Increasing cognitive demands during a cooperation-opposition game can reduce gender disparities in participation

Incrementar las demandas cognitivas durante un juego de cooperación-oposición puede reducir las desigualdades de género en la participación

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Abstract

Introduction: Physical Education contributes to the social construction of gender, particularly through activities with relational components, where participation is shaped by stereotypes and societal expectations. Gender differences in participation in traditional games and sports vary according to specific motor game characteristics, such as competitive structure, rules, and cognitive demands.
Objective: To explore how cognitive demands within motor games affect gender differences in participation patterns.
Methodology: A cross-sectional, descriptive design was employed with 123 participants across three age groups (children, adolescents and young adults). Using ''Capture the Flag'' as an experimental game, the study compared two game contexts: a traditional setup and a cognitively enriched variant that introduced dynamic, unpredictable elements to increase mental engagement. Gender-specific behaviors were analyzed through systematic observation, focusing on offensive and defensive roles.
Results: In the traditional game, males more frequently adopted offensive roles while females tended to assume defensive positions, reflecting stereotypical participation patterns. However, as cognitive demands increased, these differences diminished, leading to more balanced participation. Age also moderated these effects, with older participants showing greater adaptability to cognitive challenges, consistent with the maturation of executive functions.
Discussion: The influence of social constraints may be reduced when cognitive demands to achieve game goals are increased, leading to a balance in gender participation.
Conclusions: The findings suggest that increasing cognitive demands in motor games can reduce gender-based participation disparities and incorporating cognitively engaging activities in physical education may foster more inclusive and equitable participation across genders.

Keywords

Cognition; executive functions; gender equality; motor game; Physical Education.

Resumen

Introducción: La Educación Física contribuye a la construcción social del género, especialmente mediante actividades con componentes relacionales, donde la participación está influida por estereotipos y expectativas sociales. Las diferencias de género en la participación en juegos y deportes tradicionales varían según características como la estructura competitiva, las reglas y las demandas cognitivas.
Objetivo: Analizar cómo las demandas cognitivas en juegos motores influyen en las diferencias de género en la participación.
Metodología: Se utilizó un diseño transversal y descriptivo con 123 participantes de tres grupos de edad (niños, adolescentes y jóvenes). Mediante el juego "Atrapa la bandera", se compararon dos contextos: una versión tradicional y otra cognitivamente enriquecida. Los comportamientos según el género se analizaron mediante observación sistemática, centrándose en roles ofensivos y defensivos.
Resultados: En el juego tradicional, los niños adoptaron con mayor frecuencia roles ofensivos y las niñas posiciones defensivas, reflejando patrones estereotipados. Al incrementarse las demandas cognitivas, estas diferencias se redujeron. La edad moduló estos efectos, mostrando los participantes de mayor edad una mayor adaptabilidad a los desafíos cognitivos, en consonancia con la maduración de las funciones ejecutivas.
Discusión: La influencia de las restricciones sociales puede verse reducida cuando se incrementan las demandas cognitivas del juego, lo que conduce a un mayor equilibrio en la participación.
Conclusiones: Los resultados sugieren que el aumento de las demandas cognitivas en los juegos motores puede reducir las desigualdades de participación basadas en el género y que la incorporación de actividades cognitivamente estimulantes puede favorecer una participación más inclusiva y equitativa.

Palabras clave

Cognición; funciones ejecutivas; equidad de género; juego motor; Educación Física.

Introduction

The promotion of gender equality represents a significant challenge in the contemporary era, necessitating sustained efforts to transcend traditional models of masculinity and femininity within educational settings. In this sense, Physical Education (PE) plays a role in the social construction of gender, particularly in activities that inherently involve relational components (Gutierrez & García-López, 2012). However, PE classes do not always promote gender equality and equal opportunities (Oliva-González et al., 2025). Research has demonstrated notable gender disparities in participation in traditional games and sports, which are shaped by stereotypes and social expectations (Muñoz-Arroyave et al., 2021; Pic et al., 2020; Alcaraz-Muñoz et al., 2023; Gutierrez & García-López, 2012; Arenas et al., 2024).

There is a discrepancy in the participation of boys and girls in different PE classes (Ferry & Lund, 2018; Lamoneda et al., 2023). Generally, higher participation and motivation are observed among males during activities (Muñoz-Arroyave et al., 2021; Arenas et al., 2024), which tend to place greater importance on participating in sports and display more proactive, goal-oriented behaviour during games. Conversely, females often assume a more passive role, prioritising collaboration and responding to events unfolding in the game (Gutierrez & García-López, 2012). Additionally, girls exhibit heightened embarrassment and lack confidence in engaging in physical activities in public, which may contribute to a negative self-perception (Cowley et al., 2021). While team sports exhibit pronounced gender disparities in participation rates (Gutierrez & García-López, 2012), patterns differ markedly in aesthetic activities like gymnastics and dance, where sociocultural norms equate grace with femininity. Such contrasts highlight how participation reflects culturally constructed gender roles rather than biological predispositions alone (Hoffman et al., 2011).

Therefore, the association of sport with masculinity contributes to girls considering it a domain that is alien to them and one in which they feel undervalued, less competent, and with fewer opportunities for participation and development (Moreno-Vitoria et al., 2024; Molina et al., 2024). These disparities are particularly evident in PE, where social interactions can reinforce stereotypical gender roles, affecting engagement and behaviour in team games (Gutierrez & García-López, 2012).

The scientific literature indicates that gender stereotypes emerge early (Muñoz-Arroyave et al., 2021) and are reflected in participation patterns in physical activity and sports. Adolescents perceive sports and PE as domains strongly influenced by gender norms, which constrain their ability to challenge prevailing social expectations and engage in physical activities (Metcalfe, 2018; Molina et al., 2024). In PE, these stereotypes influence student participation considerably, with females often being underrepresented (Deng, 2023). These conditions influence game participation and impact emotional experiences, decision-making, and interpersonal relationships. This panorama highlights the importance of considering the impact of traditional sports games on students' holistic development (Muñoz-Arroyave et al., 2021).

In this sense, gender participation may be contingent on the specific characteristics of the motor game, including the competitive structure and the established rules (Alcaraz-Muñoz et al., 2023; Pic et al., 2020; Mallén-Lacambra et al., 2024). For example, the behaviour of boys and girls in competitive games indicates the presence of stereotypical forms of participation, whereby boys are more active, and girls are more passive (Gutierrez & García-López, 2012).

Gender differences in motor behaviours may also stem from the cognitive demands of the game (Harwell et al., 2018), as varying maturation rates of cognitive processes, such as executive functions (EF) (Laureys et al., 2021), play a crucial role in managing these demands in diverse sports contexts (Guillem, 2022; Ishihara et al., 2017). EFs encompass cognitive processes such as inhibitory control (resisting impulsive actions), working memory (mentally manipulating information), and cognitive flexibility (adapting to changing rules), which mature with age and enable goal-directed behaviour (Diamond, 2013). The cognitive demands inherent in motor activities underscore the role of EF in shaping participation patterns, as they affect the quantity and intricacy of mental processes that students must utilise during their participation in the activity (Pesce et al., 2018) and include aspects such as decision-making, strategy formulation, and real-time problem-solving (Kolovelonis & Goudas, 2023), prerequisites for success in cooperation-opposition games (Diamond, 2013; Rodrigues et al., 2022).

In this regard, pedagogical models such as TGfU have been developed to explicitly emphasize the cognitive engagement of students through the modification of game structures (Guijarro et al., 2022). TGfU prioritizes tactical decision-making and the understanding of game concepts over mere technical skill execution (Bunker & Thorpe, 1982). Foundational work by Bunker and Thorpe demonstrated that adapting rules and scenarios in games like "Capture the Flag" can scaffold cognitive development by requiring players to analyse dynamic game states, generate tactical options, and execute context-appropriate responses. This approach not only enriches the learning experience but also has the potential to mitigate traditional participation disparities by fostering inclusive, cognitively demanding environments that engage all students regardless of gender.

While sociocultural factors contribute to observed gender disparities in motor games (Cowley et al., 2021; Ribeiro et al., 2024), emerging evidence suggests that differences in EF development may also play a critical role. EF maturation is modulated by age and biological growth, with boys demonstrating broad improvements across EF components as biological maturity advances, whereas girls exhibit more pronounced gains primarily in inhibitory control (Laureys et al., 2021). These developmental trajectories imply that cognitive demands in dynamic games, such as real-time problem-solving and adaptive strategizing (Kolovelonis & Goudas, 2023), may disproportionately challenge participants at varying stages of EF maturation, potentially amplifying gender-based differences in motor behaviours (Harwell et al., 2018; Guillem, 2022). However, gender differences in EF are not absolute; within-gender variability often surpasses between-gender differences (Grissom & Reyes, 2019). Subtle trends, such as faster reaction times in males or enhanced working memory in females (Holfelder et al., 2020), may reflect strategic preferences rather than inherent ability gaps. For instance, task-specific strategies, influenced by neurobiological mechanisms, could lead to divergent approaches to motor challenges despite comparable EF performance (Grissom & Reyes, 2019). Thus, while EF development and biological maturation contribute to gendered participation patterns, the interplay of strategy, context, and sociocultural norms remains pivotal in shaping motor engagement.

Thus, the level of cognitive development becomes a key determinant in motor activity and sports participation, strongly influencing information processing, decision-making, and the ability to adapt to game circumstances quickly. In this context, the influence of social constraints could be reduced when cognitive demands are increased to achieve game goals, leading to a balance in gender participation (Spanou et al., 2022).

No previous research has investigated the potential impact of gender on participation in motor games with varying degrees of cognitive demand during the activity, particularly in terms of immediate behavioural responses. To address this gap, the present study employs a cross-sectional design, collecting data from all participants at a single point in time during a structured game session. This approach is well-suited for assessing the prevalence and patterns of specific behaviours as they occur in real-time, rather than evaluating changes or learning outcomes over an extended period (Kesmodel, 2018), and is aligned with studies examining acute cognitive effects (Kolovelonis & Goudas, 2023). Accordingly, the primary aim of this study is to determine gender-associated differences in immediate participation behaviours during a motor game under two different cognitive demand conditions. Furthermore, we examine whether age moderates these immediate behavioural patterns, given that the maturation of EF and game participation may vary according to developmental stage (Stuhr et al., 2020).

Building on prior research, we formulated four key hypotheses to examine how cognitive demands, gender, and age interact in motor game participation. First, consistent with Gutierrez and García-López's (2012) findings on stereotypical behaviours in competitive games, we expected boys to adopt more offensive roles than girls in the traditional game. Second, drawing from Kolovelonis & Goudas (2023) and Pesce et al. (2018), we hypothesized that a cognitively enriched game version would reduce gender disparities in participation by engaging EFs-cognitive processes less susceptible to gender bias (Harwell et al., 2018). Third, based on Stuhr et al.'s (2020) work on EF maturation, we predicted that older participants would adapt more effectively to the cognitively enriched game's cognitive demands due to their advanced EF development (Pesce et al., 2018). Finally, aligning with Lauer et al.'s (2019) observations of widening gender gaps during adolescence, we anticipated that gender differences would be most pronounced in the adolescent group, reflecting the interplay between social expectations and developmental stages. By focusing on in-the-moment responses, our research questions and hypotheses are fully

aligned with the cross-sectional methodology, allowing us to explore how gender and age relate to participation at the time of the activity without inferring causality or long-term learning effects.

Method

An observational methodology was employed, characterised by a nomothetic, punctual, and multidimensional design (Anguera et al., 2018). This approach aligns with the methodological framework utilized by Pic et al. (2020) in their analysis of participation differences through a specific punctual intervention.

Participants

The study included 123 students (M = 15.23; SD = 4.750) from different schools: 35 sixth-grade students, 50 first-year secondary education students, and 38 students from a Primary Education Teaching Degree program (see Table 1). The consent was obtained from the educational institution and parents to collect data, including curricular documents and video recordings of the students. Ethical approval was also granted by an International Ethics Committee (IRB 00003099).

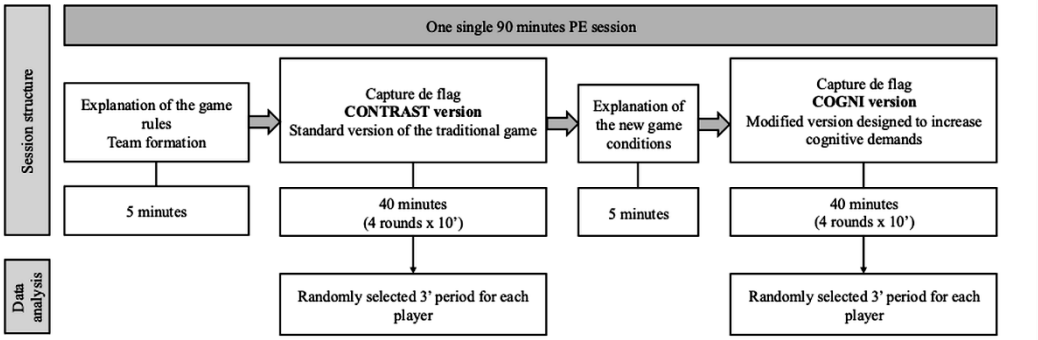
Table 1. Demographic information for the total sample, the children group, the adolescents group and the youth group

Demographics	Total sample	Children group	Adolescents group	Young adults
N	123	35	50	38
Age (year) – Mean (SD)	15.23 (4.750)	11.09 (.284)	12.82 (.388)	22.13 (.660)
Gender				
Boys	59 (48%)	20 (57.1%)	24 (48%)	15 (39.5%)
Girls	64 (52%)	15 (42.9%)	26 (52%)	23 (60.5%)

Intervention

Participants engaged in a single 90-minute session: 5-minute explanation of the game rules and team formation, 40 minutes for CONTRAST (4 rounds × 10 minutes), 5-minute debrief and explanation of the new game conditions and 40 minutes for COGNI (4 rounds × 10 minutes) (see Figure 1). Each group of students participated in the same traditional game, "Capture the Flag" (Garcia et al., 2018), classified as a cooperation-opposition game, under two conditions: the standard version of the game (CONTRAST) and a modified version designed to increase the cognitive demands (COGNI). Four rounds of each game version were played, each lasting 10 minutes. All students participated continuously throughout the entire intervention, as teams were formed to include the whole class; therefore, the playing time was identical for every participant.

Figure 1. Intervention timeline for CONTRAST and COGNI conditions.



Cooperation-opposition games inherently require tactical decision-making and adaptability, aligning with TGfU models that prioritize cognitive engagement (Steger et al., 2025). Capture the Flag, a tactical invasion game, demands spatial awareness, rapid problem-solving, and teamwork, making it ideal for studying cognitive load (Garcia et al., 2018). Furthermore, Capture the Flag, as a traditional and game-based activity, has notable pedagogical implications in PE. It supports the development of physical fitness, fundamental movement skills, tactical understanding and positive psychological outcomes, making it a valuable tool for holistic student development (Yan et al., 2023; Miller et al., 2015).

The students were part of conventional class groups and were assigned to teams by their Physical Education teachers based on two criteria: (1) each team had to include both boys and girls, and (2) the teams had comparable skill levels. The PE specialist conducted the class at each educational center and took place in the schools' sports facilities during regular PE hours.

We designed the game structure to promote optimal development and ensure player success while minimizing technical and regulatory demands. The objective was to capture the opponent's flags with the following secondary rules: (1) the playing field is divided into two halves, each with its base containing five team flags; (2) players can only intercept opponents when they are in the opposing field by tapping them on the back; (3) intercepted players become “prisoners” and must go to the “prison” on the side of the opposing field, waiting for a teammate to save them by tapping their hand; and (4) players who manage to cross the opposing field and reach the rival base (where they cannot be intercepted) can steal a flag and try to return to their field without being intercepted, to place the rival flag in their base.

In the modified version of the game (COGNI), the teacher added one of the following conditions, which were randomly updated at 30-second intervals throughout the game: (1) blue: prisons disappear; (2) green: flags cannot be captured, but opponents can be intercepted anywhere on the field; (3) white: the previous condition disappears; and (4) any other colour: acts as a distractor. In accordance with the alterations to the established game regulations, as determined by the colour indicated by the instructor, students are required to interpret the events unfolding at each moment of the game and select the most appropriate behaviour to achieve their objectives in response to the novel situation generated by the rule change. Consequently, they are not confined to associating a specific colour with a predetermined behaviour; rather, the introduction of a new rule requires them to analyse and interpret the unfolding events in real time.

Changing the game conditions, objectives, and rules during play, as well as adding distractors, are factors that increase cognitive challenge during practice (Kolovelonis & Goudas, 2023; Tomporowski et al., 2015; Pesce et al., 2016; Guillem et al., 2022), and these factors allow differentiation between the traditional version (CONTRAST) and the version with higher cognitive demands (COGNI). Specifically, the PA content with cognitive enrichment (COGNI) comprised games and game alterations designed to promote motor and cognitive development jointly, in conjunction with the extant literature on the subject (Biino et al., 2021; Pesce et al., 2021). Dynamic rule changes in COGNI mirror TGfU principles, where variability and unpredictability enhance cognitive and tactical development (Steger et al., 2025). These alterations were based on principles of variability of practice in motor skill learning, contextual interference (i.e. the interference that is experienced when performing shifts across multiple skills, or variations of a skill), mental control (stopping, updating, switching) and discovery (of motor solutions in open-ended tasks) that are suggested to promote the joint development of EF and fundamental motor skills, described in detail by Tomporowski et al. (2015).

Instrument and procedures

We explored gender-based intergroup and intragroup differences in game participation by analysing student interactions and roles using an observational method. Each player was observed for a randomly selected three-minute period from the full game recording for both game versions (CONTRAST and COGNI). A physical education teacher, acting as an external observer and unaffiliated with the educational institutions, conducted the observations. The observational register was adapted from that used by Pic et al. (2020) (see Table 2) but was modified to align with the specific characteristics of the game “Capture the Flag”. The original roles defined in the instrument were maintained, but sometimes, we added connotations to align with the new context. To illustrate, the role “Catch an opponent” was adapted to “Catch an opponent without flag (DC),” introducing a new role, “Catch an opponent with flag (DCF)”, to distinguish between the two roles, which are pertinent and specific to the dynamics of this

game. We used two video cameras (Diyeeni, 3,2 mm, 1080p) to ensure greater accuracy in assessing the players' actions and providing a second viewing angle in the event of uncertainty during observation.

Table 2. Behaviour Recording System During the Two Versions of the Game

Roles		Description
Offensive	OG	Gets the flag
	OD	Dodges an opponent
	RA	Runs away from an opponent
	OR	Helps a fellow escape
	NR	Does not recognize being caught
	OB	Back to defensive camp
	OBF	Back to defensive camp with a flag
	OC	Is caught by a defender
	DO	Goes to offensive camp
Defensive	DC	Catches an opponent without flag
	DCF	Catches an opponent with flag
	CO	Chases an opponent
	DP	Defends a prisoner

Prior to data collection, the observer underwent rigorous training to ensure consistency in role identification and coding. This training included: (1) a detailed review of the adapted observational register (Pic et al., 2020), (2) practice coding sessions using pilot video recordings, and (3) iterative feedback discussions to resolve ambiguities in role classification (e.g., distinguishing "DC" vs. "DCF"). Observations were repeated twice per condition to ensure reliability. Interobserver and intraobserver reliability and validity tests were conducted using the Kappa coefficient. The values obtained were $\alpha = .723$ and $\alpha = .885$, respectively, indicating a high correlation between the measurements provided by two observers (interobserver) and at two different times (intraobserver).

Data analysis

We assessed the data's normality and homogeneity of variance using the Kolmogorov-Smirnov and Levene tests, respectively. We employed non-parametric tests in cases where assumption criteria were not met. To identify significant associations between gender and observed behaviours in the games conditions, we conducted the Chi-square test. Furthermore, the principal descriptive indices were calculated, incorporating frequency measures, central tendency (mean), and dispersion (standard deviation and variance). All statistical analyses were performed using SPSS 27.0, with statistical significance set at $p< 0.05$ for all comparisons.

Results

The results demonstrated gender differences in the frequency of defensive and offensive roles during the traditional game version (CONTRAST), with higher male participation in most offensive roles (see Table 3). Consequently, the male gender exhibits a twofold increase in the frequency of adopting specific roles during the game compared to the female gender, as demonstrated by roles such as OD_OF and RA_OF. In contrast to the findings observed in the traditional game, the results of the cognitively enriched game (COGNI) yielded different outcomes. Table 3 illustrates greater equality in the frequency of behaviours according to gender in the COGNI condition. While the female gender still exhibits a higher level of participation in defensive roles in the COGNI version, the levels of participation between genders are slightly more balanced than in the CONTRAST version. Consequently, the pronounced differences in roles such as OD_OF are diminished when participants engage in the cognitively enriched version.

Table 3. Frequency of Roles Adopted by Players During the Two Versions of the Game by Gender

Roles	Traditional game (CONTRAST)						Cognitively enriched game (COGNI)					
	Females			Males			Females			Males		
	f	%	M	f	%	M	f	%	M	f	%	M
OG_OF	56	38	1	92	62	1.56	70	41	1.25	99	59	1.68
OD_OF	21	21	0.38	80	79	1.36	39	33	0.70	79	67	1.34
RA_OF	61	26	1.09	172	74	2.92	81	36	1.45	143	64	2.42
OR_OF	41	59	0.73	29	41	0.49	20	53	0.36	18	47	0.31

NR_OF	6	46	0.11	7	54	0.12	7	26	0.13	20	74	0.34
OB_OF	51	40	0.91	77	60	1.31	45	41	0.80	66	59	1.12
OBF_OF	27	36	0.48	48	64	0.81	35	40	0.63	53	60	0.90
OC_OF	52	39	0.93	83	61	1.41	71	45	1.27	88	55	1.49
DO_OF	103	36	1.84	182	64	3.08	110	41	1.96	159	59	2.69
DC_DEF	52	46	0.93	62	54	1.05	102	52	1.82	94	48	1.59
DCF_DEF	23	64	0.41	13	36	0.22	17	61	0.30	11	39	0.19
CO_DEF	230	57	4.11	176	43	2.98	218	59	3.89	151	41	2.56
DP_DEF	11	46	0.20	13	54	0.22	17	59	0.30	12	41	0.20

According to the levels of participation by gender discussed in Table 3, our results indicate a persistent pattern of greater male participation in offensive roles, regardless of age or game version. In contrast, females tend to play defensive roles more frequently (see table 4).

Table 4. Frequency of roles adopted by players during the two versions of the game by gender and age

Roles	Children												Pre-adolescents												Young adults											
	Traditional game						Cognitively enriched game						Traditional game						Cognitively enriched game						Traditional game						Cognitively enriched game					
	Females			Males			Females			Males			Females			Males			Females			Males			Females			Males			Females			Males		
	f	%	M	f	%	M	f	%	M	f	%	M	f	%	M	f	%	M	f	%	M	f	%	M	f	%	M	f	%	M	f	%	M	f	%	M
OG_OF	11	24	0.7	34	76	1.7	13	30	0.9	31	70	1.6	33	43	1.3	43	57	1.8	31	46	1.2	37	54	1.5	12	44	0.5	15	56	1	26	46	1.1	31	54	2.1
OD_OF	4	10	0.3	35	90	1.8	3	11	0.2	25	89	1.3	3	11	0.1	25	89	1	9	28	0.3	23	72	1	14	41	0.6	20	59	1.3	27	47	1.2	31	53	2.1
RA_OF	12	13	0.8	82	87	4.1	18	23	1.2	62	78	3.1	35	33	1.3	72	67	3	39	42	1.5	54	58	2.3	14	44	0.6	18	56	1.2	24	47	1	27	53	1.8
OR_OF	6	60	0.4	4	40	0.2	2	25	0.1	6	75	0.3	22	59	0.8	15	41	0.6	13	72	0.5	5	28	0.2	13	57	0.6	10	43	0.7	5	42	0.2	7	58	0.5
NR_OF	3	100	0.2	0	0	0	0	0	0	8	100	0.4	3	33	0.1	6	67	0.3	0	0	0	6	100	0.3	0	0	0	1	100	0.1	7	54	0.3	6	46	0.4
OB_OF	13	28	0.9	34	72	1.7	4	12	0.3	29	88	1.5	30	52	1.2	28	48	1.2	27	52	1	25	48	1	8	35	0.4	15	65	1	14	54	0.6	12	46	0.8
OBF_OF	1	6	0.1	15	94	0.8	5	28	0.3	13	72	0.7	17	43	0.7	23	58	1	16	42	0.6	22	58	0.9	9	47	0.4	10	53	0.7	14	44	0.6	18	56	1.2
OC_OF	10	31	0.7	22	69	1.1	15	36	1	27	64	1.4	32	42	1.2	45	58	1.9	23	43	0.9	30	57	1.3	10	38	0.4	16	62	1.1	33	52	1.4	31	48	2.1
DO_OF	27	23	1.8	88	77	4.4	29	31	1.9	66	69	3.3	56	46	2.2	65	54	2.7	47	47	1.8	54	53	2.3	20	41	0.9	29	59	1.2	34	47	1.5	39	53	2.6
DC_DEF	15	41	1	22	59	1.1	27	54	1.8	23	46	1.2	24	48	0.9	26	52	1.1	28	47	1.1	31	53	1.3	13	48	0.6	14	52	1	47	54	2	40	46	2.7
DCF_DEF	3	75	0.2	1	25	0.1	3	75	0.2	1	25	0.1	15	58	0.6	11	42	0.5	6	43	0.2	8	57	0.3	5	83	0.2	1	17	0.1	8	80	0.4	2	20	0.1
CO_DEF	82	53	5.5	73	47	3.7	71	55	4.7	58	45	2.9	97	58	3.7	69	42	2.9	74	52	2.8	67	48	2.8	51	60	2.2	34	40	2.3	73	74	3.2	26	26	1.7
DP_DEF	0	0	0	2	100	0.1	2	100	0.1	0	0	0	5	50	0.2	5	50	0.2	1	50	0	1	50	0	6	50	0.3	6	50	0.4	14	56	0.6	11	44	0.7

In the context of the children's group, males predominate in adopting offensive roles, as evidenced by high percentages in OG (+52%), OD (+80%), RA (+74%), OBF (+88%) and DO (+54%) during the traditional game. Conversely, female participants were observed to assume a greater proportion of defensive roles, such as DCF (+50%), although they also demonstrated superior performance compared to the male participants in the NR role (+100%). However, in the COGNI version, the levels of male participation in some offensive roles exhibit a slight decline, such as in RA (+55%) and OBF (+44%).

We observe a more balanced distribution of offensive roles in pre-adolescents during the traditional game. Female participation slightly exceeds male participation in the roles of OR (+18%) and OB (+4%), while males maintain higher participation in other roles, particularly in OD (+78%) and RA (+34%). In the cognitively enriched game, pre-adolescent females show a notable increase in offensive role participation, leading to a slight balance compared to the traditional version. As seen in the children's group, females take on a leading role in defensive positions during the traditional version, such as DCF (+16%) and CO (+16%), although these differences are not evident in the COGNI version.

In young adults, gender differences are more pronounced in specific roles. In the traditional game version, males predominated in all offensive roles except OR, where participation is balanced. Conversely, a greater proportion of females than males are in the defensive roles of DCF (+66%) and CO (+20%). In the cognitively enriched version, the differences in participation are balanced for the offensive roles, while the defensive roles remain in favour of the female gender.

Significant associations were explored according to age group. We observed significant associations in favour of the male gender in the traditional version of the game for the offensive roles OD, RA, and OBF in the children's group. However, these associations were only maintained for the role OD in the pre-adolescent group. In contrast, new significant associations emerge for the roles OG, OB, OBF, OC and DO, which are also offensive for the male gender in the young adults group. The offensive role NR was found to be significantly associated with the female gender in the younger age group, without significant associations in the other age groups. Conversely, we identified a significant association in females for the defensive role DCF in the pre-adolescent age group. The results of the chi-square test are presented in Table 5.

Table 5. Associations between gender and roles by age groups

Roles	Traditional game			Cognitively enriched game		
	Children	Preadolescents	Young adults	Children	Preadolescents	Young adults
OG_OF	$\chi^2(1, 4) = 7.277$; $p = .122$	$\chi^2(1, 5) = 6.397$; $p = .269$	$\chi^2(1, 2) = 12.756$; $p = .002$*	$\chi^2(1, 4) = 5.328$; $p = .255$	$\chi^2(1, 5) = 4.398$; $p = .494$	$\chi^2(1, 6) = 7.948$; $p = .242$
OD_OF	$\chi^2(1, 5) = 12.248$; $p = .032$*	$\chi^2(1, 4) = 11.538$; $p = .021$*	$\chi^2(1, 5) = 6.913$; $p = .227$	$\chi^2(1, 5) = 7.827$; $p = .166$	$\chi^2(1, 4) = 8.404$; $p = .078$	$\chi^2(1, 6) = 6.892$; $p = .331$
RA_OF	$\chi^2(1, 9) = 17.070$; $p = .048$*	$\chi^2(1, 7) = 11.274$; $p = .127$	$\chi^2(1, 3) = 3.861$; $p = .277$	$\chi^2(1, 6) = 8.186$; $p = .225$	$\chi^2(1, 7) = 5.325$; $p = .620$	$\chi^2(1, 6) = 5.196$; $p = .519$
OR_OF	$\chi^2(1, 2) = 1.556$; $p = .435$	$\chi^2(1, 3) = 2.173$; $p = .346$	$\chi^2(1, 3) = 2.191$; $p = .534$	$\chi^2(1, 3) = 2.197$; $p = .532$	$\chi^2(1, 3) = 4.065$; $p = .255$	$\chi^2(1, 3) = 3.818$; $p = .282$
NR_OF	$\chi^2(1, 1) = 4.375$; $p = .036$*	$\chi^2(1, 1) = 4.250$; $p = .216$	$\chi^2(1, 1) = 1.575$; $p = .210$	$\chi^2(1, 2) = 4.375$; $p = .112$	$\chi^2(1, 2) = 4.710$; $p = .095$	$\chi^2(1, 3) = 2.199$; $p = .532$
OB_OF	$\chi^2(1, 5) = 4.326$; $p = .503$	$\chi^2(1, 4) = .969$; $p = .914$	$\chi^2(1, 2) = 7.152$; $p = .028$*	$\chi^2(1, 4) = 4.988$; $p = .289$	$\chi^2(1, 5) = 4.300$; $p = .507$	$\chi^2(1, 3) = .368$; $p = .947$
OBF_OF	$\chi^2(1, 3) = 8.100$; $p = .044$*	$\chi^2(1, 4) = 2.135$; $p = .711$	$\chi^2(1, 3) = 9.870$; $p = .020$*	$\chi^2(1, 3) = 2.660$; $p = .447$	$\chi^2(1, 4) = 3.588$; $p = .465$	$\chi^2(1, 4) = 3.307$; $p = .508$
OC_OF	$\chi^2(1, 4) = 6.934$; $p = .139$	$\chi^2(1, 5) = 3.473$; $p = .627$	$\chi^2(1, 3) = 8.283$; $p = .041$*	$\chi^2(1, 4) = 2.752$; $p = .600$	$\chi^2(1, 4) = 3.069$; $p = .614$	$\chi^2(1, 6) = 4.024$; $p = .673$
DO_OF	$\chi^2(1, 9) = 13.514$; $p = .141$	$\chi^2(1, 7) = 7.622$; $p = .108$	$\chi^2(1, 5) = 9.028$; $p = .026$*	$\chi^2(1, 7) = 5.756$; $p = .569$	$\chi^2(1, 6) = 4.394$; $p = .624$	$\chi^2(1, 5) = 10.420$; $p = .064$
DC_DEF	$\chi^2(1, 5) = 3.327$; $p = .650$	$\chi^2(1, 4) = 1.958$; $p = .743$	$\chi^2(1, 3) = 2.946$; $p = .400$	$\chi^2(1, 6) = 5.600$; $p = .469$	$\chi^2(1, 6) = 7.712$; $p = .260$	$\chi^2(1, 7) = 7.722$; $p = .358$
DCF_DEF	$\chi^2(1, 1) = 1.905$; $p = .167$	$\chi^2(1, 4) = 1.851$; $p = .033$*	$\chi^2(1, 2) = 1.123$; $p = .570$	$\chi^2(1, 1) = 1.905$; $p = .167$	$\chi^2(1, 3) = 4.203$; $p = .240$	$\chi^2(1, 2) = 1.586$; $p = .452$
CO_DEF	$\chi^2(1, 11) = 11.249$; $p = .423$	$\chi^2(1, 9) = 14.054$; $p = .120$	$\chi^2(1, 8) = 5.085$; $p = .748$	$\chi^2(1, 9) = 11.521$; $p = .242$	$\chi^2(1, 8) = 9.070$; $p = .336$	$\chi^2(1, 7) = 8.781$; $p = .269$
DP_DEF	$\chi^2(1, 1) = 1.591$; $p = .207$	$\chi^2(1, 3) = 4.950$; $p = .175$	$\chi^2(1, 2) = .629$; $p = .730$	$\chi^2(1, 1) = 2.828$; $p = .093$	$\chi^2(1, 1) = 2.747$; $p = .954$	$\chi^2(1, 3) = .306$; $p = .959$

*$p < .05$

Discussion

The main findings indicate gender differences in role participation during the CONTRAST condition, with males predominantly adopting offensive roles. In contrast, the COGNI condition showed more balanced gender participation across roles, suggesting that increasing cognitive demands in physical activities can reduce gender disparities. Additionally, age moderated the influence of cognitive demands on role adoption, aligning with the maturation of EF.

First, as hypothesized (H1), in the traditional condition of the game, males were more likely to assume offensive roles, such as dodging an opponent and returning to defensive camp with a flag, whereas females were more frequently engaged in defensive roles, particularly in catching the opponents with a flag. Furthermore, significant associations were identified between specific offensive roles and the male gender and between certain defensive roles and the female gender across all age groups. However, the oldest age group exhibited the most significant gender-related differences in participation in the CONTRAST version. These findings are consistent with previous research indicating that males typically engage more in physically assertive and competitive behaviours, while females often take on supportive and defensive roles in mixed-gender physical activities (Gutierrez & García-López, 2012), confirming the stereotypical forms of participation in PE noted by other authors (Muñoz-Arroyave et al., 2021; Pic

et al., 2020; Alcaraz-Muñoz et al., 2023; Arenas et al., 2025). This aligns with sociocultural theories positing that team sports often reinforce masculine norms of assertiveness, leading girls to internalize defensive or supportive roles (Metcalfe, 2018; Moreno-Vitoria et al., 2024).

Furthermore, the levels of participation, in terms of the frequency of roles assumed during gameplay, were higher among males. This finding aligns with the existing literature, which asserts that boys are more active and exhibit higher levels of physical activity during sports games compared to girls (Ferry & Lund, 2018; Deng, 2023; Arenas et al., 2025) while also demonstrating greater motivation during practice (Muñoz-Arroyave et al., 2021; Cowley et al., 2021). This phenomenon, coupled with the observed tendency among girls towards a more reflective player-spectator behaviour (Pic et al., 2020), may explain the greater role adoption by males in the traditional version of the game. However, this study does not align with the findings of Delextrat et al. (2020) in their investigation of participation in traditional games in primary education, which found no significant associations between gender and physical activity levels during PE sessions.

The introduction of cognitive challenges in the COGNI condition resulted in a more equitable distribution of roles between genders, both in terms of active participation as measured by the frequency of roles adopted and in the variety of offensive and defensive roles assumed by participants, confirming H2. This result was evidenced by the absence of significant associations identified concerning the various roles and age groups in the cognitively enhanced version of the game. This shift suggests that an increase in cognitive demands in PE can serve to mitigate the traditional adoption of gender roles and supports our hypothesis that heightened cognitive demands—such as real-time problem-solving and dynamic rule interpretation—engage EFs, which are less gender-biased (Harwell et al., 2018). This finding aligns with the assertions of Pic et al. (2020), who have proposed that modifications to the characteristics of motor games can result in alterations to gender-based participation, and by Harwell et al. (2018), who have indicated that one potential factor that may contribute to the observed gender differences in motor behaviour is the cognitive demand of the game. By shifting focus from physical dominance to tactical decision-making, COGNI aligns with the TGfU model, which prioritizes cognitive engagement over technical execution (Guijarro et al., 2022). This framework suggests that modifying game structures to emphasize strategy can democratize participation, as seen in the diminished gender gaps in COGNI. Future research should explore the mechanisms behind this change, potentially examining how cognitive tasks influence social dynamics and individual decision-making during physical activities.

Age moderated the impact of the COGNI condition on role adoption, with older students showing a greater ability to adapt to the increased cognitive demands (H3). This finding aligns with the theory that EF, which include cognitive flexibility, inhibitory control, and working memory, mature with age (Pesce et al., 2018). As these functions develop, older students are better equipped to handle complex, changing rules and distractions within the game (Guillem, 2022). This developmental trend also interacted with gender, as the more balanced participation observed in the COGNI condition was more pronounced among older students. This relationship underscores the importance of considering developmental stages when designing cognitive challenges in educational settings (Kolovelonis & Goudas, 2023). Interestingly, while adolescents exhibited the largest gender disparities in CONTRAST, young adults showed the most pronounced balancing effect in COGNI. This nuanced interaction suggests that EF maturation and social factors (e.g., evolving gender norms in adulthood) jointly shape participation patterns.

Contrary to H4, gender differences were most pronounced in young adults during CONTRAST rather than adolescents. This divergence from Lauer et al.'s (2019) findings may reflect cohort-specific social dynamics. For instance, adolescents in our sample might have experienced stronger peer pressure to conform to gender roles, whereas young adults' greater cognitive maturity allowed them to override stereotypes in COGNI. This highlights the interplay between developmental stage and sociocultural context, underscoring the need for age-tailored interventions.

Pedagogical implications

The findings have significant social implications, suggesting that modifying PE activities to include cognitive challenges can promote gender equity in participation. The efficacy of the COGNI version in reducing gender disparities supports TGfU's emphasis on tactical complexity as a tool for inclusivity. By designing activities that require EF engagement (e.g., rapid decision-making, strategy shifts), educators

can create environments where success depends less on physical prowess and more on cognitive adaptability—a domain with smaller gender gaps (Grissom & Reyes, 2019). This approach also aligns with principles of cognitive enrichment, where variability in practice enhances both motor and EF development (Tomporowski et al., 2015). This approach could help break down traditional gender roles and encourage more balanced involvement in various physical activities.

From a pedagogical perspective, these results reinforce the value of game-based instructional models, such as TGfU, which prioritize student-centred learning and tactical problem-solving over rote technical drills (Steger et al., 2025). By embedding cognitive demands within game structures, teachers can foster equal opportunities for participation and skill development, regardless of gender. This is particularly relevant in coeducational settings, where traditional approaches often inadvertently reinforce gender stereotypes and participation imbalances. The use of modified games that emphasize strategy, cooperation, and reflection not only democratizes access but also cultivates a classroom climate where all students feel empowered to contribute and lead (Guijarro et al., 2022).

Furthermore, the integration of cognitive challenges into PE curricula has broader didactic benefits. It encourages the development of transferable skills such as critical thinking, adaptability, and collaborative problem-solving, which are essential for lifelong learning and success beyond the gymnasium (Kolovelonis & Goudas, 2023; Diamond, 2013). Research on game-based and tactical models has shown that such approaches can enhance student motivation, enjoyment, and engagement (Guijarro et al., 2022)—factors that are particularly important for sustaining girls' participation in physical activity (Alcaraz-Muñoz et al., 2023). By shifting the focus from physical dominance to cognitive engagement, educators can help dismantle traditional gender roles and foster a more inclusive, supportive environment for all learners.

Finally, these findings underscore the importance of ongoing professional development for PE teachers in the areas of gender-responsive pedagogy and cognitive-tactical curriculum design. Equipping teachers with the theoretical understanding and practical tools to implement cognitively enriched, inclusive games is essential for translating research insights into meaningful classroom change. As the literature highlights, small-scale curricular adaptations and reflective teaching practices can collectively drive significant progress toward gender equity in PE (Ribeiro et al., 2024). In this way, the adoption of cognitively demanding, game-based models represents not only a pedagogical innovation but also a concrete step toward social justice and holistic student development.

Further research is needed to investigate the long-term benefits of such interventions, particularly their impact on students' overall development, social dynamics, adherence and academic performance. It is also necessary to explore the effects of other variables, such as emotions and motivation, on student participation, which could help explain the gender differences. Furthermore, incorporating qualitative instruments into this observational design – such as integrating the perceptions of participants or even teachers – could provide deeper insights and enrich the understanding of these dynamics.

Limitations

In interpreting these findings, several limitations must be acknowledged. First, gender differences in participation for non-binary students were not explored. We did not include non-binary students because no students identified as belonging to it. As a result, no representative data could be obtained from this population, limiting the findings' generalisability to non-binary genders. Addressing these aspects will enable teachers and coaches to better design PE programs that support cognitive and social development, contributing to more holistic educational experiences for students.

Second, all participants experienced both conditions of the game. Although this within-subject design ensured comparability and reduced intergroup variability, it also raises the possibility of practice or order effects. Participants may have adapted their strategies or gained confidence over successive rounds, which could partly explain the more balanced participation in the COGNI condition. The absence of a separate control group limits the ability to fully rule out these alternative explanations. Nonetheless, the crossover design was chosen to maximize ecological validity in a school setting and to allow each student to experience both game formats within the same curricular context. Future research could address this limitation by including a parallel control group that only experiences one version of the game, or by counterbalancing the order of exposure to minimize learning effects. Moreover, while this design

captures immediate behaviours, longitudinal studies are needed to evaluate the long-term effects of cognitive enrichment.

Conclusions

The present study confirms previous research, showing that males typically engage in more physically assertive and competitive behaviours in traditional games, while females adopt supportive and defensive roles. Furthermore, males demonstrated higher overall participation levels, reflecting greater physical activity and motivation during gameplay than females. Conversely, the COGNI condition, characterised by higher cognitive demands, resulted in a more equitable distribution of roles between genders. This shift in gender-based role adoption underscores the potential of cognitive challenges to mitigate traditional gender roles in PE. Therefore, the main conclusion is that cognitively enriched games enhance cognitive engagement and foster more inclusive environments, suggesting that including cognitive challenges during PE classes can effectively reduce gender disparities. Thus, the findings hold significant promise for reimagining PE curricula to foster inclusivity and cognitive development.

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