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Intra-pair comparison among twins, physical self-esteem, and motivation for exercise and physical education in adolescence: a cross-sectional study

Ana Leonor Pereira de Oliveira [1]

[1] Master's Student at Universidade Lusófona - Centro Universitário de Lisboa , Portugal analeonor2004oliveira@gmail.com

ABSTRACT

This study analyzed the relationship between intra-pair comparison between twins in the physical domain, physical self-esteem, and motivation to exercise, physical activity in general, and participation in physical education (PE) classes, also testing the mediating role of physical self-esteem and intra-pair differences between the twin perceived as "more athletic" and "less athletic." A cross-sectional observational study was conducted with 40 adolescent twins (20 pairs), aged 12 to 18 years, who responded to self-report measures of unfavorable comparison, physical self-esteem, and motivational regulation (autonomous motivation, controlled motivation, and amotivation) in the contexts of exercise and PE. Analyses included Spearman correlations, linear regression controlling for age and gender, mediation testing, and intra-pair comparisons.

The results indicated that unfavorable comparison was strongly associated with lower physical self-esteem ($\rho = -0.792$) and maintained a substantial predictive contribution after controlling for age and gender ($b = -0.495$; $R^2 = 0.690$). At the motivational level, unfavorable comparison was associated with lower autonomous motivation for exercise ($\rho = -0.631$) and PE ($\rho = -0.398$), as well as higher amotivation for exercise ($\rho = 0.438$). The indirect effect via physical self-esteem was not supported, suggesting that the influence of comparison may occur through more proximal and situational pathways. In the intra-pair analysis (15 pairs with clear differentiation), the "more athletic" twin showed higher physical self-esteem and higher levels of autonomous motivation for exercise and PE, greater participation in PE, and lower amotivation for exercise (high effects). Despite psychometric limitations in specific subscales, the central pattern was consistent.

It is concluded that unfavorable comparison between twins is a relevant psychological marker, associated with lower physical self-esteem and less self-determined motivational profiles, with implications for pedagogical practices in PE aimed at reducing normative comparisons and promoting success criteria focused on individual progress.

Key Words*:* twins; social comparison; physical self-esteem; motivation; exercise; Physical Education.

Corresponding Author:

(Ana Leonor Oliveira)

- Master's Student at Universidade Lusófona - Centro Universitário de Lisboa , Portugal
- Email: analeonor2004oliveira@gmail.com

1. INTRODUCTION:

Regular participation in physical activity and physical education (PE) classes is recognized as a key factor in the physical, psychological, and social health of children and

adolescents. International guidelines consistently recommend at least 60 minutes of moderate to vigorous physical activity per day for young people aged 5 to 17 (Bull et al., 2020; World Health Organization, 2024). However, global data show that about 81% of adolescents do not meet these recommendations, with particularly worrying figures for girls (Guthold et al., 2020; World Health Organization, 2019). This lack of physical activity jeopardizes the current and future health of young people and reinforces the importance of school PE and motivational factors that promote physical activity inside and outside of school.

The literature has consistently shown that physical activity is positively associated with physical self-concept and physical self-esteem in children and adolescents, which are important constructs for overall well-being and adherence to exercise (Fox & Corbin, 1989; Babic et al., 2014; Scarpa, 2011). Meta-analysis studies indicate that higher levels of physical activity are related to more positive perceptions of physical competence, physical condition, and body appearance (Babic et al., 2014), while research on European adolescents reinforces the role of physical self-concept in sports participation and psychological health (Scarpa, 2011; Pérez-Mármol et al., 2021). In the Portuguese context, the adaptation of the Physical Self-Perception Profile highlighted the relevance of body self-esteem as a specific dimension of the physical self, linked to exercise and body image (Bernardo, 2003).

The way students perceive themselves physically is strongly influenced by social comparison processes. Since the formulation of Social Comparison Theory, Festinger (1954) argued that, in the absence of objective criteria, people evaluate their own abilities by comparing themselves with others (Festinger, 1954). In a school context, these comparison processes help explain phenomena such as the Big-Fish–Little-Pond Effect, in which the performance of peers can negatively influence the academic self-concept of less outstanding students, despite maintaining good objective results (Koivuhovi et al., 2020). In PE, approaches based on Self-Determination Theory show that motivational climates focused on performance, competition, and normative comparison tend to undermine self-determined motivation and engagement in class, while mastery climates, focused on personal improvement, favor participation and the intention to engage in physical activity during leisure time (Standage et al., 2003; Ntoumanis & Standage, 2009).

In the specific case of twins, the issue of comparison takes on particular significance. Studies with large samples of twins have shown that participation in exercise and attitudes toward physical activity are influenced by genetic factors, but also by shared and unshared experiences within the pair (Stubbe et al., 2006; Huppertz et al., 2013; Leskinen et al., 2015; Kujala et al., 2022). More recently, studies in school settings suggest that twins may form their self-concept based on their relationship with their twin, using internal comparisons that affect self-esteem and perceived competence (Kim et al., 2023; Segal, 2023). Despite this, little research has been done on how explicit comparisons between twins—made by themselves, their peers, or teachers—influence physical self-esteem and motivation to exercise, engage in physical activity, and participate in PE classes.

Therefore, investigating the influence of comparison between twins on physical self-esteem and motivation to exercise, engage in physical activity, and participate in physical education classes is particularly relevant for understanding subtle inequalities in these students' school experience and for guiding pedagogical practices that are more sensitive to the dynamics between twins.

- ***What are Twins?***

Twins are two individuals resulting from the same pregnancy, thus sharing the maternal womb and prenatal environment, but they may differ substantially at the genetic and phenotypic levels. The classic distinction is between monozygotic (MZ) twins, resulting from

the division of a single fertilized egg, who share virtually 100% of their genetic material, and dizygotic (DZ) twins, originating from the fertilization of two different eggs, who share on average 50% of their segregating genes, just like "non-twin" siblings (Segal, 2012; Bouchard et al., 1990).

This configuration makes twins a privileged "natural laboratory" for studying the relative role of heredity and environment in physical, psychological, and social development, since the comparison between MZ and DZ twins allows us to estimate the genetic influence on traits such as personality, physical fitness, motor skills, or attitudes toward exercise (Bouchard et al., 1990; Wilson et al., 2019).

In addition, longitudinal studies with twins show that, although there is an important genetic component, shared experiences (family, school, common sports practices) and unshared experiences (peer groups, teachers, training contexts) contribute significantly to intra-pair differences in health, academic performance, and motor behavior (Segal, 2012; Wilson et al., 2019).

- ***Comparison between twins in the physical domain***

The comparison between twins can be understood as a particular case of social comparison processes, that is, the tendency that people have to evaluate their abilities and attributes using others as a reference standard (Festinger, 1954). In the case of twins, the co-twin is a particularly salient target for comparison because they share age, family context, and often school and sports context, which makes differences—even small ones—in motor performance, physical appearance, or fitness more evident and significant. Recent literature on comparison theories (such as Dimensional Comparison Theory) emphasizes that comparisons can produce assimilation effects ("we are alike, so I must be as good as him") or contrast effects ("he is the athlete, I am the academic one"), subtly shaping self-concept in different domains (Möller & Marsh, 2013, 2024).

Studies with twins in a school context show that many form their academic and social self-concept explicitly in relation to their twin, using them as an internal "mirror" to evaluate themselves, which can affect self-esteem and sense of competence (Kim et al., 2023; Segal, 1992). Qualitative studies with teachers and families reinforce that labels such as "the athlete" and "the more fragile" or "the competitive" and "the cooperative" are often attributed to twins in contrast to each other, influencing the expectations of adults and peers and the way each sees themselves (Lindley, 2024; Segal, 1992).

Furthermore, twin studies on participation in exercise and physical activity indicate that, in addition to the strong genetic component, shared and unshared experiences within the pair—including comparisons, differential incentives, and role specialization—help explain marked differences in exercise involvement between co twins (Stubbe et al., 2006; Kujala et al., 2022). In this research, the "comparison between twins" in the physical domain can be defined as each student's perception of the frequency, direction ("upward" or "downward" comparison), and emotional impact of comparisons with their twin sibling regarding motor competence, physical fitness, and body appearance, whether these comparisons are initiated by themselves, peers, family, or teachers.

- ***Physical Self-Esteem***

Physical self-esteem is generally conceptualized as a person's overall assessment of the value and satisfaction they derive from their own body and physical abilities, functioning as an intermediate level between specific physical self-concepts (e.g., athletic competence, physical condition, strength, body appearance) and overall self-esteem (Fox & Corbin, 1989).

Hierarchical and multidimensional models of the physical self in adolescents show that specific dimensions—perceived athletic competence, physical fitness, strength, and body attractiveness—contribute to a factor of "physical self-worth," which in turn is closely related to overall self-esteem (Hagger et al., 2003, 2005). This physical self esteem integrates both aspects of competence (feeling capable in motor tasks, sports, PE activities) and aspects of appearance (feeling good about one's body, weight, shape), and is particularly sensitive in adolescence, a phase in which body image and athletic performance take on great social relevance.

Systematic reviews indicate that higher levels of physical activity and sports participation tend to be associated with more positive perceptions of physical competence, condition, and body appearance, which translates into higher self-concept and physical self-esteem in children and adolescents (Babic et al., 2014). Instruments such as the Physical Self-Perception Profile and the Physical Self-Inventory operationalize these dimensions in relatively independent subscales (competence, condition, strength, appearance, overall physical self-esteem), with good validity and reliability in adolescent populations (Fox & Corbin, 1989; Maïano et al., 2008).

In the Portuguese context, the adaptation of the Physical Self-Perception Profile showed that dimensions such as sports competence and body self-esteem are central t ing young people's physical self and are related to exercise and body image (Bernardo & Matos, 2003). Thus, in this study, "physical self-esteem" refers to the relatively stable overall assessment that students make of their physical value—that is, how satisfied they are with their bodies and physical performance—integrating perceptions of motor competence and body appearance, and functioning as an important mediator between PE experiences and psychological well-being.

- ***What is motivation***

Motivation can be understood as the psychological process that gives energy, direction, and persistence to behavior, explaining why people initiate, maintain, or abandon certain activities (Ryan & Deci, 2000a, 2000b). Within the framework of Self Determination Theory, motivation is conceptualized on a continuum ranging from amotivation (absence of intention to act), through different forms of extrinsic motivation (external, introjected, identified, and integrated regulation), to intrinsic motivation, in which the activity is performed for its inherent interest and pleasure (Deci & Ryan, 2000; Ryan & Deci, 2000b).

The quality of motivation depends on the degree to which basic psychological needs for autonomy, competence, and relatedness are satisfied in the contexts of action; environments that support autonomy, provide feedback on competence, and promote positive relationships tend to favor more self-determined forms of motivation, associated with greater involvement, persistence, and well-being (Ryan & Deci, 2000a; Deci & Ryan, 2000).

In the context of physical education, these distinctions are particularly relevant, as motivational climates that emphasize choice, personal progress, and emotional support from teachers tend to promote intrinsic motivation and self-determined regulation, while contexts focused on external rewards, punishments, or normative comparisons favor more controlled forms of motivation or even amotivation, with a negative impact on participation in physical activity (Ntoumanis & Standage, 2009; Ryan & Deci, 2017).

- ***What is physical exercise?***

Physical exercise is a specific subtype of physical activity, characterized by being planned, structured, repetitive, and oriented toward the explicit goal of improving or

maintaining one or more components of physical fitness, such as cardiorespiratory capacity, muscle strength, flexibility, or body composition (Caspersen et al., 1985).

Unlike other forms of everyday movement (e.g., unintentional walking to school, household chores, or spontaneous play), exercise involves prescribing parameters such as frequency, intensity, duration, and type of effort (e.g., three weekly sessions of moderate running for 30 minutes), often organized into programs or training plans (Caspersen et al., 1985; World Health Organization, 2020).

This definition is central to research in health and physical education, as it allows us to differentiate between "general" physical activity and physical exercise interventions as a structured strategy for promoting fitness and preventing chronic diseases, as well as to study the dose-response relationship between exercise volume and indicators of physical, psychological, and cognitive health (Caspersen et al., 1985; Corbin, 2021).

- ***What is physical activity?***

Physical activity is classically defined as any bodily movement produced by skeletal muscle contraction that results in energy expenditure above resting levels (Caspersen et al., 1985). This definition includes a wide variety of behaviors, from leisure activities (playing, practicing sports, walking, or cycling) to occupational, domestic, or active transportation tasks, which can occur at different intensities—light, moderate, or vigorous—and in multiple everyday contexts (Caspersen et al., 1985; World Health Organization, 2020).

International recommendations for children and adolescents (at least 60 minutes of moderate to vigorous physical activity per day) refer precisely to this broad concept, which is not limited to physical education classes or formal sports training, but encompasses all movement that contributes to energy expenditure and t benefits in cardiometabolic, musculoskeletal, cognitive, and emotional health (World Health Organization, 2020).

From a research perspective, the distinction between spontaneous physical activity (e.g., playing at recess) and structured physical exercise is important, but both are considered relevant contributions to the total volume of physical activity, often quantified in minutes per day or week through questionnaires, accelerometry, or other objective methods (Caspersen et al., 1985; Guthold et al., 2020).

- ***What are physical education classes?***

Physical education (PE) classes are formal teaching units, integrated into the school curriculum, which use physical activity and movement as pedagogical means to develop motor skills, knowledge, attitudes, and values related to lifelong physical activity (Corbin, 2021; Kirk, 2010).

More than just "exercise time," PE is designed as a field of study with specific educational goals: to promote physical literacy (motivation, confidence, physical competence, knowledge, and understanding to value and take responsibility for participating in physical activities throughout life), developing health-related physical fitness, fostering responsible social behaviors (cooperation, respect, fair play), and supporting students' overall well-being (Corbin, 2021; International Physical Literacy Association, 2014).

In many education systems, PE norms and standards define that a "physically literate" student should demonstrate competence in a variety of motor skills and movement patterns, apply knowledge of training and health principles, participate regularly in physical activity, adopt safe and respectful behaviors, and recognize the value of physical activity for health, enjoyment, challenge, and social interaction (Corbin, 2021; SHAPE America, 2014).

Thus, PE classes provide a privileged, and often mandatory, context for providing structured movement experiences, explicit teaching of health and exercise content, and

opportunities to motivate young people to engage in physical activity both inside and outside of school.

- ***Motivation to engage in exercise and physical activity***

Motivation to exercise and engage in physical activity is understood, in light of Self-Determination Theory (SDT), not only in terms of the "quantity" of motivation, but above all in terms of its "quality"—that is, the degree to which motives are autonomous (self-endorsed) or externally controlled (externally imposed) (Ryan & Deci, 2000, 2017). More autonomous motivations include intrinsic motivation (practicing because it is fun or challenging) and identified regulation (practicing because one recognizes the value for health, well-being, physical fitness), while controlled motivations include introjected regulation (practicing out of guilt, shame, or to feel "deserving") and external regulation (practicing due to pressure from parents, teachers, or peers). Amotivation describes the absence of intention or meaning in practice. Systematic reviews show that satisfying the basic psychological needs of autonomy, competence, and relatedness—central to SDT— favors more autonomous forms of motivation and, consequently, greater adherence to and maintenance of exercise practice (Teixeira et al., 2012).

In children and adolescents, meta-analyses indicate that higher levels of self-determined motivation (greater weight of intrinsic and identified motives) are consistently, albeit moderately, associated with higher levels of physical activity measured objectively or by self-report (Owen et al., 2014). These studies emphasize that motives centered on pleasure, perceived competence, health, and well-being are better predictors of regular exercise than motives centered solely on appearance or external pressures.

Thus, in the context of this research, “motivation to exercise and engage in physical activity” can be defined as the set of reasons, more or less autonomous, that lead students to engage in planned physical activities (exercise) and everyday movement (physical activity), including both quantitative dimensions (strength of intention, expected frequency) and qualitative dimensions (degree of self-determination), which can be modulated by comparisons with their twin in the physical domain.

- ***Motivation to Participate in Physical Education Classes***

Motivation to participate in Physical Education classes is a contextual construct that describes the student's willingness to actively engage, strive, cooperate, and persevere in the tasks proposed in PE, as well as the subjective importance they attach to the subject. Studies in PE based on SDT conceptualize this motivation, as in physical activity in general, on a continuum of regulation ranging from intrinsic and identified motivation (participating because one enjoys the class and values learning motor skills and healthy habits) to more controlled forms and amotivation (participating only to avoid problems or not seeing the point of the class) (Standage et al., 2005; Ntoumanis, 2005).

Systematic reviews show that when PE teachers create a classroom climate that supports the needs for autonomy (giving meaningful choices, explaining tasks rationally), competence (positive feedback, adjusted challenges), and relatedness (safe environment, absence of humiliation), students tend to show higher levels of self-determined motivation, greater behavioral and emotional involvement, and a greater intention to be physically active outside of school (White et al., 2021; Curran & Standage, 2017).

From this perspective, motivation to participate in PE is not reduced to mere attendance, but includes the degree to which the student participates in an engaged manner (effort, attention, persistence), experiences positive emotions (enjoyment, interest), and attributes meaning to the subject, seeing it as relevant to their health, well being, and physical

identity. Prospective research shows that students with higher levels of self-determined motivation in PE are more likely to choose optional PE subjects or maintain higher levels of physical activity in the future (Ntoumanis, 2005).

In the context of twins, it is plausible that constant comparisons with their twin in terms of performance, fitness, or appearance may affect both their perception of competence and their sense of belonging in class, influencing the quality of their motivation to participate – for example, a twin who systematically perceives themselves as "the least athletic" may become less involved, participate out of obligation, or even avoid class, while the other engages more autonomously and confidently.

- ***Physical self-esteem and motivation of twins in physical exercise, physical activity, and participation in PE classes***

Physical self-esteem and twins' motivation to engage in exercise, physical activity, and participate in PE classes can be understood as two psychological "building blocks" that mutually reinforce each other and that, in twins, are further shaped by a very specific combination of genetics, shared environment, and constant within-pair comparison.

First, physical self-esteem (or the physical self) refers to the overall way young people evaluate their worth as a "body in motion": how competent they feel in motor tasks, how fit they believe they are, and how satisfied they feel with their own physical appearance. Hierarchical models show that specific perceptions of motor competence, physical condition, and appearance feed into a more global sense of physical worth, which in turn relates to global self-esteem and physical activity behavior (Fox & Corbin, 1989; Babic et al., 2014). More recent work reinforces that physical self-concept is an important predictor of physical activity practice and persistence in children and adolescents: children with a better physical self-concept tend to be more active and to maintain that activity over time (Dreiskämper, Tietjens, & Schott, 2022; Henning, Dreiskämper, & Tietjens, 2022). In the context of twins, this means that small differences in perceived competence or appearance between the two siblings—often amplified by comparisons made by themselves, peers, or adults—can create very distinct profiles of physical self-esteem, despite sharing age, family context, and often the same opportunities for practice.

On the motivation side, Self-Determination Theory describes a continuum ranging from amotivation, through more controlled forms of extrinsic motivation (driven by external pressure or guilt), to more autonomous forms of motivation, such as intrinsic motivation and identified regulation (doing it because it makes sense and is personally valued). Systematic reviews show that more autonomous motives are consistently associated with greater engagement, persistence, and long-term adherence to exercise and physical activity (Teixeira et al., 2012). In school settings, PE studies indicate that students with higher self-determined motivation in class—i.e., those who participate because they enjoy it, feel competent, and perceive teacher support—show greater effort, engagement, enjoyment, and intention to be physically active outside of school (Standage, Duda, & Ntoumanis, 2003; Ntoumanis & Standage, 2009). Thus, when we talk about twins' "motivation" for exercise, physical activity, and PE, we are referring not only to the intensity of their intention to participate, but especially to the quality of the motives that sustain that behavior (more autonomous vs. more controlled).

The link between physical self-esteem and motivation is bidirectional: young people who perceive themselves as physically competent, fit, and possessing an acceptable body tend to show more intrinsic and autonomous motivation to be active, while regular practice and positive experiences of success, in turn, strengthen physical self-esteem (Babic et al., 2014; Dreiskämper et al., 2022; Henning et al., 2022). Longitudinal studies with children show that higher levels of physical self-concept are associated with more autonomous motivation and

more physical activity months later, suggesting a virtuous cycle between "feeling capable," "wanting to take part," and "being more active" (Henning et al., 2022). In twins, this cycle may diverge within the pair: if one twin is consistently perceived (and perceives themselves) as "the more athletic one," they may develop higher physical self-esteem and more autonomous motives to practice, while the other, feeling "less competent" by comparison, may progressively withdraw from practice or participate mainly due to external pressure (parents, teacher, PE grades).

Research with twins also shows that both exercise behavior and attitudes toward exercise have a significant genetic component, but are also strongly shaped by the environment and each individual's experiences (Stubbe et al., 2006; de Geus et al., 2014). Large-scale studies with twins and siblings indicate that an important part of individual differences in exercise participation and in beliefs about exercise benefits/barriers is heritable and, at the same time, that these attitudes robustly predict active leisure behavior (Huppertz et al., 2013).

In practical terms, this means that, between twins, there may be different predispositions to feel enjoyment, energy, or embarrassment in exercise contexts, which then interact with the school environment, the relationship with the PE teacher, and, above all, the constant comparisons within the pair and with peers. These interactions can lead to contrasting profiles: one twin with high physical self-esteem and positive attitudes toward exercise, with intrinsic motivation both for structured practice (exercise) and for spontaneous physical activity and engagement in classes; and another twin with lower physical self-esteem, more sensitive to failure experiences or negative comparison, with more controlled motives and a greater tendency to avoid situations in which the body is exposed or evaluated, such as PE classes.

In summary, physical self-esteem and twins' motivation to practice exercise, engage in physical activity, and participate in PE classes refer to how each twin evaluates their own physical worth and the reasons that lead them to be active, in a context where genetic factors, shared environment, and within-pair comparison dynamics intertwine. Twins with higher physical self-esteem tend to show more autonomous motivations, a higher likelihood of meeting physical activity recommendations, adhering to exercise programs, and engaging more positively in PE classes; conversely, unfavorable comparison patterns may reduce one twin's physical self-esteem, pushing them toward a more controlled or amotivated motivational profile, with lower participation both inside and outside school. This theoretical framework supports the importance of specifically studying how these processes manifest in twins, in order to guide pedagogical practices and physical activity promotion strategies that are more sensitive to within-pair differences.

- ***Knowledge Gap***

The main knowledge gap this study seeks to address lies in the very specific combination of three elements that, so far, have rarely been examined together: twins, comparison in the physical domain, and motivation/participation in exercise, physical activity, and Physical Education (PE) classes. There is extensive research on physical activity and physical self-esteem in children and adolescents, many studies on motivation in PE, and even some twin research in areas such as academic performance, personality, or general health. However, there are virtually no studies examining how explicit comparison between twins (by themselves, peers, family, or teachers) shapes how each twin feels about their body, their physical abilities, and their willingness to participate in physical practice contexts.

First, there is a lack of knowledge about how twins actually experience these comparisons in physical contexts. It is known that twins are often labeled in contrast ("the

sporty one," "the shy one," "the stronger one," "the thinner one"), but it is unclear how these labels and comparisons translate into differences in physical self-esteem between the two members of the pair. For instance, it is not clear whether a twin who is consistently seen as "the less athletic one" develops a more fragile physical self-esteem profile and a more negative relationship with exercise and PE classes, nor how this evolves throughout schooling. It is also necessary to understand who the main agents of comparison are (parents, siblings, peers, PE teachers) and which contexts make these comparisons most salient (classes, recess, sports training, home).

Second, there is a specific gap regarding the psychological mechanisms linking twin comparison to motivation to be physically active. The literature generally shows that physical self-concept and motivation influence each other, but it has not yet been explored whether, in twins, within-pair comparison acts as a trigger that weakens or strengthens this link. For example, it is unknown whether unfavorable comparison with the co-twin operates mainly through a drop in physical self-esteem (first I feel weak/inadequate, then I stop wanting to participate), or whether it produces direct effects on motivation (I avoid the class or exercise so as not to expose myself to judgment, even if I maintain some objective competence). It is also unclear whether this process is the same for structured exercise, more spontaneous physical activity, and participation in PE classes—three different but interconnected contexts that may be experienced differently by each twin.

Third, there is an important gap at the level of within-pair analysis. Most twin studies focus on averages from large samples to estimate genetic and environmental contributions, but they rarely explore, in depth, intra-pair differences in physical self-esteem, motivation, and participation patterns. In school contexts, this means we know almost nothing about why, within the same pair, one twin may be highly engaged and motivated in PE and exercise while the other withdraws or participates minimally, despite having the same curricular opportunities and often the same teacher and class group. Evidence is lacking to identify typical "divergence" profiles between twins (for example, an "athlete twin" and an "avoidant twin") and the pedagogical and relational conditions that fuel or attenuate these trajectories.

Finally, there is also an applied gap: there is little research-based practical guidance on how PE teachers and schools should work with twins in class, specifically regarding comparison, feedback, pairing/grouping, and assessment. It is unclear whether seemingly neutral practices (such as always placing twins together, comparing them informally, or using one as a model for the other) may have differential effects on their physical self-esteem and motivation. By systematically studying the relationship between twin comparison, physical self-esteem, and motivation for exercise, physical activity, and PE participation, this work aims to fill that void, providing an empirical basis for pedagogical decisions that are more sensitive to twins' unique dynamics and to the potential "invisible inequalities" that can develop within the pair.

- ***Objectives and Hypotheses***

Considering the literature review conducted and the identified knowledge gaps, the study seeks to answer the following research question: How does comparison between twins influence physical self-esteem and motivation to engage in exercise, physical activity, and participation in Physical Education (PE) classes among adolescent twins?

The overall aim of this study is to analyze the influence of twin-to-twin comparison on physical self-esteem and on motivation to engage in exercise, physical activity, and participation in PE classes in adolescent twins.

- **Specific objectives**

1. To characterize twin comparison in terms of frequency, direction (favorable/unfavorable comparison), and main agents (self-comparison, peers, family, teachers).
2. To describe levels of physical self-esteem and different forms of motivation (autonomous, controlled, and amotivation) for:

- exercise practice,
- physical activity in general,
- and participation in PE classes, among adolescent twins.

3. To analyze the relationship between twin comparison and each twin's physical self-esteem (within the pair).
4. To examine the relationship between twin comparison and motivation to engage in exercise, physical activity, and PE participation, distinguishing between:

- autonomous motivation (intrinsic/identified),
- controlled motivation (introjected/external),
- and amotivation.

5. To test the mediating role of physical self-esteem in the relationship between twin comparison and:

- motivation to engage in exercise,
- motivation to engage in physical activity in general,
- motivation to participate in PE classes.

6. To compare within each twin pair the twin perceived as "more athletic" and the twin perceived as "less athletic" regarding:

- physical self-esteem,
- forms of motivation for exercise, physical activity, and PE,
- and levels of participation/engagement in PE classes.

7. To explore whether the relationships between comparison, physical self-esteem, and motivation vary as a function of sex, school age/grade, or pair type (MZ/DZ, if available).

- ***Hypotheses***

Hypothesis 1 – It is expected that a higher frequency of unfavorable comparison with the co-twin (feeling "worse" in terms of body, abilities, or performance in physical activities) will be associated with lower levels of physical self-esteem. Conversely, twins who report more favorable or more balanced comparisons are expected to show higher physical self-esteem.
Hypothesis 2 – It is expected that a higher frequency of unfavorable comparison with the co-twin will be associated with:

- lower autonomous motivation (fewer intrinsic and identified reasons),
- higher controlled motivation (more reasons based on external pressure, guilt, or shame),
- higher amotivation, for:
    - engaging in exercise,
    - engaging in physical activity in general,
    - and participating in PE classes.

More favorable comparisons, or comparisons perceived as encouraging, are expected to be associated with higher levels of autonomous motivation across these three contexts.
Hypothesis 3 – It is expected that physical self-esteem will mediate the relationship between twin comparison and motivation, such that:

- more unfavorable comparisons → are associated with a decrease in physical self-esteem → which, in turn, is associated with lower autonomous motivation and higher controlled motivation/amotivation for:
    - exercise,
    - physical activity,
    - and PE participation.

Hypothesis 4 – Within each twin pair, it is expected that the twin perceived (by themselves and/or by others) as "more athletic" will show:

- higher physical self-esteem,
- higher autonomous motivation for exercise, physical activity, and PE,
- lower controlled motivation and amotivation,
- greater participation/engagement in PE classes, compared to the twin perceived as "less athletic," who is expected to show the opposite pattern.

- ***Material & methods***
- ***Study Designn***

The present study used an observational, cross-sectional design, as data collection was carried out at a single time point with the participants. Data collection was predominantly quantitative, using standardized self-report questionnaires to assess twin comparison in the physical domain, physical self-esteem, and motivation to engage in exercise, physical activity, and participation in Physical Education (PE) classes.

Whenever appropriate, 1–2 optional open-ended questions were included to clarify certain responses (e.g., examples of comparative comments made by teachers or peers), but these served only an exploratory and illustrative purpose. This methodological approach made it possible to describe patterns of association between the study variables in a sample of adolescent twins, in a way that was feasible within a school setting.

- ***Sample***

The study's target population consisted of adolescent twins, approximately 12 to 18 years old, attending lower secondary (3rd cycle of basic education) and upper secondary education in Portuguese schools where Physical Education (PE) is a compulsory curricular subject. A convenience sample was used, composed of twin pairs attending the same schools who met the following inclusion criteria: (a) both members of the pair being enrolled in and regularly attending PE classes; (b) age within the defined range; (c) ability to understand and respond to questionnaires in Portuguese; and (d) written informed consent from parents/guardians and assent from the students themselves. Twin pairs were excluded if either twin had a medical condition that prevented regular participation in PE or in habitual physical activity.

Participants were recruited through contact with school cluster leadership teams and PE teachers. After school authorization, teachers identified twin students in their classes and distributed study information and the consent form to parents/guardians. All twins who returned signed consent were invited to participate. In the manuscript, the sample was described in terms of the number of twin pairs and total participants, sex, age (M ± SD, minimum and maximum), school grade, twin type (when information on zygosity—

MZ/DZ—was available), and self-perception of being the "more athletic" vs. "less athletic" twin, reported using absolute (N) and relative (%) frequencies.

- ***Instruments***

1. Sociodemographic and physical practice questionnaire: A brief characterization questionnaire was administered, including items on: age, sex, school grade, school, current participation in PE classes (perceived attendance, engagement/active participation), structured exercise practice (type, weekly frequency, average duration), and general physical activity (modes of commuting to school, active leisure activities). It also included: (a) perceived twin type ("identical/monozygotic" or "fraternal/dizygotic," when parents knew); (b) each twin's self-perception of who was the "more athletic" or "less athletic" twin; and (c) participation in sports clubs or federated/organized training, when applicable.

2. Twin Comparison in the Physical Domain Scale: To assess the core variable "twin comparison," a study-specific instrument was developed: the Twin Comparison in the Physical Domain Scale (ECGDF). The scale included items organized into three sections:

    - Frequency of comparison (e.g., "How often do you compare yourself to your twin brother/sister in physical activities or sport?");
    - Direction of comparison (items assessing whether the student felt better, equal, or worse than the co-twin in physical appearance, fitness, and motor performance);
    - Agents of comparison (perceived frequency with which peers, family, and teachers compared the two twins).

    Responses were given on a 5-point Likert scale (e.g., 1 = "Never" to 5 = "Very often"; or 1 = "Much worse than my twin" to 5 = "Much better than my twin," depending on the item). Mean scores were calculated for each dimension (frequency, direction, agents) and, when psychometrically appropriate, a global score of unfavorable comparison. Internal consistency (Cronbach's alpha) was examined for each subscale prior to the main analyses.

3. Physical self-esteem: Physical self-esteem was assessed using the Portuguese version of the Physical Self-Perception Profile (PSPP) for adolescents, adapted by Bernardo & Matos (2003). This measure assesses multiple dimensions of the physical self (e.g., sport competence, physical condition, strength, body attractiveness) and a global physical self-worth factor (physical self-esteem). The questionnaire consisted of items presented in a structured alternative format, subsequently scored on a 1–4 scale. Mean scores were calculated for each subscale and for global physical self-esteem, following the authors' instructions. Internal consistency (Cronbach's alpha) for each dimension was verified in the present sample.

4. Motivation for exercise and physical activity: Motivation for structured exercise and for general physical activity was assessed using an adapted version of a Self-Determination Theory–based questionnaire (e.g., the Behavioural Regulation in Exercise Questionnaire), previously validated in Portuguese contexts. The instrument measured different forms of motivational regulation (intrinsic motivation, identified regulation, introjected regulation, external regulation, and amotivation), allowing the computation of mean scores for each subscale and, where applicable, a self-determination index. Instructions were adapted to refer both to planned "exercise" and to "day-to-day physical activity," and participants responded on a Likert scale (e.g., 1 = "Strongly disagree" to 5/7 = "Strongly agree").

5. Motivation to participate in PE classes: To assess motivation specifically related to PE participation, a PE motivation scale grounded in Self-Determination Theory was used (e.g., the Portuguese version of the Perceived Locus of Causality for PE). The questionnaire assessed intrinsic motivation, identified, introjected and external regulations, and amotivation toward the subject, through items beginning with "I participate in PE classes because…". Responses were given on a 5-point Likert scale ("Strongly disagree" to "Strongly agree"), and mean scores were computed for each regulation type and, when useful, aggregated indicators of autonomous and controlled motivation.

All instruments were presented as a single questionnaire pack, administered either in paper format or online (Google Forms), preceded by an instruction sheet and anonymity assurances. Instrument selection aimed to ensure adequate validity and reliability, drawing on measures previously used in the literature whenever possible and including a specifically developed scale to capture twin comparison in the physical domain.

Operational Procedures

The study was implemented in a school setting, following approval from the management teams of the participating schools and, where applicable, an institutional ethics committee, in accordance with the Declaration of Helsinki for research involving human participants.

1. Permissions and consent: In the first stage, a formal request for authorization was sent to the boards of the school clusters, describing the responsible institution, the study's general objectives, data collection procedures, and guarantees of confidentiality and anonymity. After approval, PE teachers were informed about the study and supported the identification of twin students in their classes.

An information sheet and informed consent form were then distributed to parents/guardians, explaining: (a) the study's purpose; (b) the voluntary nature of participation; (c) the absence of relevant risks; (d) the right to withdraw at any time without penalty; (e) confidentiality and aggregated data processing; and (f) contact details of the project team. Adolescents only participated after the signed consent form was returned and after providing their own informed assent, indicating that they understood the information provided.

2. Data collection: Data were collected during school hours, preferably in a PE lesson or another class period made available for this purpose, in a group setting but with individual, silent completion. The researcher (or research team) was present to explain the general purpose of the study, reinforce that there were no right or wrong answers, clarify any doubts regarding item comprehension, and ensure that participants did not talk to each other or consult their co-twin's responses.

Each twin pair received matched numerical codes (e.g., A1/A2, B1/B2), allowing the two members of the same pair to be identified later without using names. Questionnaires took approximately 20–30 minutes to complete. At the end, instruments were collected by the researcher, data completeness was checked, and—when necessary—missing or ambiguous responses were clarified (without pressuring students to answer). When an online questionnaire was used, a school-specific link was created and it was ensured that each student accessed the form individually using their participant code.

3. Data management and security: Data were entered into an Excel file and later exported to a format compatible with statistical software (e.g., .csv), following

recommendations for database construction and error cleaning (variable coding, checks for impossible values, and handling of missing data). All files were stored on a password-protected computer accessible only to the research team.

- ***Statistic Procedures***

Statistical analyses were conducted using JASP (version available at the time of analysis) and, when necessary for specific procedures (e.g., mediation models), an additional regression package. Statistical significance was set at $\alpha = 0.05$.

1. Descriptive statistics: First, the sample and study variables were characterized. For quantitative variables (age, physical self-esteem scores, motivation, twin comparison indices, frequency of exercise/physical activity), measures of central tendency and dispersion were computed (mean, standard deviation, minimum and maximum values). For qualitative variables (sex, school grade, twin type, perception of being "more/less athletic," participation in organized/federated sport, physical activity frequency categories), absolute (N) and relative (%) frequencies were calculated. Internal consistency (Cronbach's alpha) was examined for all scales.

2. Assumption testing: Prior to inferential analyses, the normality of the main continuous variables was tested using the Shapiro–Wilk test, as well as inspection of skewness and kurtosis. Homogeneity of variances between groups was assessed with Levene's test, where applicable. The choice between parametric and non-parametric tests followed these results.

3. Analyses addressing the study objectives:

   - Objectives 1 and 2 – Characterizing comparison, physical self-esteem, and motivation: Mean values, standard deviations, and response distributions were reported for the dimensions of twin comparison, physical self-esteem, and the different forms of motivation for exercise, general physical activity, and PE, along with illustrative graphs when appropriate.

   - Objective 3 – Relationship between comparison and physical self-esteem: Associations between unfavorable/favorable comparison indices and physical self-esteem scores were examined using Pearson correlations (when normality assumptions were met) or Spearman correlations (when they were not). Simple linear regression models were also explored, with physical self-esteem as the dependent variable and unfavorable comparison as the predictor, controlling for sex and age when necessary.

   - Objective 4 – Relationship between comparison and motivation for exercise, physical activity, and PE: Correlations (Pearson or Spearman) were computed between twin comparison dimensions and different types of motivation (autonomous, controlled, and amotivation) across the three contexts (exercise, general physical activity, PE). When appropriate, multiple linear regression models were used, with autonomous/controlled/amotivation indices as dependent variables and unfavorable comparison, physical self-esteem, and control variables (sex, age, sport participation) as predictors.

   - Objective 5 – Mediating role of physical self-esteem: To test whether physical self-esteem mediated the relationship between unfavorable twin comparison and motivation (autonomous, controlled, and amotivation) across contexts, mediation models were run using linear regression with bootstrapping (e.g., 5,000 resamples to

estimate 95% confidence intervals for indirect effects). The indirect effect was considered significant when the confidence interval did not include zero.

- Objective 6 – Within-pair comparison ("more athletic" vs. "less athletic"): To compare, within each pair, the twin perceived as "more athletic" with the "less athletic" twin in terms of physical self-esteem, motivation, and engagement in PE classes, paired-samples t-tests were used (when normality assumptions were met) or, alternatively, the Wilcoxon signed-rank test.
- Objective 7 – Moderation analyses by sex, age, or twin type: When sample size allowed, differences in key variables were explored by sex, age group, or twin type (MZ/DZ) using independent-samples t-tests or ANOVA (or, when required, non-parametric tests such as Mann–Whitney or Kruskal–Wallis), as well as group-stratified correlation analyses.

Across all inferential analyses, p-values were reported along with effect size estimates (e.g., Cohen's d for mean comparisons and r for correlations), in order to complement statistical significance with the practical relevance of findings.

Results

The sample included 40 adolescent twins (20 pairs), aged 12 to 18 years (M = 14.97, SD = 1.97). A total of 22 girls (55.0%) and 18 boys (45.0%) participated. Regarding twin type, 14 (35.0%) reported being monozygotic (MZ), 12 (30.0%) dizygotic (DZ), and 14 (35.0%) did not know. Concerning structured exercise practice, 18 participants (45.0%) reported exercising regularly.

Tab. 1 - Sample characterization.

Variable	N	%	M ± SD	Min	Max
Participants	40	-	-		
Twin pairs	20	-	-		
Age (years)		-	M = 14.97; DP = 1.97	12	18
Sex: Female	22	55.0%	-		
Sex: Male	18	45.0%	-		
Twin type: Monozygotic	14	35.0%	-		
Twin type: Dizygotic	12	30.0%	-		
Twin type: Unknown	14	35.0%	-		
Structured exercise: Yes	18	45.0%	-		
Structured exercise: No	22	55.0%	-		

Caption: The table presents the total number of participants and twin pairs, age (mean, standard deviation, and range), sex distribution, twin type (monozygotic, dizygotic, or unknown), and participation in structured exercise (yes/no). Values are reported as n and %, or as M, SD, minimum, and maximum, as applicable.

On average, unfavorable comparison showed moderate values ($M = 2.98$, $SD = 1.35$), whereas physical self-esteem showed moderate to high values ($M = 3.04$, $SD = 0.84$). Internal consistency was high for twin comparison ($\alpha = 0.868$) and for physical self-esteem ($\alpha = 0.937$). Regarding motivation, reliability was adequate for the autonomous motivation subscales across the three contexts (α between 0.870 and 0.885). In contrast, the controlled motivation and amotivation subscales showed low internal consistency in several contexts ($\alpha = 0.189–0.442$), and these results should therefore be interpreted with caution. Moreover, because some subscales displayed low internal consistency—particularly controlled motivation and amotivation across different contexts—results based on these subscales should not underpin the main conclusions. When possible, it is recommended to also report McDonald's ω and/or to reassess item/subscale aggregations based on theoretical and psychometric criteria.

The sample included 40 adolescent twins (20 pairs), aged 12 to 18 years ($M = 14.97$; $SD = 1.97$), with 55% girls. Descriptively, unfavorable comparison was moderate ($M = 2.98$; $SD = 1.35$), and physical self-esteem was moderate to high ($M = 3.04$; $SD = 0.84$). Internal consistency was high for the social comparison and physical self-esteem measures ($\alpha \geq 0.937$). For motivational dimensions, reliability was adequate for autonomous motivation subscales across the three contexts (α between 0.870 and 0.885). In contrast, controlled motivation and amotivation subscales showed low internal consistency in several contexts ($\alpha = 0.189–0.553$), and these results should be interpreted with caution and should not support the study's main conclusions.

Tab. 2 - Descriptive statistics and internal consistency of the main variables.

Variable	M ± SD	α	N
Social comparison (frequency)	3.40 ± 1.17	0.953	40
Unfavorable social comparison	2.98 ± 1.35	0.954	40
Social comparison (agents)	3.36 ± 0.77	0.852	40
Physical self-esteem	3.04 ± 0.84	0.937	40
Exercise motivation (autonomous)	2.46 ± 0.87	0.885	40
Exercise motivation (controlled)	2.79 ± 0.37	0.442	40
Exercise motivation (amotivation)	2.76 ± 0.49	0.400	40
Physical activity motivation (autonomous)	2.08 ± 0.71	0.870	40
Physical activity motivation (controlled)	2.65 ± 0.39	0.345	40
Physical activity motivation (amotivation)	2.80 ± 0.52	0.269	40
PE motivation (autonomous)	1.98 ± 0.73	0.871	40

PE motivation (controlled)	2.83 ± 0.32	0.189	40
PE motivation (amotivation)	2.59 ± 0.48	0.553	40

Caption: *N* = number of participants with valid data; *M* = mean; *SD* = standard deviation; α = Cronbach's alpha. The reported *N* refers to the computation of *M/SD* and α (and may vary by variable if there are missing data).

Descriptive statistics (*M* ± *SD*) and internal consistency (Cronbach's α) for measures of social comparison, physical self-esteem, and motivation (for exercise, physical activity [PA], and Physical Education [PE]). Values are presented as mean (*M*) and standard deviation (*SD*), alongside the α coefficient for each scale/subscale.

Shapiro–Wilk tests indicated departures from normality in several key variables; therefore, Spearman correlations were prioritized for association analyses. For between-group comparisons, the choice between parametric and non-parametric tests was based on the distribution of differences and, when applicable, the homogeneity of variances.

A strong negative association was found between unfavorable comparison and physical self-esteem ($\rho = -0.792$, $p < 0.001$; 95% CI [-0.885, -0.638]). In a linear regression model controlling for age and sex, unfavorable comparison remained a significant predictor of physical self-esteem ($b = -0.495$, $SE = 0.057$, $t = -8.63$, $p < 0.001$; 95% CI [-0.610, -0.380]; $R^2 = 0.690$).

Unfavorable comparison was associated with lower autonomous motivation for exercise ($\rho = -0.631$, $p < 0.001$; 95% CI [-0.788, -0.398]) and higher amotivation for exercise ($\rho = 0.438$, $p = 0.005$; 95% CI [0.146, 0.660]). In the context of PE classes, moderate negative associations were observed between unfavorable comparison and autonomous motivation ($\rho = -0.398$, $p = 0.011$; 95% CI [-0.631, -0.099]).

Overall, an inverse relationship was observed between unfavorable social comparison and physical self-esteem, indicating that higher levels of unfavorable comparison are related to lower physical self-esteem. Figure 1 graphically illustrates this association.

In line with the Shapiro–Wilk results, several variables deviated from normality; thus, Spearman correlations were prioritized in the association analyses.

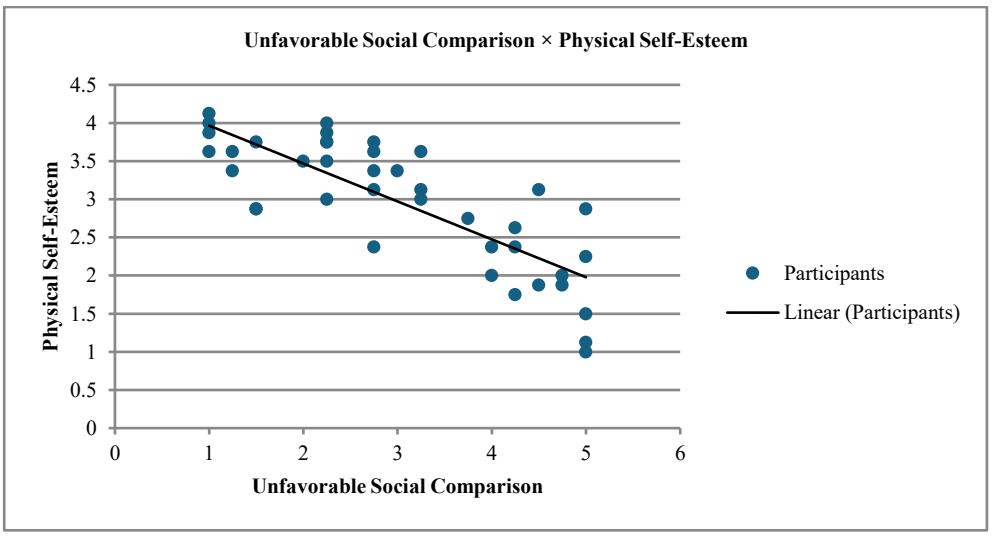

Fig. 1 - Association between Unfavorable Social Comparison and Physical Self-Esteem

Caption: Scatterplot of unfavorable social comparison and physical self-esteem ($n = 40$), with a linear trend line. Each point represents one participant.

A strong negative association was found between unfavorable social comparison and physical self-esteem, indicating that higher levels of unfavorable comparison are related to lower levels of physical self-esteem ($\rho = -0.792$, $p < .001$; 95% CI [−0.885, −0.638]). This association is illustrated in Figure 1, where a consistent linear trend can be observed between the two variables.

Table 2 presents the descriptive statistics (*M*, *SD*) and internal consistency of the measures. To facilitate readability and comparisons across variables, Figure 2 displays the means (*M*) with their corresponding 95% confidence intervals (95% CI) for the study variables ($n = 40$).

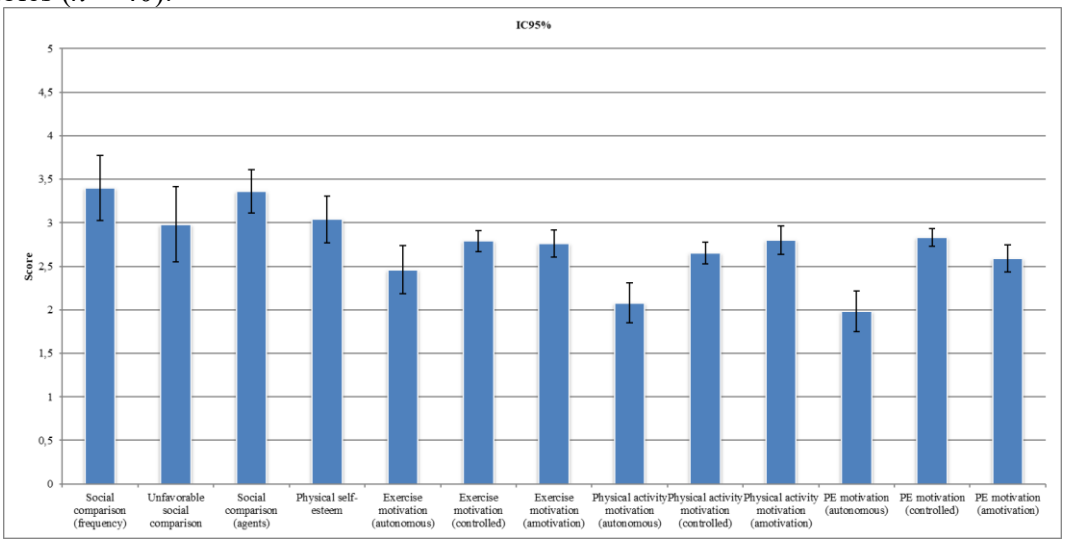

Fig. 2 - Means (M) and 95% CIs of the study variables.

Caption: Means (M) with 95% confidence intervals (95% CI) for the variables of social comparison, physical self-esteem, and motivation (n = 40).

Tab. 3 - Spearman correlations between unfavorable comparison and key variables.

Variable 1	Variable 2	ρ	*p*	IC95%
Unfavorable comparison	Physical self-esteem	−0.792	< .001	[-0.885, -0.638]
Unfavorable comparison	Exercise motivation (autonomous)	−0.631	< .001	[-0.788, -0.398]
Unfavorable comparison	Exercise motivation (amotivation)	0.438	.005	[0.146, 0.660]
Unfavorable comparison	PE motivation (autonomous)	−0.398	.011	[-0.631, -0.099]

Caption: ρ = Spearman's rank correlation coefficient. *p* values below 0.05 were considered statistically significant. 95% confidence intervals (95% CI) were estimated using Fisher's transformation (approximation).

In the motivational domain, unfavorable comparison was associated with lower autonomous motivation for exercise (ρ = −0.631, p < .001; 95% CI [−0.788, −0.398]) and higher amotivation for exercise (ρ = 0.438, p = .005; 95% CI [0.146, 0.660]). In the context of Physical Education (PE) classes, a moderate negative association was also observed between unfavorable comparison and autonomous motivation (ρ = −0.398, p = .011; 95% CI [−0.631, −0.099]). Figure 3 visually summarizes the direction and magnitude of these associations.

	Unfavorable comparison	Exercise motivation (amotivation)	PE motivation (autonomous)	Physical self-esteem	Exercise motivation (autonomous)
Unfavorable comparison	1,000	0,438	-0,398	-0,792	-0,631
Exercise motivation (amotivation)	0,438	1,000			
PE motivation (autonomous)	-0,398		1,000		
Physical self-esteem	-0,792			1,000	
Exercise motivation (autonomous)	-0,631				1,000

Fig. 3 - Heatmap of Spearman correlations (ρ) between social comparison, physical self-esteem, and motivation.

Caption: Heatmap of Spearman correlations (ρ) between social comparison, physical self-esteem, and motivation (by context), providing an overall view of the direction and magnitude of associations (n = 40).

Complementarily, in a linear regression model controlling for age and sex, unfavorable comparison remained a significant predictor of physical self-esteem (b = −0.495, SE = 0.057, t = −8.63, p < .001; 95% CI [−0.610, −0.380]), explaining a substantial proportion of the outcome variance (R^2 = 0.690).

Unfavorable comparison was a significant predictor of physical self-esteem (a = −0.476, p < .001). However, the indirect effects of unfavorable comparison on motivation via physical self-esteem were not statistically significant. For example, for autonomous motivation in exercise, a*b = 0.088, 95% CI [−0.061, 0.240]. A similar pattern was observed for the remaining dimensions/contexts (95% CIs included zero).

In 15 pairs with clear differentiation in athletic self-perception, the twin perceived as more athletic showed higher physical self-esteem than the twin perceived as less athletic (mean difference = 1.54; p < .001). Additionally, the more athletic twin reported higher

autonomous motivation for exercise (mean difference = 1.18; p < .001) and lower amotivation (p = .021).

To strengthen interpretation and reduce the influence of between-family differences, a within-pair comparison was conducted in twin pairs with clear differentiation in athletic self-perception, contrasting the twin perceived as "more athletic" with the one perceived as "less athletic."

Tab. 4 - Comparação intra-par (mais atlético vs menos atlético).

Variable	N (pairs)	M (more athletic)	M (less athletic)	p	Effect size (r)
Physical self-esteem	15	3.90	2.36	< .001	0.99
Exercise motivation (autonomous)	15	3.12	1.93	< .001	0.81
Exercise motivation (controlled)	15	3.03	2.60	.004	0.67
Exercise motivation (amotivation)	15	2.53	3.00	.021	−0.57
PE motivation (autonomous)	15	2.32	1.70	.042	0.51
Participation in PE classes	15	3.07	2.27	.037	0.54

Caption: *M* = mean. *p* refers to the paired comparison between the "more" and "less" conditions. Effect size is reported as *r*; positive values indicate *M*(more) > *M*(less), and negative values indicate *M*(more) < *M*(less).

Regarding the objective of testing the mediating role of physical self-esteem, unfavorable comparison was a significant predictor of physical self-esteem (a = −0.476, p < .001). However, the indirect effects of unfavorable comparison on motivation through physical self-esteem were not statistically significant. For example, for autonomous motivation in exercise, the estimated indirect effect was a*b = 0.088, with a 95% CI [−0.061, 0.240], and a similar pattern was observed across the remaining dimensions and contexts (confidence intervals including zero).

Exploratorily, no statistically significant differences were found in the main variables as a function of sex or twin type (MZ vs. DZ), nor was there evidence of an interaction between sex and unfavorable comparison in predicting motivation (ps > 0.05).

In this analysis, the twin perceived as more athletic showed higher physical self-esteem than the twin perceived as less athletic (mean difference = 1.54; p < .001; r = 0.99). Additionally, the more athletic twin reported higher autonomous motivation for exercise

(mean difference = 1.18; p < .001; r = 0.81) and lower amotivation for exercise (p = .021; r = −0.57). Differences were also observed in controlled motivation for exercise (p = .004; r = 0.67), autonomous motivation in PE (p = .042; r = 0.51), and participation in PE classes (p = .037; r = 0.54). Figures 4 and 5 graphically present the paired pattern of these within-pair differences for physical self-esteem and autonomous motivation for exercise, respectively.

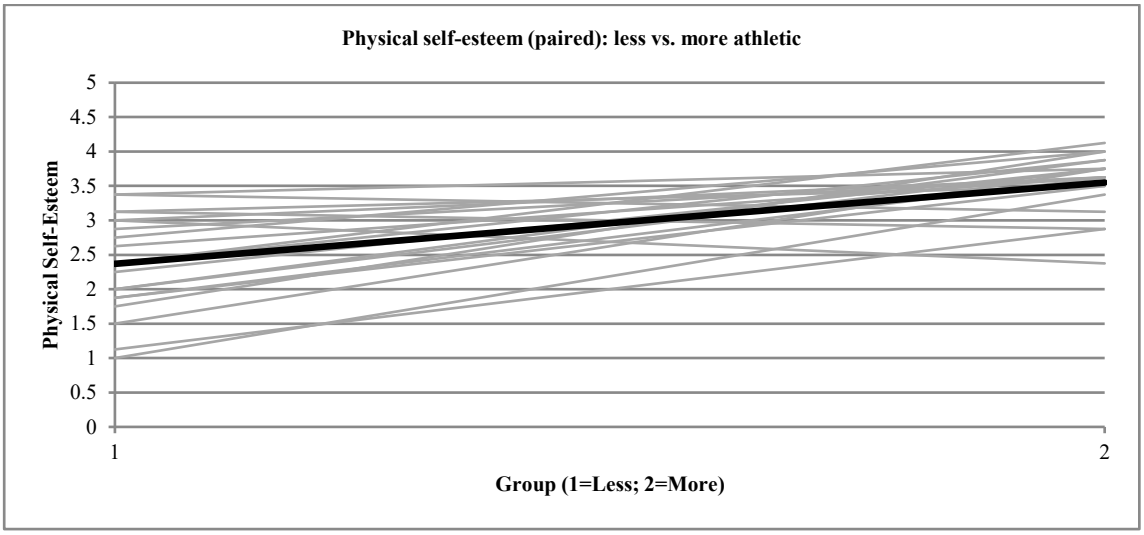

Fig. 4 - Physical self-esteem (pairs).

Caption: Paired (spaghetti) plot of physical self-esteem (recoded; higher values = better) for participants classified as less athletic (1) and more athletic (2) within each pair (n = 20 pairs). Grey lines represent each twin pair; the black line represents the mean.

Overall, variability across pairs is evident, with the average trend summarized by the black line.

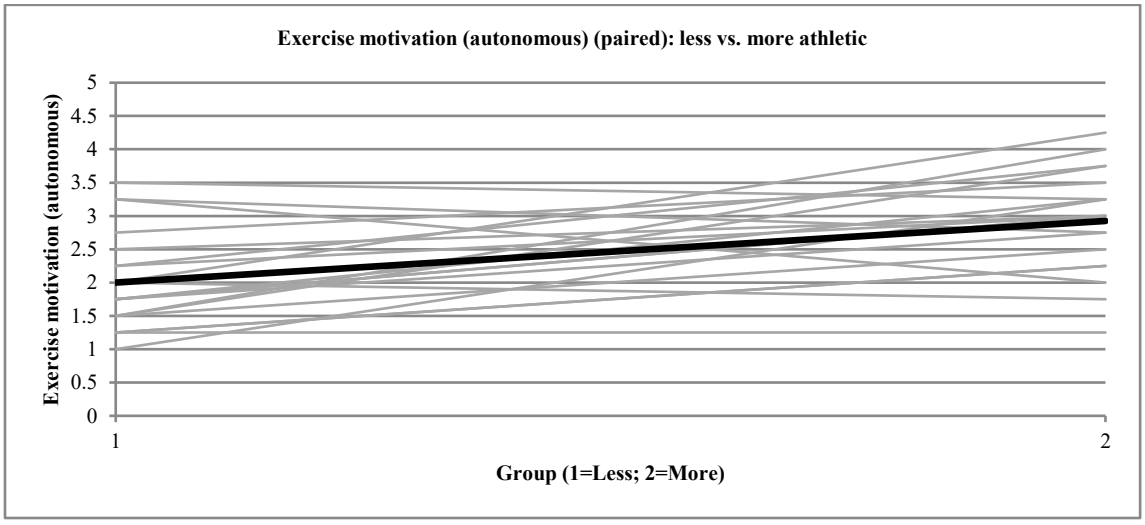

Fig. 5 - Exercise motivation (autonomous) (pairs).

Caption: Paired (spaghetti) plot of autonomous motivation for exercise comparing the less athletic member (1) and the more athletic member (2) within each pair (n = 20 pairs). Grey lines represent each twin pair; the black line represents the mean.

Exploratorily, no statistically significant differences were observed in the main variables as a function of sex or twin type (MZ vs. DZ), nor was there evidence of an interaction between sex and unfavorable comparison in predicting motivation (ps > 0.05).

- ***Discussion***

The present study aimed to examine how twin comparison in the physical domain relates to physical self-esteem and to motivation for engaging in exercise, general physical activity, and participation in Physical Education (PE) classes. It also tested (i) the mediating role of physical self-esteem and (ii) within-pair differences between the twin perceived as "more athletic" and the twin perceived as "less athletic." Overall, the findings converge on a coherent and substantively meaningful pattern: unfavorable comparison was strongly associated with lower physical self-esteem ($\rho = -0.792$) and retained high predictive value even after controlling for age and sex ($b = -0.495$; $R^2 = 0.690$). In motivational terms, unfavorable comparison was associated with lower autonomous motivation for exercise ($\rho = -0.631$) and for PE ($\rho = -0.398$), as well as higher amotivation for exercise ($\rho = 0.438$). Mediation via physical self-esteem was not supported and, in contrast, the within-pair analysis revealed very robust differences favoring the "more athletic" twin in physical self-esteem, autonomous motivation (exercise and PE), and PE participation, alongside lower amotivation for exercise. These findings must also be interpreted in light of psychometric performance: low internal consistency in some subscales—especially controlled motivation and amotivation in certain contexts—warrants caution for those domains and reinforces that the most solid conclusions rest on the robust effects observed for unfavorable comparison, physical self-esteem, and autonomous motivation.

Regarding Hypothesis 1, it was clearly supported: the more unfavorable the comparison with the co-twin, the lower the physical self-esteem. This result aligns with prior evidence indicating that social comparison is a central mechanism in the development of adolescents' physical self-concept, particularly when the comparison target is highly relevant and similar. In twins, proximity and comparability make perceived differences especially "diagnostic," reducing the likelihood of attributing discrepancies to contextual factors and increasing the risk of contrast effects ("I'm the less capable one") when comparison is consistently unfavorable. The observed magnitude (very high ρ and an explanatory model with $R^2 = 0.690$) suggests a potentially important impact on these youths' psychological functioning, going beyond a small or circumstantial effect: within-pair comparison appears to operate as a particularly strong social determinant of how individuals evaluate their physical worth.

With respect to Hypothesis 2, the results provide partial support and, crucially, help clarify the domains in which within-pair comparison seems most detrimental. The negative association with autonomous motivation was stronger for exercise ($\rho = -0.631$) than for PE ($\rho = -0.398$), suggesting that unfavorable comparison may have a more direct impact when the behavior is, in principle, chosen and self-regulated (exercise) than in a compulsory curricular context (PE), where motivation may be more shaped by external factors (grading, class rules, teacher, and peer dynamics). This gradient is informative: unfavorable comparison may not only reduce the "wanting to do" (autonomy) but also foster a disengagement profile in exercise, reflected in the positive association with amotivation ($\rho = 0.438$). This pattern is consistent with literature showing that threats to perceived competence and expectations of failure tend to undermine motivational quality and promote avoidance, especially in activities

where performance and progress are salient and easily comparable. In PE specifically, the negative association with autonomous motivation—though smaller—remains meaningful because PE often exposes students to public evaluation of performance; in this sense, within-pair comparison may function as an "interpretive filter" of the same stimulus: identical tasks may be experienced as opportunities for mastery and improvement by one twin and as threats by the other, shaping willingness to participate and invest.

Still within Hypothesis 2, conclusions regarding controlled motivation should be treated cautiously. The low reliability of controlled motivation subscales (and some amotivation subscales in certain contexts) increases the likelihood of attenuated associations and complicates the interpretation of null results. Therefore, the absence of clear relations with controlled motivation should be viewed as inconclusive evidence under psychometric constraints, rather than proof that no relationship exists. This caution is essential to maintain interpretive robustness: discussion should prioritize effects that are both theoretically coherent and empirically supported by measures with stronger internal consistency.

Regarding Hypothesis 3, it was not supported: although unfavorable comparison strongly predicted physical self-esteem, there was no statistically significant indirect effect of comparison on motivation through physical self-esteem. Rather than invalidating the role of physical self-esteem, this lack of mediation suggests that comparison may influence motivation through more proximal and situational pathways than a global physical self-esteem indicator can capture. For example, unfavorable comparison may directly affect success expectations, task-specific competence perceptions, anxiety about exposure, and anticipation of negative evaluation, influencing motivation in the moment and within the context (exercise/PE) without necessarily "passing through" measurable changes in global physical self-esteem. Additionally, the cross-sectional design limits the temporal inference required for mediation: it is plausible that physical self-esteem and motivation reciprocally reinforce each other over time in cyclical processes (lower motivation → lower engagement → fewer competence experiences → lower physical self-esteem), which may not be detectable in a single assessment. Finally, with N = 40 and substantial measurement error in part of the motivational subscales, power to detect small-to-moderate indirect effects is limited; thus, a real indirect effect may exist but may not be estimated with sufficient precision in this sample. The most conservative interpretation, therefore, is that physical self-esteem is clearly involved in the relational system, but it was not possible to demonstrate, in these data, that it is the primary mediating mechanism between comparison and motivation.

Hypothesis 4 was supported particularly convincingly, strengthening the conclusions through a methodologically demanding lens. The within-pair analysis showed that, within the same pair, the "more athletic" twin had higher physical self-esteem ($r = 0.99$), higher autonomous motivation for exercise ($r = 0.81$) and PE ($r = 0.51$), higher PE participation ($r = 0.54$), and lower amotivation for exercise ($r = -0.57$). This pattern is especially informative because it substantially reduces the influence of shared family factors and brings the explanation closer to pair-specific processes: labeling ("the athletic one"), role specialization, differential reinforcement, and internalized expectations. Practically, these results suggest that within-pair comparison is not merely "social noise": it may crystallize distinct trajectories of physical identity and motivational self-regulation, with observable effects on PE participation and exercise-related motivational profiles.

An additional finding that warrants careful interpretation is the within-pair difference in controlled motivation for exercise (higher in the "more athletic" twin). Even given the caution imposed by low internal consistency, this trend is theoretically plausible: the status of being "more athletic" can coexist with pressure to meet expectations and maintain performance, generating both autonomous motives (enjoyment, valuing) and controlled

motives (obligation, pressure). If this pattern is confirmed with more robust instruments, it carries relevant implications: intervention should not focus only on the "less athletic" twin (due to risks of demotivation and avoidance), but should also protect the autonomy and well-being of the "more athletic" twin, who may be exposed to less visible pressures.

Study limitations help contextualize the scope of conclusions and also explain some less expected results. The cross-sectional design prevents causal inference and limits the robustness of mediation testing. The sample size (40 adolescents; 20 pairs) and convenience recruitment restrict generalizability and reduce power to detect indirect effects and moderations (by sex and twin type). Unknown zygosity for part of the sample limits more nuanced interpretations regarding potential differences between MZ and DZ twins. Reliance on self-report may introduce biases (social desirability, common-method variance), and the "more/less athletic" classification may reflect not only objective competence but also identity, internalized comparison, and context-shaped perceptions. Finally, low internal consistency in some subscales suggests that findings in those domains should be treated as preliminary, reinforcing the need for psychometric refinement and replication.

Despite these limitations, the study has clear strengths and adds value to the field. Conceptually, it focuses on a specific and underexplored mechanism—within-pair comparison between twins in the physical domain—and links it to central outcomes (physical self-esteem, motivational quality, and participation). Methodologically, the inclusion of within-pair analysis is a substantive strength, enabling observation of meaningful differences within a "microcontext" of high similarity and strengthening the interpretation of relational processes within the twin dyad. Appliedly, the results support direct implications for PE: minimizing practices and comments that promote normative comparison between twins, avoiding labeling ("the athletic one" vs. "the less athletic one"), and prioritizing success criteria based on individual progress, informational feedback, and graded opportunities to experience competence. These strategies may protect the more vulnerable twin's physical self-esteem and promote more autonomous and sustainable motivation in both twins, with potential impact on PE participation and engagement in exercise outside school.

For future research, a longitudinal design is recommended to test directionality and mediation, objective confirmation of zygosity, integration of objective fitness/activity measures to disentangle perceived from actual performance, assessment of contextual variables (e.g., comparison experiences induced by peers/teachers and perceived motivational climate), and use of motivational instruments with more consistent psychometric performance. Together, these extensions will help clarify the most proximal mechanisms linking unfavorable comparison to disengagement and identify more precise intervention targets to reduce the impact of within-pair comparisons and promote regular, psychologically healthy participation in PE and exercise.

- ***Conclusions***

The present study showed that within-pair physical-domain comparison among twins was consistently associated with key indicators of psychological and motivational functioning in adolescence. In particular, unfavorable comparison with the co-twin was strongly associated with lower physical self-esteem and a less adaptive motivational profile, characterized by lower autonomous motivation for exercise and for participation in Physical Education (PE) classes, as well as higher amotivation for exercise. Taken together, these findings indicate that persistent, negative within-pair comparison may constitute a specific risk factor for the devaluation of the physical self and for disengagement from physical-activity-related behaviors, with simultaneous repercussions for both the school experience (PE) and exercise practice outside school.

The absence of evidence supporting physical self-esteem as a mediator between comparison and motivation did not reduce the relevance of the observed associations; rather, it suggests that the impact of within-pair comparison on motivational self-regulation may operate primarily through more proximal and situational mechanisms, such as success expectations, task-specific competence perceptions, anxiety about exposure, and interpretations of the social climate. In parallel, the within-pair results particularly reinforced the robustness of the conclusions: the twin perceived as "more athletic" reported higher physical self-esteem, higher autonomous motivation for exercise and PE, greater class participation, and lower exercise amotivation, pointing to the possibility that perceived asymmetries within the pair may translate over time into differentiated trajectories of physical identity, engagement, and participation. Although some domains should be interpreted with caution due to psychometric limitations in specific subscales, the core empirical pattern was clear and consistent regarding the structuring role of unfavorable comparison and the physical self in motivational differentiation.

From an applied perspective, these findings support direct recommendations for educational practice, particularly in PE: reducing normative comparison between twins, avoiding labeling processes, and promoting success criteria centered on individual progress, informational feedback, and graded opportunities for competence, in order to protect physical self-esteem and foster more autonomous and sustainable motivation in both twins. For future research, longitudinal studies with larger and more representative samples are needed, alongside objective confirmation of zygosity, integration of objective fitness/physical activity measures, and systematic assessment of contextual variables (including perceived motivational climate and comparison experiences induced by peers/teachers), to clarify directionality and identify more proximal mediators. In sum, this study highlights within-pair comparison as a specific and still underexplored social mechanism that is nevertheless pivotal for understanding—and intervening in—how adolescent twins build their physical self and regulate their participation in PE and exercise, promoting a healthier, more consistent, and sustained relationship with physical activity.

Conflicts of interest - No conflicts of interest to declare.

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