is need to shed more light on the longitudinal interplays between different forms of motivations and PA in children because motivational and behavioral dynamics tend to fluctuate over time (Ryan & Deci, 2017). Given the mixed evidence on the role of controlled motivation, it is essential to examine whether its effects on PA behavior vary by regulation type and over time. To our knowledge, few longitudinal studies have explored this, and their findings remain inconsistent regarding the influence of autonomous and controlled motivation on PA over time. Gonzalez-Cutre et al. (2014) and Koka et al. (2019) observed that adolescents' autonomous, relative to controlled, motivation for PA at Time 1 was positively associated with their PA at Time 2, whereas Hagger et al. (2009) showed that autonomous, relative to controlled, motivation for PA at Time 1 was unrelated to PA at Time 2. These longitudinal studies focused on adolescents and they did not consider the potential reciprocal effects from PA behavior to each motivational form, and operationalized motivation using the relative autonomy index (i.e., a composite score that reflects the balance between controlled and autonomous motivation, with higher values indicating that a person's behavior is guided more by self-determined reasons than by external pressures), which made it impossible to examine the differential impact of autonomous and controlled motivation. In addition, sex differences emerge as a need for analysis in the relationship between motivation and PA. Previous SDT-grounded research, including evidence synthesized in Owen et al. (2014), has suggested that boys and girls may engage in PA for qualitatively different motivational reasons. Particularly, boys tend to exhibit higher levels of autonomous motivation (i.e., intrinsic motivation, integrated regulation and identified regulation) than girls when engaging in PA behaviors (De Meester, Aelterman, Cardon, De Bourdeaudhuij, & Haerens, 2014; Renninger et al., 2022; Romero-Parra et al., 2023). Conversely, girls are more likely than boys to show higher levels of controlled motivation (i.e., introjected regulation and external regulation) for PA (De Meester, Aelterman, Cardon, De Bourdeaudhuij, & Haerens, 2014; Renninger et al., 2022; Romero-Parra et al., 2023). Although previous research has demonstrated these motivational differences, it remains unclear whether they translate into distinct longitudinal relationships with PA behaviors. Given that SDT posits that the relationship between motivation and behavior is influenced by both contextual and individual factors, it is plausible that gender may act as a moderating factor in these associations. In addition, previous studies have found that while girls tend to report lower levels of autonomous motivation, they may maintain PA engagement due to social norms, external pressures, or body image concerns (Romero-Parra et al., 2023). In contrast, boys are more likely to engage in PA based on perceived competence and enjoyment (De Meester et al., 2014). These findings suggest that although overall levels of PA may appear similar, the underlying motivational mechanisms driving participation may differ between genders.

To our knowledge, no previous studies have examined sex differences in the relationships between autonomous and controlled motivation with PA over time. To fill this gap, the present study also conducted a multi-group analysis to test whether gender moderates these relationships formally. This information may be of great interest to coaches, teachers, parents, and legal guardians for future motivational interventions aimed at promoting PA in children. Knowing what motivates boys and girls to be physically active may help to design and implement more effective strategies to motivate both boys and girls to remain physically active in the future. Therefore, the present study seeks to expand the previous knowledge by analyzing the longitudinal relationships between the distinguishable nature of the high quantity of motivation for PA and PA behavior in school-aged children, considering the role of children's sex.

1.3. The present study

The aims of the present study were: 1) to examine the longitudinal relationships between children' autonomous and controlled motivation with their PA behavior over time; 2) to explore the potential reciprocal association from PA behavior to autonomous and controlled motivation over time; and 3) to analyze whether all these relationships are different between boys and girls. Following previous SDT-based literature, the first hypothesis posits that autonomous motivation would be positively related to PA behaviors (Owen et al., 2014; Ryan & Deci, 2017, 2019). However, the relationship between controlled motivation and PA behaviors remains less clear. While some studies suggest that introjected regulation may contribute positively to PA (Owen et al., 2014), others indicate that external regulation may not be significantly related to PA affect (Costa et al., 2021). Nevertheless, longitudinal findings provide additional support for a potential positive association between controlled motivation and PA behaviors. For instance, introjected regulation has been positively correlated with PA over time (González-Cutre et al., 2014; Koka et al., 2019; Yli-Piipari et al., 2009),

and external regulation has shown positive associations with intentions to exercise and leisure-time PA (Taylor et al., 2010; Yli-Piipari et al., 2009). Based on this body of evidence, we hypothesize that controlled motivation will be positively associated with PA behaviors over time. Furthermore, according to the second objective and given the lack of prior evidence, no hypothesis could be made for the second objective (Taylor, 2017). For the third objective, it is hypothesized that differences in the types of motivation between boys and girls will influence their PA behavior differently. Particularly in girls, controlled motivation may not have a negative impact on PA, as some external concerns (such as those related to body image or weight) may be internalized and reflect more autonomous motives in certain cases (Romero-Parra et al., 2023). Conversely, in boys, autonomous motivation is expected to have a stronger and more positive effect on PA levels, as it is more closely related to the perception of competence and enjoyment in the sports domain (De Meester et al., 2014).

2. Method

2.1. Participants

A three-wave longitudinal design and convenience sample were carried out in four primary schools located in ([omitted for blind review]). Three evaluations were conducted at three different times between February and October 2022 (separately 3 months at least each other): Time 1 in February, Time 2 in June, and Time 3 in October. During their fourth and fifth years of primary school, a total of 291 children aged 9–11 years (M_{age} = 10.50; SD = .58; which 160 boys [M_{age} = 10.53; SD = .53] and 131 girls [M_{age} = 10.49; SD = .53]) participated in this study. Specifically, the Time 1 included 278 children (M_{age} = 10.51 years, SD = .53; 154 boys and 124 girls). The time 2 involved 266 children (M_{age} = 10.50 years, SD = .53; 148 boys and 118 girls). The time 3 included 266 children (M_{age} = 10.50 years, SD = .53; 148 boys and 118 girls). Class sizes ranged from 11 to 26 children per group. Children were included if they met the established inclusion criteria: 1) belonging to primary education; 2) completing in full the questionnaires on motivation for PA and PA at Time 1, Time 2, and Time 3, ensuring valid responses.

2.2. Measures

2.2.1. Autonomous and controlled motivation for PA

The Spanish version of the Behavioral Regulation Exercise Questionnaire (BREQ-3), adapted and validated in the Spanish PA context (González-Cutre & Sicilia, 2010), was used to assess autonomous and controlled motivation for PA. It starts with a stem phrase: "I participate in PA …", and followed by 19 items that measure intrinsic motivation (e.g., "… because I think the exercise is fun"), integrated regulation (e.g., "… because I consider exercise a fundamental part of who I am), identified regulation (e.g., "… because I value the benefits of exercise"), introjected regulation (e.g., "… because I feel guilty when I don't practice"), and external regulation (e.g., "… because other people say I should"). Items were rated on a 5-point Likert scale ranging from 0 ("Strongly disagree") to 4 ("Strongly agree"). Consistent with Vansteenkiste et al. (2010), a composite score for autonomous motivation was calculated by averaging intrinsic motivation, integrated regulation and identified regulation. Similarly, a composite score for controlled motivation was calculated by averaging introjected and external regulation. In this research, the hierarchical two-factor correlated model obtained a good fit: χ^2(df = 151) = 298.23, $p < .001$; comparative fit index (CFI) = .95; Tucker-Lewis index (TLI) = .94; standardized root mean square residual (SRMR) = .07; root mean square error of approximation (RMSEA) = .04 (.04–.05). Furthermore, reliability analyses showed adequate internal consistency values for Omega at all three measures (see Table 2).

2.2.2. PA behaviors

PA behaviors were assessed using the Spanish version of the PA Questionnaire for Children (PAQ-C; Benítez-Porres et al., 2016). The PAQ-C has been shown to be a valid (r = .30–.40, Marasso et al., 2021) and reliable (ω = .76 and Intraclass Correlation Coefficient [ICC] = .96) measure to assess PA behavior in Spanish children (Manchola-González et al., 2017). In the present study, reliability analyses were performed showing adequate values of internal consistency in Omega at all three measures (see Table 2). The PAQ-C comprises nine questions that assess the frequency of participation in physical activities in the last 7 days at different moments, including during Physical Education (PE) lessons, during school breaks, during lunchtime, after school, evenings, and weekends. Each answer is scored on a 5-point scale ranging from 1 to 5. The PA score was measured as the average value of all responses. Therefore, higher scores indicate higher PA levels.

2.3. Procedure

APA ethical standards (i.e., consent, confidentiality, and anonymity of responses) and the Declaration of Helsinki were followed and conducted in this study. Also, this research was approved by the Ethics Committee of the main author's University prior to the commencement of data collection ([omitted for blind review]). The research team contacted the PE teachers at each school. Also, a letter of consent was designed for the parents or legal guardians of the children, who had to return it signed to authorize the collaboration in the study. After approval, responses were obtained at the middle of the academic year (February; Time 1), at the end of the academic year (June; Time 2), and the follow-up was assessed after the first month of the next academic year (October; Time 3). The participating children filled the questionnaires individually, during PE classes, with the help of a supervisor (time between 20 and 22 min). Therefore, questionnaires were matched over time using a coding system to protect confidentiality. The same procedures were followed with all teams and time points to ensure the players were familiar with data collection.

2.4. Data analyses

All statistical analyses were performed using Mplus version 7.3 (Muthén & Muthén, 1998-2017). Prior to the main analyses, longitudinal invariance tests were conducted following the methodological proposal by Milfont and Fischer (2010) that inspects the tenability of configural invariance (i.e., no equality constraints), weak invariance (i.e., equality constraints in items' factor loading, simultaneously). strong invariance (i.e., equality constraints in items' factor loading and intercept, simultaneously), and strict invariance (i.e., equality constraints in items' factor loading, intercept and error variance, simultaneously). In addition to these four progressively constrained models, structural weight invariance (i.e., equality constraints in items' factor loading, intercept and error variance, and structural weights, simultaneously), and structural residual invariance (i.e., equality constraints in items' factor loading, intercept and error variance, structural weights, and structural error variance, simultaneously) were examined for the hierarchical two-factor model for autonomous and controlled motivation (Milfont & Fischer, 2010). The invariance assumption was evaluated based on differences of up to .010 in CFI and as high as .015 in RMSEA among each pair of increasingly constrained models (Milfont & Fischer, 2010). Moreover, to decide whether we needed to include any covariate in the model, a MANOVA test was conducted to explore differences in the sex-based study variables. Furthermore, a multi-group analysis was performed to assess gender invariance of the target paths comprising the model. Specifically, a configural model (i.e., free constraints) and a constrained model (i.e., with constraints applied to all paths) were compared. For model comparisons, the same criteria regarding changes in CFI and RMSEA outlined above were applied. McDonald's omega reliability coefficient was computed for every target variable and

intra-class correlation coefficient (ICC) was additionally calculated to determine the hierarchical nature of data at the classroom level.

On the other hand, descriptive statistics (i.e., means and standard deviations), and correlations were estimated for all study variables. To test the longitudinal relationships between autonomous and controlled motivation with PA (see Fig. 1), a cross-lagged panel model (CLPM) with a structural equation modelling approach specified in terms of manifest variables (i.e., path analysis) was performed using the robust maximum likelihood (MLR) estimator, as it is robust for non-normal observations and can handle random missing data (Muthén & Muthén, 1998-2017), and the parameters using the Mplus COMPLEX instruction (Muthén & Muthén, 1998-2017). This approach allows us to examine reciprocal longitudinal relationships, considering both stability over time and cross-lagged effects between variables. Furthermore, every indirect (mediated) effect is significant when its 95 % confidence interval (95 % CI) does not include zero (Hayes & Little, 2017). The assessment of the model's fit was made using a variety of goodness-of-fit measures: ratio between chi-square and degrees of freedom (χ^2/df), CFI, Tucker Lewis index (TLI), standardized root mean square (SRMR), and RMSEA. While values up to 3 for χ^2/df, greater than .95 in CFI and TLI, and up to .06 for SRMR and RMSEA are indicative of a good fit to data (Hu & Bentler, 1999); scores as high as 5 for χ^2/df, above .90 for CFI and TLI, and as high as .08 for SRMR and RMSEA are representative of an acceptable fit to data (Marsh et al., 2004).

3. Results

3.1. Preliminary results

Table 1 shows differences between −.004 and .000 in CFI and between −.004 and .004 in RMSEA among the progressively more constrained models for the hierarchical two-factor model of autonomous and controlled motivation. Regarding the PA questionnaire, Table 1 also displays changes from −.010 to −.006 in CFI and from −.002 to .000 in RMSEA between the increasingly more constrained models. Altogether, the longitudinal invariance assumption was supported for the measure both of autonomous and controlled motivation, and of PA.

Regarding sex differences in the study variables, a MANOVA tests were conducted. Significant sex differences were found in the target variables at Time 2 (Wilks's $\lambda = .96$, $F(7, 68) = 3.83$, $p < .001$, partial $\eta^2 = .03$). In addition, changes greater than .010 in CFI and .015 in RMSEA between the configural model (χ^2 [$df = 282$] = 724.6; CFI = .92; TLI = .91, SRMR = .07; RMSEA = .07) and the constrained model (χ^2 [$df = 315$] = 1076.18; CFI = .91; TLI = .90; SRMR = .05; RMSEA = .05) were found suggesting a violation of the hypothesis of gender invariance between both models.

Table 2 presents McDonald's omega scores between .81 and .84 in autonomous motivation, between .73 and .77 in controlled motivation, and of .84 in PA for each of the three time points. Lastly, a null model for autonomous and controlled motivation and PA was specified to calculate the ICC. Its values – which show the degree of shared variance due to classroom membership – were very low for both factors (ICCs = .01–.08; <.10, Hox et al., 2010).

3.2. Descriptive statistics

Table 2 shows mean scores, standard deviations, and correlations of the variables included in the investigation. Regarding the descriptive statistics, scores for autonomous motivation and PA behaviors at all three measurement points were above the midpoint of their respective measurement scales, whereas scores for controlled motivation were below the midpoint of its measurement scale. As for the bivariate correlations, participants reported a significant and positive correlation between autonomous motivation and PA behaviors during all time points, and vice versa ($rs = .35$–$.47$; $p < .01$). Conversely, controlled motivation showed a non-significant relationship with autonomous motivation and PA behavior, nor vice versa ($ps < .05$).

3.3. Main results

The hypothesized model (see Fig. 1) was tested including autonomous and controlled motivation, and PA at three time points. The model showed adequated fit indices: χ^2 ($df = 125$) = 301.33, $p < .001$, χ^2/df = 2.41, CFI = .92, TLI = .90, SRMR = .07, RMSEA = .07 (95 % CI = .06–.08). Furthermore, autonomous and controlled motivation, and PA presented a positive relationship within each time point (i.e., autonomous motivation at Time 1 → Time 2 → Time 3 [$\beta = .60 - .62$; $ps < .001$; 95 % CI [.59 − .64, .57 − .64]]; controlled motivation at Time 1 → Time 2 → Time 3 [$\beta = .56 - .69$; $ps < .001$; 95 % CI [.49 − .63, .47 − .92]], and PA at Time 1 → Time 2 → Time 3 [$\beta = .45 - .54$; $ps < .001$; 95 % CI [.48 − .65, .31 − .67]], respectively).

3.3.1. Motivation (autonomous and controlled) → PA

Positive relationships between autonomous motivation with PA perceived by boys and girls at Time 1 ($\beta = .40$; $p < .001$, 95 % CI [.29, .50]), as well as at Time 2 ($\beta = .34$; $p < .001$, 95 % CI [.25, .42]), and Time 3 ($\beta = .26$; $p < .001$, 95 % CI [.22, .31]) emerged. However, controlled motivation was positively associated with PA perceived by boys and girls at Time 2 ($\beta = .13$; $p < .001$, 95 % CI [.09, .17]) but not at Time 1 ($\beta = .01$; $p = .874$, 95 % CI [-.08, .10]), and negatively only in girls at Time 3 ($\beta = -.09$; $p = .011$, 95 % CI [-.15, −.19]).

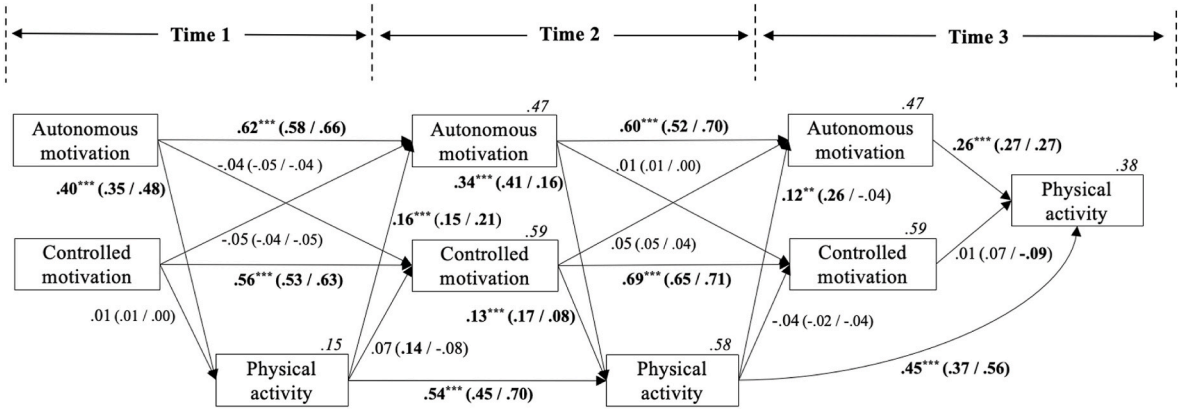

Fig. 1. Hypothesized Model for the Full Sample and for Boys (First Coefficient in parentheses) and Girls (Second Coefficient in parentheses)
Note. Standardized coefficients and statistically significant at .05 level (***$p < .001$ and **$p < .01$). Statistically significant paths are presented in bold. Explained variance is presented in italics.

Table 1
Longitudinal invariance for the measures of autonomous and controlled motivation, and PA.

Hierarchical two-factor model for autonomous and controlled motivation							
	χ^2 (*df*)	CFI	RMSEA (90 %CI)	Model comparison	$\Delta\chi^2$ (Δdf)	ΔCFI	ΔRMSEA
1. Configural invariance	973.90 (438)	.91	.04 (.03.04)	–	–	–	–
2. Weak invariance	1014.65 (466)	.91	.04 (.03–.04)	2 *versus* 1	40.74 (28)	−.002	<.001
3. Strong invariance	1072.37 (504)	.90	.03 (.03–.04)	3 *versus* 2	57.73 (38)*	−.004	−.004
4. Strict invariance	1189.72 (542)	.90	.04 (.03–.04)	4 *versus* 3	117.34 (38)***	−.003	.004
5. Structural weight invariance	1192.63 (548)	.90	.04 (.03–.04)	5 *versus* 4	2.92(6)	<.001	<.001
6. Structural residual invariance	1213.25 (558)	.90	.04 (.03–.04)	6 *versus* 5	20.62(10)*	−.002	<.001
Physical activity questionnaire							
	χ^2 (*df*)	CFI	RMSEA (90 %CI)	Model comparison	$\Delta\chi^2$ (Δdf)	ΔCFI	ΔRMSEA
1. Configural invariance	113.39 (42)	.96	.03 (.02–.04)	–	–	–	–
2. Weak invariance	134.79 (54)	.95	.03 (.02–.04)	2 *versus* 1	21.40 (12)*	−.006	−.002
3. Strong invariance	170.40 (68)	.94	.03 (.02–.04)	3 *versus* 2	35.61 (14)**	−.010	<.001
4. Strict invariance	191.97 (82)	.93	.03 (.02–.03)	4 *versus* 3	21.57 (14)	−.007	−.002

Note. ***$p < .001$, **$p < .01$, *$p < .05$.

Table 2
Descriptive statistics, reliability coefficients and Pearson's correlations for the Study's variables.

	Range	*M*	*SD*	ω	ICC	1	2	3	4	5	6	7	8
1. Autonomous motivation Time 1	0–4	3.06	.80	.82	.01	–							
2. Controlled motivation Time 1	0–4	1.30	.99	.78	.01	.14	–						
3. PA behaviors Time 1	1–5	4.19	2.67	.84	.02	.37***	.11	–					
4. Autonomous motivation Time 2	0–4	3.07	.77	.81	.01	.57***	−.01	.32***	–				
5. Controlled motivation Time 2	0–4	1.16	.92	.73	<.01	−.03	.56***	−.01	.01	–			
6. PA behaviors Time 2	1–5	4.34	2.75	.84	.02	.47***	.09	.70***	.52***	.08	–		
7. Autonomous motivation Time 3	0–4	4.00	3.01	.84	.01	.45***	−.13	.39***	.55***	−.13	.37***	–	
8. Controlled motivation Time 3	0–4	.92	.85	.73	.08	.02	.40***	−.16	−.09	.55***	−.06	−.07	–
9. PA behaviors Time 3	1–5	2.63	.62	.84	.02	.35***	.07	.72***	.35***	.01	.71***	.53***	−.07

Note. ***$p < .001$.

3.3.2. PA → motivation (autonomous and controlled)

There was a positive association between PA perceived by boys and girls at Time 1 with autonomous motivation at Time 2 ($\beta = .16$; $p < .001$, 95 % CI [.29, .50]), as well as PA (only perceived by boys) at Time 2 and autonomous motivation at Time 3 ($\beta = .12$; $p = .001$, 95 % CI [.22, .31]). However, only PA at Time 1 showed a positive and significant relationship with controlled motivation at Time 2 in boys ($\beta = .14$; $p < .001$, 95 % CI [.11, .17]). The remaining relationships were not significant (i.e., $p > .05$).

4. Discussion

This study aimed to examine the longitudinal and reciprocal relationships between autonomous and controlled motivation with PA behavior in primary school children. Moreover, this study attempted to investigate the differences between boys and girls in the associations between motivation and PA behaviors. In general, results showed a longitudinal and reciprocal relationship between autonomous motivation and PA behavior, not being as evident as between controlled motivation and PA. In addition, there were several differences between boys and girls, especially in the bidirectional relationship between controlled motivation and PA. Overall, this study advances current understandings of the SDT framework regarding the role of the distinctive nature of motivation in PA behavior over time, and a step forward in terms of the positive role of PA behavior on motivation over time. At the same time, it is important to consider that our study showed that children with a predominance of autonomous over controlled motivation, or with an adequate frequency of participation in out-of-school physical activities, will continue to have stable motivational profiles and consistent PA behaviors at subsequent times.

4.1. Motivation (autonomous and controlled) → PA

Specifically, our findings indicated a positive relationship between children's perceptions of autonomous motivation and PA behavior at both sexes in Time 1, Time 2, and Time 3. These results are consistent with previous SDT-based studies providing additional insight by examining the longitudinal relationship between these variables through a three-wave design focused on reciprocal associations and sex differences in children (Owen et al., 2014; Teixeira, Carraça, Markland, Silva, & Ryan, 2012). In fact, our findings underline that children who are autonomously motivated tend to remain physically active in the future. Moreover, these findings emphasized the importance that these positive associations were pointed out in both sexes. These findings could be explained by the fact that children who are autonomously motivated towards PA tend to engage in PA with a sense of enjoyment and fun, maintaining these levels of practice in the future and a lower risk of dropping out (Costa et al., 2021). Therefore, these results reinforce the role of autonomous motivation towards PA, as maintaining high levels of autonomous motivation increases the likelihood of engaging in PA behaviors in the future. However, caution should be taken into account as, up to our knowledge, studies specifically in children that aim to examine the relationship between autonomous motivation and behavior towards PA behaviors over time are still relatively scarce.

Regarding controlled motivation, our findings indicated a significant association between controlled motivation and PA behavior at Time 2 and Time 3 —only in girls—. Although we cannot definitively establish a longitudinal relationship between these two variables over time, our results suggest a potential connection worth exploring further (Leo et al., 2022). Similarly, the systematic review by Vasconcellos et al. (2020) identified controlled motivation as a positive association with a range of behavioral outcomes, including the intention to engage in PA. However, the absence of a longitudinal relationship between controlled motivation and PA behavior is justified by the fact that, as confirmed by the

autonomous motivation and PA behavior relationship, autonomous forms of motivation are the strongest predictors of positive and adaptive outcomes toward PA. Furthermore, the systematic review and meta-analysis by Owen et al. (2014) found that young people with higher levels of controlled motivation may negatively influence long-term PA participation (Teixeira et al., 2012). They seem to be in line with the "dual process model" proposed by SDT (Jang et al., 2016; Ryan & Deci, 2017). According to SDT, controlled motivational forms are more related to maladaptive and negative outcomes representing the "dark" side of human functioning, while autonomous motivational forms represent the "bright" side and are more connected to positive outcomes and adaptive outcomes (i.e., enjoyment, interest, and engagement towards PA; Costa et al., 2021). In relation to sex, although the relationships for girls were stronger (Leo et al., 2022), no significant changes were found to boys. Considering the variability of findings in previous studies, it would be interesting for further studies to investigate the relationship between controlled motivation and PA over time, as this relationship may vary by sex.

4.2. PA → motivation (autonomous and controlled)

Positive empirical support for the longitudinal relationship —notably in boys— between PA behavior and autonomous motivation was found. Our results suggest that children who engage in PA behaviors in a voluntary and self-initiated manner perceived it as interesting and enjoyable, and integrated it into their daily lives, providing positive benefits. Therefore, this can help children remain autonomously motivated over time. These findings support previous research findings suggesting that PA in which young people feel autonomous, competent, and have good social relationships can help shape children's beliefs and behaviors and improve motivation for PA (Owen et al., 2014; Teixeira et al., 2012). In this regard, positive PA behaviors and strategies to satisfy basic psychological needs (autonomy, competence, and relatedness) in which children feel autonomous, competent, and have good social relationships can help to improve motivation for PA (See [Behzadnia & FatahModares, 2020] for more information).

Meanwhile, PA behavior was not related to controlled motivation over time, except the association between PA behavior at Time 1 and controlled motivation at Time 2 in boys. These null findings may be explained by the fact that children start PA (e.g., basketball, football, etc.) either for pleasure or external factors (e.g., social pressure or feeling part of a group), but when these external motivators are eliminated or lose value, the PA behavior disappears. In addition, although no longitudinal studies have deeply explored how PA influences-controlled motivation in children, previous correlational studies have shown either a non-significant or very weak relationship between PA and controlled motivation (e.g., (Chatzisarantis et al., 2002; Owen et al., 2013). Overall, our results shed light on the relationship between motivation and PA over time, and how the latter can help maintain and/or modify certain levels of motivation.

4.3. Limitations and future research

The results of this study should be used with its limitations in mind. First, PA was measured by self-report to obtain a relatively large sample of children at three-time points. Although self-report measurement has been advocated previously (Biddle et al., 2011), it would be useful for future studies to replicate the proposed relationships using electronic devices to obtain more accurate estimates of PA and eliminate potential memory and response bias effects (Prince et al., 2008). The second limitation of this study concerns the variables that might be relevant to understanding these relationships were not included. Future studies could look at children's perceptions of teacher support for PA to gain a broader view of the antecedents that may motivate children. Finally, this study was based on a convenience sample of children which limits the generalizability of the results. Future works could generalize these findings using a more heterogeneous and larger sample.

5. Conclusion and practical applications

The findings provide evidence that autonomous motivation is related to PA behavior over time, and vice versa, specially appears to be more evidence of relationship between autonomous motivation and PA. However, a more controlled form of motivation does not seem to reciprocally affect PA over time. These results have a strong practical implication, as it suggests that when children engage in PA, they are autonomously motivated rather than motivated by controlled forms of motivation. Children motivated by autonomous forms of motivation are more likely to continue to engage in PA over time, whereas when these children are motivated by controlled forms of motivation, they are more likely to show less interest in PA and consequently are more likely to abandon PA behavior. Therefore, it is crucial to promote autonomous forms of motivation that foster positive experiences towards PA and sport, and to maintain PA behavior over time.

From a psychoeducational perspective, it is important to implement evidence-based programs aimed at fostering autonomous motivation towards PA. It is of paramount importance to consider the role of the various key agents, such as parents, coaches, monitors, PE teachers, and peers, who can exert a significant influence on the development of autonomous motivation. Therefore, it would be offering opportunities for exploration, creativity, and self-expression by connecting tasks and goals to the children's values, interests, and long-term aspirations that they find interesting or enjoyable. Furthermore, researchers, practitioners and families need to understand the relevance of physical activities in promoting well-being, not only in the physical and motor domain.

Funding

This study was supported by the Ministry of Science, Innovation and Universities (RTI2018- 096619-A-I00). We gratefully acknowledge the financial support of the Spanish State Research Agency and the European Regional Development Fund of the European Union. MATS is supported by the INVESTIGO programme, (Ref. INVESTIGO 048-17), included in the framework of the Recovery, Transformation and Resilience Plan.

CRediT authorship contribution statement

Miguel Ángel López-Gajardo: Writing – review & editing, Writing – original draft, Software, Methodology, Investigation, Formal analysis, Conceptualization. **Miguel Ángel Tapia-Serrano:** Writing – review & editing, Writing – original draft, Resources, Methodology, Formal analysis, Conceptualization. **Rafael Burgueño:** Visualization, Supervision, Software, Conceptualization. **Ángel Abós:** Visualization, Supervision. **Francisco M. Leo:** Visualization, Supervision, Resources, Project administration, Formal analysis. **Pedro Antonio Sánchez-Miguel:** Visualization, Supervision, Project administration, Methodology, Funding acquisition. **Luis García-González:** Visualization, Validation, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

References

Behzadnia, B., & FatahModares, S. (2020). Basic psychological need-satisfying activities during the COVID-19 outbreak. *Applied Psychology: Health and Well-Being, 12*(4), 1115–1139. https://doi.org/10.1111/aphw.12228

Benítez-Porres, J., Alvero-Cruz, J. R., De Albornoz, M. C., Correas-Gómez, L., Barrera-Expósito, J., Dorado-Guzmán, M., Moore, J. B., & Carnero, E. A. (2016). The influence of 2-year changes in physical activity, maturation, and nutrition on adiposity in adolescent youth. *PLoS One, 11*(9), 1–13. https://doi.org/10.1371/journal.pone.0162395

Biddle, S. J., Gorely, T., Pearson, N., & Bull, F. C. (2011). An assessment of self-reported physical activity instruments in young people for population surveillance: Project ALPHA. *International Journal of Behavioral Nutrition and Physical Activity, 8*(1), 1. https://doi.org/10.1186/1479-5868-8-1

Bull, F. C., Al-Ansari, S. S., Biddle, S., Borodulin, K., Buman, M. P., Cardon, G., Carty, C., Chaput, J.-P., Chastin, S., Chou, R., Dempsey, P. C., DiPietro, L., Ekelund, U., Firth, J., Friedenreich, C. M., Garcia, L., Gichu, M., Jago, R., Katzmarzyk, P. T., … Willumsen, J. F. (2020). World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *British Journal of Sports Medicine, 54*(24), 1451–1462. https://doi.org/10.1136/bjsports-2020-102955

Chatzisarantis, N. L., Hagger, M. S., Biddle, S. J., & Karageorghis, C. (2002). The cognitive processes by which perceived locus of causality predicts participation in physical activity. *Journal of Health Psychology, 7*(6), 685–699. https://doi.org/10.1177/1359105302007006872

Costa, S., Bianco, A., Polizzi, V., & Alesi, M. (2021). Happiness in physical activity: A longitudinal examination of children motivation and negative affect in physical activity. *Journal of Happiness Studies, 22*(4), 1643–1655. https://doi.org/10.1007/s10902-020-00289-7

De Meester, A., Aelterman, N., Cardon, G., De Bourdeaudhuij, I., & Haerens, L. (2014). Extracurricular school-based sports as a motivating vehicle for sports participation in youth: A cross-sectional study. *International Journal of Behavioral Nutrition and Physical Activity, 11*, 1–15. https://doi.org/10.1186/1479-5868-11-48.

Deci, E. L., & Ryan, R. M. (2000). The "What" and "Why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry, 11*(4), 227–268. https://doi.org/10.1207/S15327965PLI1104_01

García-Hermoso, A., Ezzatvar, Y., Ramírez-Vélez, R., Olloquequi, J., & Izquierdo, M. (2021). Is device-measured vigorous physical activity associated with health-related outcomes in children and adolescents? A systematic review and meta-analysis. *Journal of Sport and Health Science, 10*(3), 296–307. https://doi.org/10.1016/j.jshs.2020.12.001

González-Cutre, D., & Sicilia, Á. (2010). Towards a better understanding of motivation in physical activity: Measuring integrated regulation in the Spanish context. *Psichothema, 22*, 841–847.

González-Cutre, D., Sicilia, Á., Beas-Jiménez, M., & Hagger, M. S. (2014). Broadening the trans-contextual model of motivation: A study with Spanish adolescents. *Scandinavian Journal of Medicine & Science in Sports, 24*(4), E306–E319. https://doi.org/10.1111/sms.12142

Grao-Cruces, A., Sánchez-Oliva, D., Padilla-Moledo, C., Izquierdo-Gómez, R., Cabanas-Sánchez, V., & Castro-Piñero, J. (2020). Changes in the school and non-school sedentary time in youth: The UP&DOWN longitudinal study. *Journal of Sports Sciences, 38*(7), 780–786. https://doi.org/10.1080/02640414.2020.1734310

Guthold, R., Stevens, G. A., Riley, L. M., & Bull, F. C. (2020). Global trends in insufficient physical activity among adolescents: A pooled analysis of 298 population-based surveys with 1·6 million participants. *The Lancet Child and Adolescent Health, 4*(1), 23–35. https://doi.org/10.1016/S2352-4642(19)30323-2

Hagger, M., Chatzisarantis, N. L. D., Hein, V., Soós, I., Karsai, I., Lintunen, T., & Leemans, S. (2009). Teacher, peer and parent autonomy support in physical education and leisure-time physical activity: A trans-contextual model of motivation in four nations. *Psychology and Health, 24*(6), 689–711. https://doi.org/10.1080/08870440801956192

Hayes, A. F., & Little, T. D. (2017). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach*.

Hox, J., Moerbeek, M., & van de Schoot, R. (2010). *Multilevel analysis*. Routledge. https://doi.org/10.4324/9780203852279

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal, 6*(1), 1–55. https://doi.org/10.1080/10705519909540118

Jang, H., Kim, E. J., & Reeve, J. (2016). Why students become more engaged or more disengaged during the semester: A self-determination theory dual-process model. *Learning and Instruction, 43*, 27–38. https://doi.org/10.1016/j.learninstruc.2016.01.002

Koka, A., Tilga, H., Kalajas-Tilga, H., Hein, V., & Raudsepp, L. (2019). Perceived controlling behaviors of Physical Education teachers and objectively measured leisure-time physical activity in adolescents. *International Journal of Environmental Research and Public Health, 16*(15), 2709. https://doi.org/10.3390/ijerph16152709

Leo, F. M., Mouratidis, A., Pulido, J. J., López-Gajardo, M. A., & Sánchez-Oliva, D. (2022). Perceived teachers' behavior and students' engagement in physical education: The mediating role of basic psychological needs and self-determined motivation. *Physical Education and Sport Pedagogy, 27*(1), 59–76. https://doi.org/10.1080/17408989.2020.1850667

Manchola-González, J., Bagur-Calafat, C., & Girabent-Farrés, M. (2017). Fiabilidad dela versión espãnola del cuestionario de actividad física PAQ-C. *Revista Interna-cional de Medicina y Ciencias de la Actividad Fisica y del Deporte, 17*(65), 139–152. https://doi.org/10.15366/rimcafd2017.65.010

Marasso, D., Lupo, C., Collura, S., Rainoldi, A., & Brustio, P. R. (2021). Subjective versusobjective measure of physical activity: A systematic review and meta-analysisof the convergent validity of the Physical Activity Questionnaire for Children (PAQ-C). *International Journal of Environmental Research and Public Health, 18*(7), 3413. https://doi.org/10.3390/ijerph18073413

Marsh, H. W., Hau, K. T., & Wen, Z. (2004). In search of golden rules: Comment on hypothesis-testing approaches to setting cutoff values for fit indexes and dangers in overgeneralizing Hu and Bentler's (1999) findings. *Structural Equation Modeling, 11*(3), 320–341. https://doi.org/10.1207/s15328007sem1103_2

Milfont, T., & Fischer, R. (2010). Testing measurement invariance across groups: Applications in cross-cultural research. *International Journal of Psychological Research, 3*(1), 111–130. https://doi.org/10.21500/20112084.857

Muthén, L. K., & Muthén, B. O. (1998-2017). *Mplus user's guide* (8th ed.). Muthén & Muthén.

Owen, K. B., Astell-Burt, T., & Lonsdale, C. (2013). The relationship between self-determined motivation and physical activity in adolescent boys. *Journal of Adolescent Health: Official Publication of the Society for Adolescent Medicine, 53*(3), 420–422. https://doi.org/10.1016/j.jadohealth.2013.05.007

Owen, K. B., Smith, J., Lubans, D. R., Ng, J. Y., & Lonsdale, C. (2014). Self-determined motivation and physical activity in children and adolescents: A systematic review and meta-analysis. *Preventive Medicine, 67*, 270–279. https://doi.org/10.1016/j.ypmed.2014.07.033

Prince, S. A., Adamo, K. B., Hamel, M., Hardt, J., Connor Gorber, S., & Tremblay, M. (2008). A comparison of direct versus self-report measures for assessing physical activity in adults: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity, 5*(1), 56. https://doi.org/10.1186/1479-5868-5-56

Renninger, D., Kelso, A., Reimers, A. K., Marzi, I., Beck, F., Engels, E. S., … Demetriou, Y. (2022). Motivation and active travel in adolescent girls and boys in Germany–Findings from the ARRIVE study. *Transportation Research Part F: Traffic Psychology and Behaviour, 90*, 425–437. https://doi.org/10.1016/j.trf.2022.09.015.

Romero-Parra, N., Solera-Alfonso, A., Bores-García, D., & Delfa-De-La-Morena, J. M. (2023). Sex and educational level differences in physical activity and motivations to exercise among Spanish children and adolescents. *European Journal of Pediatrics, 182*(2), 533–542. https://doi.org/10.1007/s00431-022-04742-y

Ryan, R. M., & Deci, E. L. (2017). *Self-Determination Theory: Basic psychological needs in motivation, development, and wellness*. New York.

Ryan, R. M., & Deci, E. L. (2019). Brick by brick: The origins, development, and future of Self-Determination Theory. *Advances in Motivation Science, 6*, 111–156. https://doi.org/10.1016/bs.adms.2019.01.001

Taylor, I. M. (2017). Reciprocal effects of motivation in physical education and self-reported physical activity. *Psychology of Sport and Exercise, 31*, 131–138. https://doi.org/10.1016/j.psychsport.2017.01.003

Taylor, I. M., Ntoumanis, N., Standage, M., & Spray, C. M. (2010). Motivational predictors of physical education students' effort, exercise intentions, and leisure-time physical activity: A multilevel linear growth analysis. *Journal of Sport & Exercise Psychology, 32*(1), 99–120. https://doi.org/10.1123/jsep.32.1.99

Teixeira, P. J., Carraça, E. V., Markland, D., Silva, M. N., & Ryan, R. M. (2012). Exercise, physical activity, and self-determination theory: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity, 9*(78), 1–30. https://doi.org/10.1186/1479-5868-9-78.

Vansteenkiste, M., Niemiec, C. P., & Soenens, B. (2010). The development of the five mini-theories of self-determination theory: An historical overview, emerging trends, and future directions. *The Decade Ahead: Theoretical Perspectives on Motivation and Achievement, 16*, 105–165. https://doi.org/10.1108/S0749-7423, 2010)000016A007.

Vasconcellos, D., Parker, P. D., Hilland, T., Cinelli, R., Owen, K. B., Kapsal, N., … Lonsdale, C. (2020). Self-determination theory applied to physical education: A systematic review and meta-analysis. *Journal of Educational Psychology, 112*(7), 1444.

Verloigne, M., Loyen, A., Van Hecke, L., Lakerveld, J., Hendriksen, I., De Bourdheaudhuij, I., Deforche, B., Donnelly, A., Ekelund, U., Brug, J., & van der Ploeg, H. P. (2016). Variation in population levels of sedentary time in European children and adolescents according to cross-European studies: A systematic literature review within DEDIPAC. *International Journal of Behavioral Nutrition and Physical Activity, 13*(1), 69. https://doi.org/10.1186/s12966-016-0395-5

World Health Organization. (2020). World Health Organization guidelines on physical activity and sedentary behaviour. http://apps.who.int/bookorders.

Yli-Piipari, S., Watt, A., Jaakkola, T., Liukkonen, J., & Nurmi, J. E. (2009). Relationships between physical education students' motivational profiles, enjoyment, state anxiety, and self-reported physical activity. *Journal of Sports Science and Medicine, 8*(3), 327–336.