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STRUCTURAL ANALYSIS OF THE RELATIONSHIPS AMONG PHYSICAL ACTIVITY, PHYSICAL SELF-CONCEPT, AND ACADEMIC PERFORMANCE: AN APPLICATION OF STRUCTURAL EQUATION MODELING

ANÁLISIS ESTRUCTURAL DE LA RELACIÓN ENTRE ACTIVIDAD FÍSICA, AUTOCONCEPTO FÍSICO Y RENDIMIENTO ACADÉMICO: UNA APLICACIÓN DE MODELOS DE ECUACIONES ESTRUCTURALES

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Structural Analysis of the Relationships Among Physical Activity, Physical Self-Concept, and Academic Performance: An Application of Structural Equation Modeling

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ABSTRACT

The relationship between physical activity, physical self-concept, and academic performance has attracted considerable attention across different disciplines because of its relevance to students' overall development. However, the complexity of these interactions requires advanced statistical methodologies capable of modeling simultaneous relationships among observed and latent variables. The aim of this study was to analyze the structural relationship among physical activity, physical self-concept, and admission examination results through the application of Structural Equation Modeling. A theoretical model was proposed in which physical activity acted as an exogenous variable, whereas physical self-concept and the admission examination result were considered endogenous variables. The findings showed a positive and statistically significant effect of physical activity on physical self-concept. Physical self-concept, in turn, showed a negative and statistically significant relationship with the admission examination result, while the direct effect of physical activity on the examination result was not significant. Although the global fit indices indicated a limited fit of the model, the structural estimates provided exploratory evidence about the direction and magnitude of the relationships among the variables. These findings highlight the usefulness of structural equation modeling as a methodological tool for examining complex multivariate relationships in educational contexts.

***Keywords*:** physical activity, physical self-concept, admission examination result, academic performance, structural equation modeling.

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Análisis Estructural de la Relación entre Actividad Física, Autoconcepto Físico y Rendimiento Académico: Una Aplicación de Modelos de Ecuaciones Estructurales

RESUMEN

La relación entre la actividad física, el autoconcepto físico y el rendimiento académico ha sido objeto de interés en diversas disciplinas debido a su impacto en el desarrollo integral de los estudiantes. Sin embargo, la complejidad de estas interacciones requiere metodologías estadísticas avanzadas capaces de modelar relaciones simultáneas entre variables observadas y latentes. En este contexto, el presente estudio tuvo como objetivo analizar la relación estructural entre la actividad física, el autoconcepto físico y el rendimiento académico mediante la aplicación de modelos de ecuaciones estructurales. Se propuso un modelo teórico en el que la actividad física actúa como variable exógena, mientras que el autoconcepto físico y el rendimiento académico se consideran variables endógenas. Los resultados evidenciaron un ajuste adecuado del modelo estructural, mostrando que la actividad física presentó una asociación positiva y estadísticamente significativa con el autoconcepto físico. Asimismo, el autoconcepto físico mostró una relación negativa y significativa con el rendimiento académico. Estos hallazgos destacan la utilidad de los modelos de ecuaciones estructurales como una herramienta robusta para el análisis de relaciones multivariadas complejas en contextos educativos.

***Palabras clave*:** actividad física, autoconcepto físico, rendimiento académico, modelos de ecuaciones estructurales.

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INTRODUCTION

Academic performance is one of the main indicators of student achievement and educational development; therefore, its analysis has become highly relevant in fields such as education, psychology, sport sciences, and health. Within this context, several physical, cognitive, and psychosocial factors have been identified as potential determinants of academic outcomes, among which physical activity and physical self-concept stand out because of their influence on students' integral development (Aaltonen et al., 2020; Claver et al., 2020).

Physical activity has been widely recognized as an essential component of health and well-being, not only because of its physiological benefits but also because of its positive effects on cognitive, emotional, and behavioral variables. Previous studies have indicated that regular physical activity may support cognitive functions such as attention, memory, and concentration, all of which are closely related to academic performance (Aaltonen et al., 2020). In addition, physical activity can strengthen psychological dimensions associated with self-esteem, body perception, and self-evaluation.

Within these dimensions, physical self-concept is a construct of particular interest because it describes individuals' perceptions of their physical abilities, body condition, and motor competence. Recent evidence suggests that higher levels of physical activity are usually associated with a more favorable physical self-concept, strengthening a positive perception of personal abilities and psychological well-being (Sevil-Serrano et al., 2020; Lohbeck et al., 2021). Nevertheless, the relationship between physical self-concept and academic performance continues to show heterogeneous results in the literature, suggesting complex interactions among physical, psychological, and academic variables.

The study of these relationships involves important methodological challenges due to the multidimensional nature of the constructs involved. Physical activity, physical self-concept, and academic performance are part of complex systems in which direct, indirect, and potential mediation effects may coexist. Therefore, the analysis of these associations requires advanced statistical methods capable of modeling multiple dependency relationships simultaneously and representing latent constructs with adequate precision.

In this sense, Structural Equation Modeling (SEM) has become one of the most robust and versatile statistical techniques for the multivariate analysis of complex phenomena. SEM integrates confirmatory

factor analysis and structural regression models within a single analytical framework, allowing the simultaneous estimation of relationships among observed and latent variables. This feature offers substantial advantages over traditional statistical approaches, such as multiple linear regression, because it provides a more comprehensive evaluation of hypothetical causal structures.

One of the main strengths of SEM is its capacity to test complex theoretical models, estimate direct and indirect effects, and evaluate global model fit through indices such as the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR). This makes it possible not only to identify significant associations among variables but also to understand the underlying structure of these relationships with greater statistical rigor (Vollmer et al., 2021).

In recent years, the application of SEM in educational and behavioral studies has increased considerably because of its ability to model behavioral, psychological, and academic variables simultaneously. In studies related to physical activity, self-concept, and academic performance, this technique has proven useful for validating theoretical models and explaining complex relationships among multidimensional constructs (Núñez et al., 2021).

From this perspective, the present study aims to analyze the structural relationship among physical activity, physical self-concept, and academic performance measured through admission examination results. A theoretical model is proposed in which physical activity acts as an exogenous variable, whereas physical self-concept and academic performance are conceptualized as endogenous variables within a relational structure. Through this approach, the study seeks to provide empirical and methodological evidence that contributes to a deeper understanding of the interactions among physical, psychological, and academic variables in educational contexts.

Recent research has reinforced the usefulness of structural equation modeling for studying complex relationships among behavioral, psychological, and academic variables. For example, SEM has been successfully used to model relationships among physical activity, self-esteem, and academic performance, allowing the estimation of both direct and mediating effects within complex multivariate structures. Villodres et al. (2023), through a structural model applied to primary education students, found that physical activity, together with other healthy lifestyle behaviors, was positively associated

with self-esteem and indicators of academic performance, suggesting that psychoemotional variables may act as relevant mediators within the educational process.

Similarly, Zurita-Ortega et al. (2023) developed a structural equation model to evaluate the relationship among levels of physical activity, family functioning, and self-concept in elementary and high school students. Their results showed that higher levels of physical activity were associated with higher scores in self-concept dimensions, supporting the hypothesis that regular physical activity favors psychosocial development and a positive perception of the physical self.

Regarding academic performance, recent studies have noted that the association between physical activity and school achievement is not always direct but is often mediated by cognitive and psychological variables. Muntaner-Mas et al. (2022), using SEM, reported that physical fitness and executive function significantly mediated the relationship between physical activity and academic achievement, suggesting that the effects of physical activity on academic performance operate through more complex intermediate mechanisms than a simple linear association.

Likewise, research in university contexts has shown that structural models can capture complex relationships among self-concept, emotional variables, and academic performance. Ubago-Jiménez et al. (2023) found that self-concept is significantly related to academic performance, although the magnitude and direction of this association may vary depending on the population context and the psychosocial characteristics analyzed. These findings support the need to continue exploring these relationships through advanced statistical approaches that allow a more precise understanding of their interactions.

METHODOLOGY

This study was conducted under a quantitative approach, with a cross-sectional, non-experimental design and a correlational-explanatory scope. The main objective was to analyze the relationships among physical activity, physical self-concept, and academic performance in university students through the application of structural equation modeling (SEM). This technique was selected because of its capacity to model complex relationships among observed and latent variables simultaneously, making it possible to identify both direct and indirect effects within the same analytical framework.

Data were obtained through an online survey administered to university students from a Mexican institution. After the data cleaning and validation process, a total of 208 complete records were available for the analysis. The database included sociodemographic variables such as age, sex, and degree program, as well as information related to physical activity, physical self-concept, and academic performance. For analyses that included the admission examination result, complete cases were used according to the availability of the PCE, PMA, PRIN, PCL, and PING scores.

The sample consisted of university students of different sexes (117 women, 85 men, and 6 who preferred not to report this information) and from different disciplinary areas, which provided a heterogeneous population for analysis. The average age of participants was 19.18 years (SD = 3.01). Regarding academic performance, the global score on the admission examination had a mean of 67.47 points (SD = 11.53). Students also reported devoting an average of 2.6 hours per day to physical activity.

The physical activity variable was defined as the number of daily hours devoted to physical activity, obtained through self-report. Physical self-concept was measured using the Physical Self-Concept Questionnaire (CAF) by Goñi, Ruiz de Azúa, and Rodríguez (2006), one of the reference instruments for Spanish-speaking populations. This questionnaire consists of 36 items grouped into dimensions related to physical ability, physical condition, physical attractiveness, and strength, allowing physical self-concept to be modeled as a latent construct. Academic performance was operationalized through the global score obtained by participants on the university admission examination, used as a quantitative indicator of academic performance in this study.

The statistical analysis was performed in Python using the semopy library for estimating the structural equation model. A clear and sufficient theoretical description of these models can be found in Tarka (2018). Initially, a descriptive analysis was conducted to characterize the sample and explore the behavior of the variables of interest. Subsequently, a structural model was specified in which physical activity was considered an exogenous variable, while physical self-concept and academic performance were modeled as endogenous variables. The model included direct relationships between physical activity and physical self-concept, between physical self-concept and academic performance, and between physical activity and academic performance.

The global fit of the model was evaluated using several goodness-of-fit indices commonly employed in SEM, including χ^2, CFI, GFI, AGFI, NFI, TLI, RMSEA, AIC, and BIC. The obtained values were χ^2 = 113.613, CFI = 0.649, GFI = 0.638, AGFI = 0.357, NFI = 0.638, TLI = 0.376, RMSEA = 0.239, AIC = 22.892, and BIC = 62.768.

Overall, the obtained indices suggest a limited fit of the structural model to the observed data. This behavior may be associated with several factors, including the sample size. Although the sample allowed the model to be estimated and the proposed structural relationships to be explored, relatively small sample sizes in SEM may affect the stability of estimates and limit the quality of the global model fit. Despite this limitation, the analysis made it possible to identify relevant structural relationships among the variables studied, providing useful evidence for understanding the interactions among physical activity, physical self-concept, and academic performance.

RESULTS AND DISCUSSION

Descriptive and Exploratory Analysis

After importing the database into the Python working environment, the integrity of the information and the consistency of the variables included in the study were verified. The database contained sociodemographic information on the participants, as well as variables related to physical activity, physical self-concept, and results obtained on the admission examination.

As part of the data preparation process, variable names were standardized to ensure proper handling during the different stages of the statistical analysis. Subsequently, an academic performance indicator corresponding to the global admission examination score was constructed as the average of the scores obtained in Critical Thinking (PCE), Mathematical Thinking (PMA), Research Principles (PRIN), Reading Comprehension (PCL), and English (PING). The integration of these areas made it possible to obtain a synthetic measure of the academic performance achieved by applicants during the selection process.

The global admission examination score was considered the main response variable of the study, since it constitutes an overall indicator of students' academic performance. In addition, the scores corresponding to each of the areas that make up the examination were analyzed individually in order to identify specific performance patterns that might not be evident when only the global indicator was

considered. This complementary analysis provided a more detailed characterization of participants' academic behavior and contributed additional elements for interpreting the structural model results.

Table 1 presents the distribution of the main descriptive variables considered in the study, including sex, physical activity level, physical self-concept category, and the number of daily hours devoted to physical activity.

The descriptive statistics made it possible to characterize the initial behavior of the variables included in the analysis. Overall, the distribution of the measures of central tendency and dispersion showed sufficient variability among participants, which is favorable for estimating the structural equation model. In addition, the graphical exploration of the data and the descriptive analysis did not show patterns that compromised the continuation of subsequent analyses; therefore, the associations among variables and the specification of the structural model were evaluated.

Table 1. Distribution of the main descriptive variables.

Variable	Category	Frequency	Percentage
Sex	Women	117	56.25
Sex	Men	85	40.87
Sex	Preferred not to say	6	2.88
Physical activity level	Low	33	15.87
Physical activity level	Medium	125	60.10
Physical activity level	High	50	24.04
Physical self-concept category	Low	34	16.35
Physical self-concept category	Medium	138	66.35
Physical self-concept category	High	36	17.31
Daily hours of physical activity	1 hour	23	11.06
Daily hours of physical activity	2 hours	59	28.37
Daily hours of physical activity	3 hours	104	50.00
Daily hours of physical activity	4 hours	22	10.58

Figure 1 shows the distribution of students by sex. The sample was mainly composed of women, followed by men and, to a lesser extent, students who preferred not to report this information.

Figure 1. Distribution of students by sex.

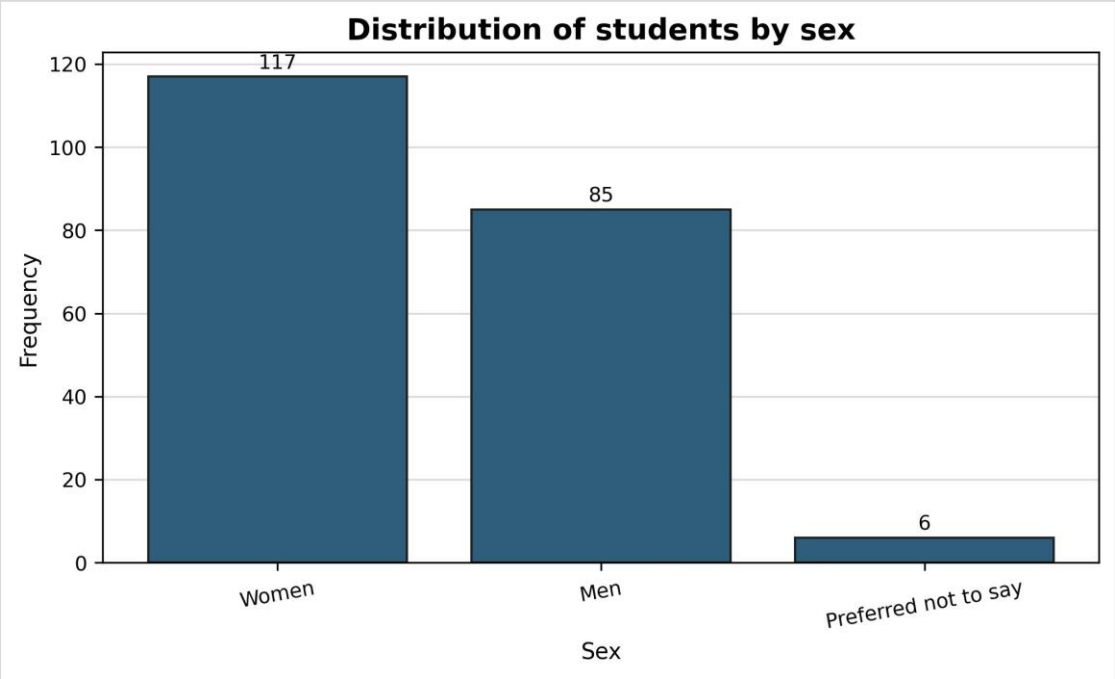


Figure 2 shows the distribution of the physical activity level reported by students. The highest frequency was concentrated at the medium level, followed by the high level and, finally, the low level.

Figure 2. Distribution by level of physical activity.

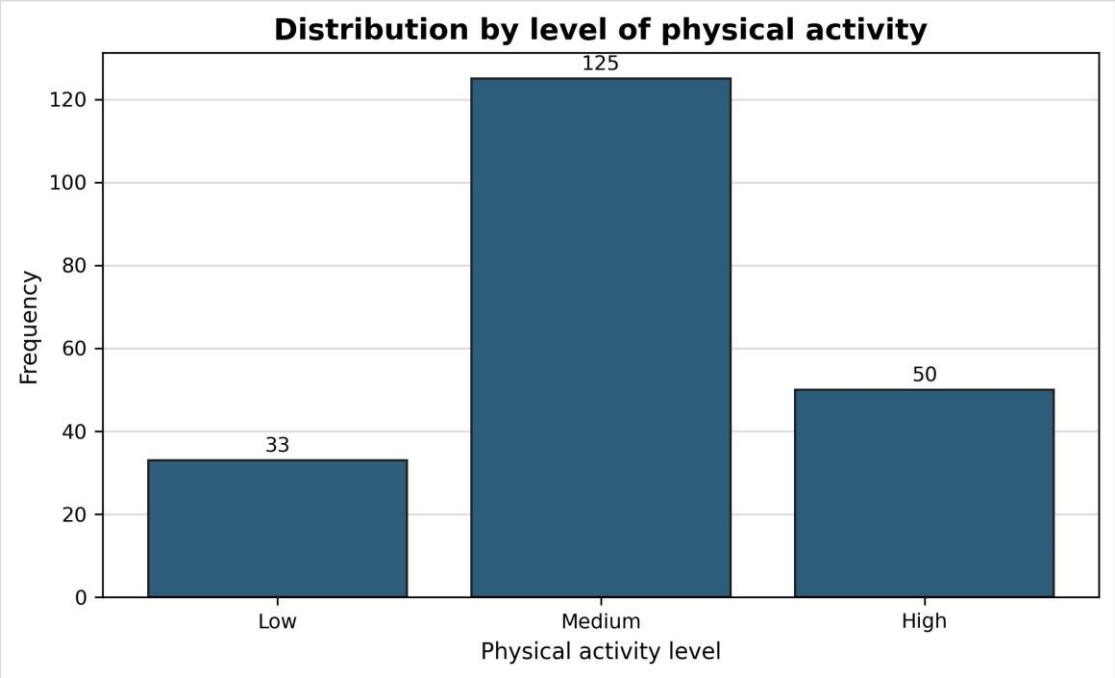
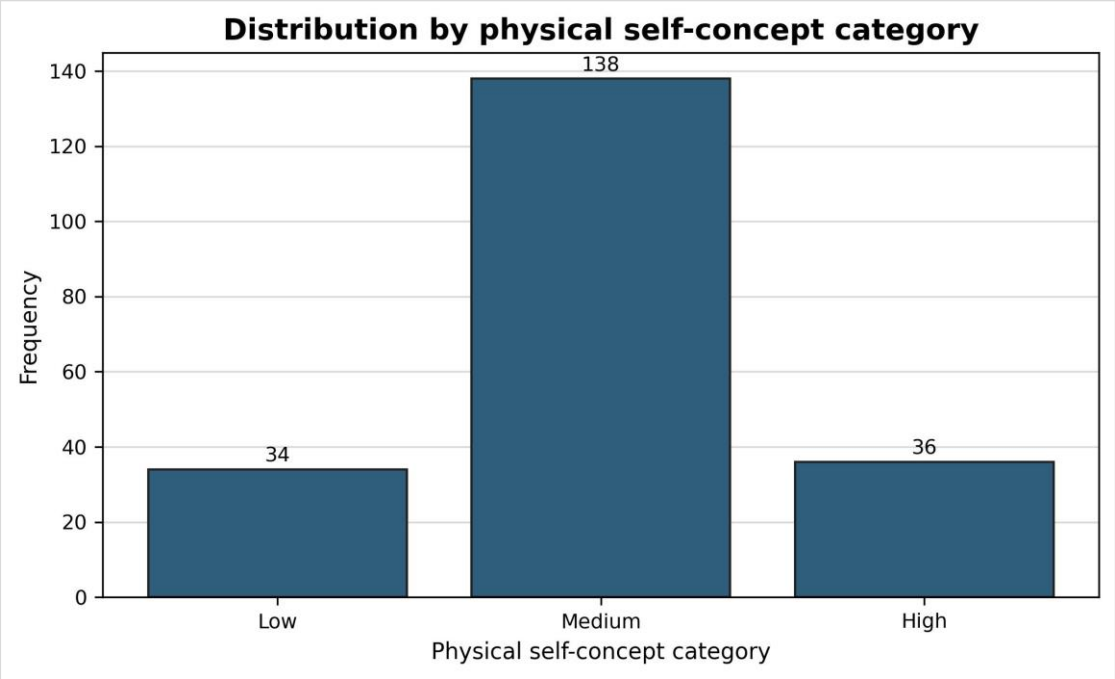


Figure 3 presents the distribution by physical self-concept category. Most students were located in the medium category, suggesting a general tendency toward moderate physical perceptions within the sample.

Figure 3. Distribution by physical self-concept category.



Regarding the time devoted to physical activity, Figure 4 shows that the most frequent category was three hours per day, followed by two hours, one hour, and four hours.

Figure 4. Daily hours devoted to physical activity.

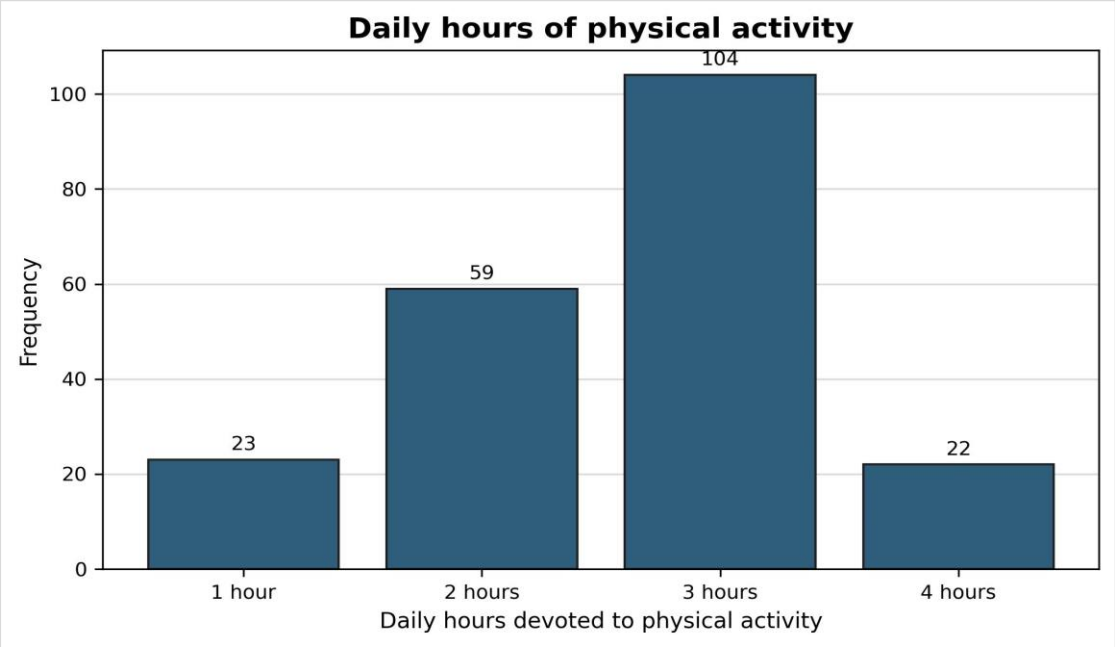


Figure 5 compares the average admission examination result according to physical self-concept category. Although the descriptive differences should not be interpreted as causal evidence, this comparison made it possible to observe initial variations between groups, which justified further analysis of the association between these variables.

Figure 5. Average admission examination result by physical self-concept category.

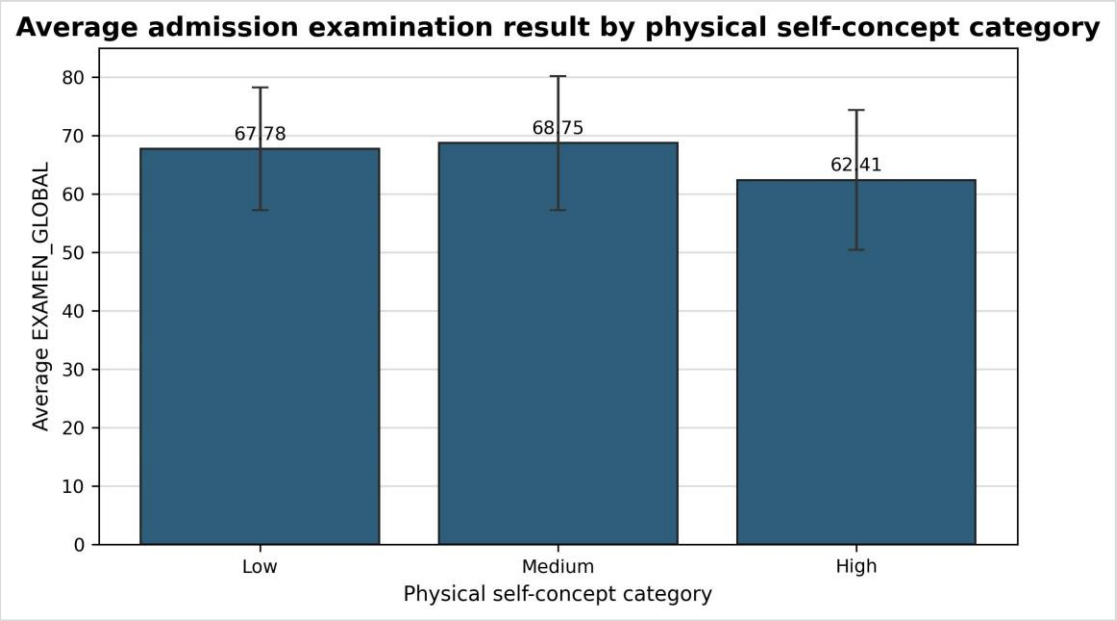


Table 2. Average admission examination result by physical self-concept category.

Physical self-concept category	Average EXAMEN_GLOBAL
Low	67.78
Medium	68.75
High	62.41

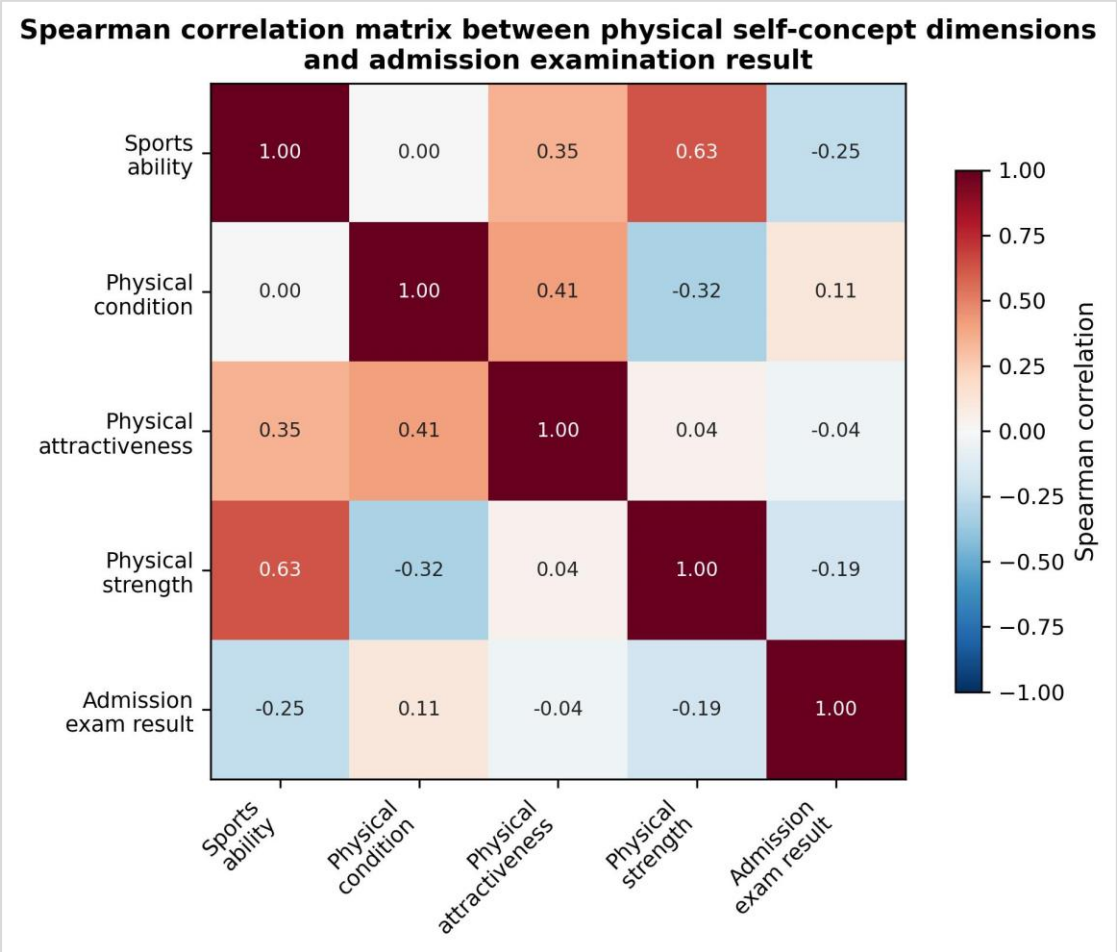
Spearman Correlational Analysis

Figure 6 presents the Spearman correlation matrix among the variables considered in the study. In general terms, the correlations showed low to moderate associations among the dimensions of physical self-concept, physical activity, and academic performance. As expected, the dimensions that make up physical self-concept showed positive correlations with one another, reflecting the conceptual consistency of the construct.

Regarding physical activity, positive associations were observed with the global physical self-concept score and with its different dimensions, suggesting that greater dedication to physical activity tends to accompany a more favorable perception of one's own physical abilities. In contrast, the correlations between academic performance and the physical self-concept variables were of lower magnitude, anticipating that the relationships between these constructs may be more complex than a simple bivariate association.

Taken together, the results of the correlational analysis provide an initial approximation to the structure of relationships among the variables studied and support the relevance of evaluating these associations through a structural equation model, which allows the simultaneous analysis of the direct and indirect effects proposed in the theoretical model.

Figure 6. Spearman correlation matrix between physical self-concept dimensions and admission examination result.



In general terms, the observed associations showed an intensity ranging from low to moderate, suggesting that, although the dimensions of physical self-concept share some degree of relationship, each one contributes differentiated information about students' physical perceptions.

The highest relationship was identified between sports ability and physical strength ($\rho = 0.63$), showing a positive association of moderately high magnitude. This result indicates that participants who perceived higher levels of ability for sports practice also tended to perceive themselves as physically stronger, which is consistent with the conceptual structure of the Physical Self-Concept Questionnaire (CAF). Likewise, a positive correlation was observed between physical condition and physical attractiveness ($\rho = 0.41$), as well as between sports ability and physical attractiveness ($\rho = 0.35$), suggesting that a better perception of physical condition and physical performance is usually accompanied by a more favorable evaluation of body image.

In contrast, some associations among dimensions were practically nonexistent or even negative. The absence of a relationship between sports ability and physical condition ($\rho \approx 0.00$) is noteworthy, as it indicates independence between both perceptions within the analyzed sample. Similarly, physical condition showed a moderate negative correlation with physical strength ($\rho = -0.32$), suggesting that the perception of better physical condition is not necessarily accompanied by greater self-perceived strength. Although this behavior differs from what might be expected conceptually, it shows that the dimensions of physical self-concept retain some independence and may be influenced by personal experiences, specific sports practices, or individual characteristics of the participants.

With respect to academic performance, represented by the global admission examination result, the observed associations were generally low in magnitude. The highest negative correlation was found with the sports ability dimension ($\rho = -0.25$), followed by physical strength ($\rho = -0.19$), whereas physical attractiveness showed an almost null relationship ($\rho = -0.04$). Conversely, physical condition was the only dimension that presented a positive association with academic performance ($\rho = 0.11$), although its magnitude was small. These results indicate that the relationships between physical self-concept and academic performance are neither linear nor homogeneous, and that the different dimensions of the construct may behave differently with respect to academic performance.

Overall, the correlation matrix shows that bivariate associations between the dimensions of physical self-concept and academic performance are relatively weak, while relationships among the physical self-concept dimensions themselves are stronger. This pattern is a relevant finding because it suggests that the influence of physical self-concept on academic performance can hardly be explained through simple correlations. Consequently, it is appropriate to use a multivariate approach such as structural equation modeling, which allows the simultaneous analysis of the structure of relationships among observed variables and latent constructs, estimating direct and indirect effects that are not evident through bivariate analysis.

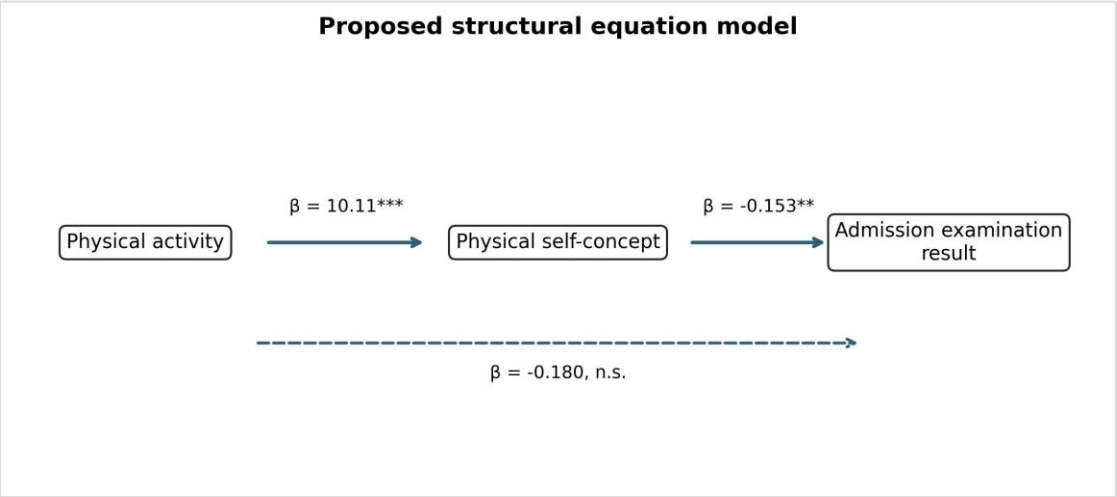
Finally, it is important to note that Spearman correlations represent monotonic associations between pairs of variables and, therefore, do not constitute evidence of causal relationships. Their usefulness lies in providing a first empirical approximation to the behavior of the variables studied and in supporting the specification of the theoretical model that was subsequently evaluated through structural equation modeling.

Structural Equation Model

Based on the evidence obtained from the descriptive analysis and the correlation matrix, a structural equation model was estimated in order to evaluate the relationships among physical activity, physical self-concept, and academic performance simultaneously. The model consisted of two complementary elements: a measurement model, designed to represent physical self-concept as a latent construct based on its observed dimensions, and a structural model, aimed at estimating the hypothesized relationships among the variables of interest.

Figure 7 shows the specification of the theoretical model evaluated. In this model, physical activity was proposed as an exogenous variable with a direct effect on physical self-concept and, additionally, on academic performance, represented by the global score obtained on the admission examination. Physical self-concept was also modeled as a latent variable with a direct effect on academic performance, allowing the evaluation of both the influence of physical activity on students' physical perceptions and the possible mediating role of physical self-concept in explaining academic performance.

Figure 7. Proposed structural equation model**.**



The global fit indices indicate that the structural equation model presented a limited fit to the observed data. Specifically, the values obtained for CFI (0.649), GFI (0.638), NFI (0.638), and TLI (0.376) were below the reference criteria commonly accepted for satisfactory fit, while RMSEA (0.239) exceeded the threshold recommended in the literature. Overall, these results suggest that the proposed model does not optimally reproduce the observed covariance structure; therefore, the estimated relationships should be interpreted with due caution.

Table 3. Global fit indices of the structural equation model.

Index	Obtained value	Interpretation
χ^2	113.613	Limited fit
CFI	0.649	Limited fit
GFI	0.638	Limited fit
AGFI	0.357	Limited fit
NFI	0.638	Limited fit
TLI	0.376	Limited fit
RMSEA	0.239	Limited fit
AIC	22.892	Information criterion
BIC	62.768	Information criterion

Nevertheless, global fit is only one criterion for evaluating structural equation models. In exploratory studies or studies with moderate sample sizes, such as the present one, it is possible to obtain informative structural estimates even when global fit indices do not reach ideal values. In this sense, the model made

it possible to examine the relationships proposed in the theoretical framework and to provide empirical evidence on the direction and magnitude of the effects among the variables analyzed.

In particular, the model identified a positive association between physical activity and physical self-concept, as well as a negative relationship between physical self-concept and academic performance. These results constitute the main findings of the study and are analyzed in greater detail below. Consequently, the structural coefficients should be interpreted as exploratory evidence limited to the sample studied, whose confirmation will require future research with larger samples and alternative models that improve global fit.

Table 4. Estimated structural effects.

Dependent variable	Predictor variable	Coefficient β	Standard error	z	p-value
Physical self-concept	Hours of physical activity	10.1075	1.3295	7.6026	<0.001
Admission examination result	Physical self-concept	-0.1530	0.0540	-2.8320	0.0046
Admission examination result	Hours of physical activity	-0.1796	1.0905	-0.1647	0.8692

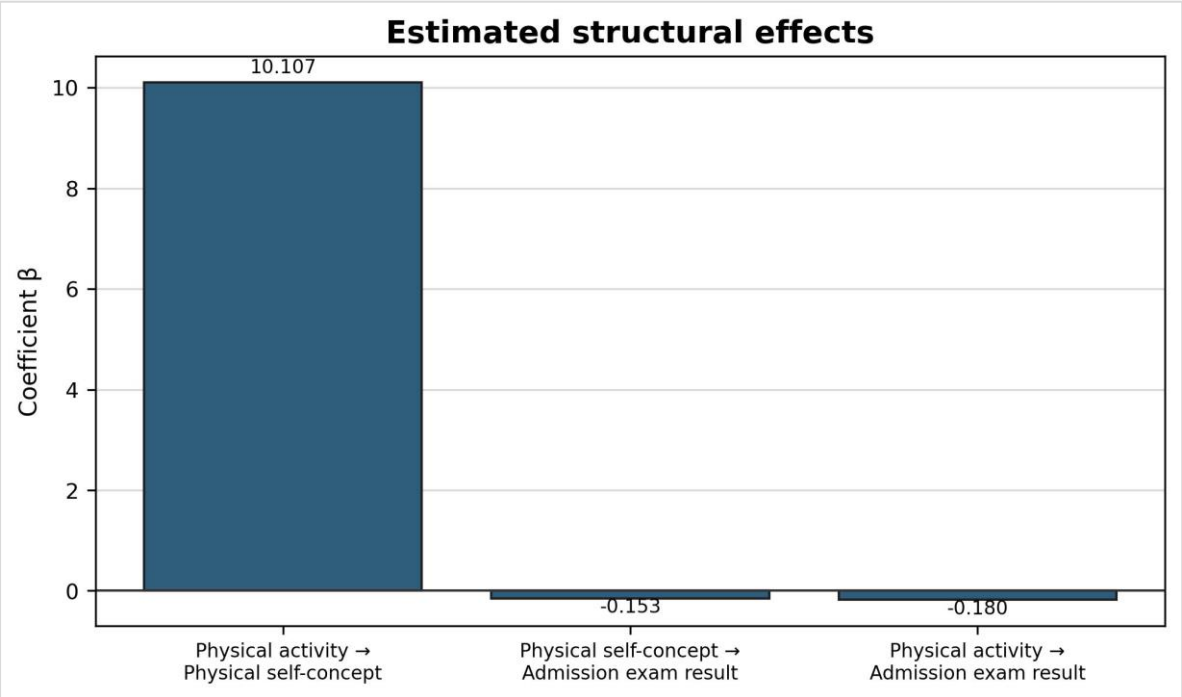
The estimated structural coefficients show that physical activity had a direct, positive, and statistically significant effect on physical self-concept, indicating that greater time devoted to physical activity is associated with a more favorable perception of one's own physical abilities and characteristics. This result is consistent with the theoretical approach of the model and supports the hypothesis that physical activity is a relevant factor in the construction of physical self-concept among university students.

In contrast, physical self-concept showed a direct negative and statistically significant effect on academic performance, represented by the global admission examination score. Although the magnitude of this effect was small, the direction of the relationship suggests that, in the analyzed sample, higher levels of physical self-concept were associated with slightly lower scores on the admission examination. This finding differs from part of the specialized literature and highlights the complexity of the interactions between physical factors and academic performance, particularly when these relationships are evaluated through multivariate models.

On the other hand, the direct effect of physical activity on academic performance did not reach statistical significance, indicating that the time devoted to physical activity did not, by itself, explain the observed differences in participants' academic performance. Consequently, the results suggest that the influence of physical activity on academic performance may be mediated by other personal, psychological, or contextual factors that were not incorporated into the structural model.

Considering the global fit obtained for the model, these results should be interpreted as exploratory evidence limited to the population studied. Nevertheless, the identified effects provide relevant information on the structure of relationships among the variables analyzed and constitute a starting point for future research that incorporates larger samples, new explanatory constructs, and alternative model specifications to improve explanatory capacity.

Figure 8. Estimated structural effects of the SEM model.



The sports competence and participation dimension was used as the reference indicator to establish the scale of physical self-concept; therefore, its factor loading was fixed at 1.0000 and no standard error, z-value, or p-value was estimated for this parameter. In contrast, perceived physical strength and general physical self-evaluation presented statistically significant loadings, providing relevant evidence for the construction of the latent variable of physical self-concept.

Table 5. Factor loadings of physical self-concept.

Indicator	Factor loading	Standard error	z	p-value
Sports competence and participation	1.0000	--	--	--
Physical attractiveness and body image	0.0179	0.0449	0.399	0.690
Perceived physical strength	0.2156	0.0419	5.144	<0.001
General physical self-evaluation	0.4189	0.0586	7.143	<0.001

Taken together, the results show that the bivariate correlations made it possible to identify preliminary associations between the dimensions of physical self-concept and academic performance; however, these relationships were insufficient to explain the complexity of the phenomenon analyzed. The incorporation of a structural equation model made it possible to integrate these associations into a broader analytical framework, representing physical self-concept as a latent construct and simultaneously estimating the direct relationships among physical activity, physical self-concept, and academic performance. Although the global fit of the model was limited, the structural analysis provided evidence about the direction and magnitude of the effects among the variables, allowing the identification of association patterns that cannot be captured through traditional correlational analyses.

CONCLUSIONS

The results obtained allow us to conclude that physical activity is positively associated with physical self-concept among university students, confirming the main hypothesis proposed in this study. This finding is consistent with the results reported by Sevil-Serrano et al. (2020), Núñez et al. (2021), and Lohbeck et al. (2021), who documented that greater participation in physical activities favors a more positive perception of students' physical abilities and characteristics. Overall, the evidence reinforces the importance of promoting physically active lifestyles as an element that contributes to strengthening physical self-concept during university education.

In contrast, the relationship identified between physical self-concept and academic performance showed a negative and statistically significant direction, a result that differs from a substantial part of recent literature. Studies such as those by Villodres et al. (2023) and Muntaner-Mas et al. (2022) have

documented positive associations among variables related to physical condition, well-being, and academic performance. This discrepancy shows that the relationship between both constructs depends on the context, the characteristics of the population studied, and the way in which academic performance is operationalized. In the present study, academic performance was represented by the score obtained on an admission examination, which constitutes a specific measure of cognitive performance at a given moment and does not necessarily reflect sustained academic performance throughout the university trajectory.

Similarly, the structural model showed that physical activity did not have a significant direct effect on academic performance. This result suggests that the influence of physical activity on school performance may be mediated by psychological, cognitive, or contextual variables that were not incorporated into the model. In this sense, the findings support the need to develop more comprehensive models that include variables such as motivation, executive functions, psychological well-being, study habits, or family support, which have been identified in recent research as relevant factors for understanding academic performance.

From a methodological perspective, one of the main contributions of this study lies in the application of structural equation modeling as a tool for analyzing relationships among observed variables and latent constructs simultaneously. Unlike traditional correlational analyses, SEM made it possible to represent physical self-concept as a latent variable and to integrate, within the same model, the direct effects among physical activity, physical self-concept, and academic performance. This approach is consistent with the methodological literature that recognizes SEM as one of the most robust techniques for studying complex multivariate phenomena in the social and behavioral sciences (Tarka, 2018).

Although the global fit indices showed a fit below conventionally accepted criteria, the structural coefficients provided exploratory evidence consistent with the proposed theoretical model. Consequently, the results should be interpreted with caution and limited to the analyzed sample. Future research should consider larger sample sizes, incorporate new explanatory constructs, and evaluate alternative models that improve global fit and deepen the understanding of the mechanisms linking physical activity and academic performance.

Finally, this study shows that the incorporation of advanced analytical methodologies, such as structural equation modeling, expands the possibilities of educational research by making it possible to understand the simultaneous interaction among physical, psychological, and academic factors. Beyond the specific findings obtained, the study demonstrates the potential of SEM to generate explanatory models with greater analytical richness, contributing to the development of evidence-based research and to the strengthening of data science applied to complex educational problems, a trend that continues to consolidate in contemporary educational research.

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