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Behavioral and Psychosocial Profiles Associated with Physical Activity Among University Women: A Hierarchical Segmentation Analysis

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Abstract

Physical activity (PA) participation among university women is influenced by behavioural, psychosocial, and contextual factors. This study aimed to identify hierarchical profiles associated with PA participation using exploratory segmentation methods. A multicentre cross-sectional study was conducted with 417 university women from Chile, Spain, Italy, and Mexico (mean age = 22.2 ± 5.1 years). Participants completed validated questionnaires assessing habitual PA (IPAQ-SF), perceived barriers to PA (BBAQ-21), dietary quality (HEI), and health-related characteristics. Classification and Regression Trees (CART) and Exhaustive Chi-square Automatic Interaction Detection (CHAID) analyses were performed. Self-reported PA change since the pandemic emerged as the first-order segmentation variable within both exploratory models. Women reporting reduced PA since the pandemic had lower observed compliance with WHO recommendations (62.7%) than those reporting stable or increased PA (85.8%). Lack of energy ($\chi^2 = 18.61$, $p < 0.001$) and lack of willpower ($\chi^2 = 28.63$, $p < 0.001$) were the barriers most strongly associated with less favourable PA profiles. These findings support the value of segmentation-oriented approaches for understanding behavioural heterogeneity and informing gender-sensitive health-promotion initiatives in higher education settings. Given the cross-sectional and self-reported design, findings should be interpreted as exploratory segmentation patterns rather than predictive or causal evidence.

Keywords: university women; health-promoting universities; psychosocial barriers; CART; CHAID analysis



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1. Introduction

Physical activity (PA) and healthy dietary behaviours are key modifiable determinants of long-term physical and psychological health. Regular PA is associated with improved cardiovascular, metabolic, and mental well-being, while healthy dietary patterns contribute to weight regulation and reduced risk of chronic disease [1,2]. Increasingly, these behaviours are understood as interconnected components of broader lifestyles that also encompass sleep, stress management, and emotional well-being [3–5].

The university years represent a critical period for the development and consolidation of health-related habits. During this transition, young adults experience substantial changes in autonomy, academic responsibilities, social relationships, and daily routines [6–8]. Although this stage can promote positive lifestyle development, it is frequently associated with declining PA participation, increased sedentary behaviour, poorer dietary quality,

and heightened psychological distress [3,9,10]. Because these patterns often persist beyond graduation, identifying factors associated with healthier lifestyles during emerging adulthood remains an important public health priority [3].

These concerns are particularly relevant among women. Compared with men, women consistently report lower PA participation and higher levels of sedentary behaviour, with disparities often widening during emerging adulthood [11–13]. Female university students also report greater psychosocial barriers to PA, including concerns related to body image, social evaluation, perceived competence, emotional burden, and competing academic demands [11,14]. Qualitative studies further suggest that exercise settings may be perceived as intimidating or uncomfortable when women anticipate judgment or unfavourable social comparisons [14]. Together, these findings indicate that women's PA behaviours are influenced by a complex combination of behavioural, psychosocial, and contextual factors.

Socioecological approaches provide a useful framework for understanding this complexity by recognising that PA behaviours emerge through interactions among individual, interpersonal, organisational, and environmental influences [15,16]. Within university settings, PA participation has been linked to psychological resources, social support, accessibility of facilities, and opportunities for engagement provided by the institution [7,17]. Research informed by the Capability, Opportunity, Motivation–Behaviour (COM-B) model and the Theoretical Domains Framework (TDF) similarly highlights the role of social influences, environmental opportunities, and motivational processes in shaping PA participation [7]. Time constraints, academic pressures, low energy, and motivational difficulties remain among the most frequently reported barriers [18].

Psychosocial experiences appear equally important. Supportive peer relationships and positive exercise environments can facilitate PA participation and adherence [19,20], whereas limited social support, emotional exhaustion, stress, and depressive symptoms may discourage engagement in active lifestyles [14,19]. At the same time, regular PA has been associated with improved emotional well-being, reduced stress, and enhanced self-esteem [19].

Dietary behaviours often show similar vulnerabilities. University students frequently report suboptimal dietary quality, emotional eating patterns, and increased consumption of processed foods [3,21]. Importantly, health behaviours rarely occur in isolation. Growing evidence suggests that PA tends to cluster with dietary, psychosocial, and contextual characteristics, generating broader lifestyle configurations that differ in their implications for health and well-being [22–24].

Recognition of this heterogeneity has stimulated increasing interest in person-centred approaches capable of identifying differentiated behavioural profiles within university populations [4,9,25]. Traditional variable-centred methods estimate the independent contribution of specific predictors but may overlook the ways in which behavioural and psychosocial characteristics combine within individuals. In contrast, segmentation approaches seek to identify subgroups characterised by distinct configurations of experiences, behaviours, and vulnerabilities.

The Health-Promoting Universities (HPU) framework further supports the value of such approaches by recognising universities as settings capable of shaping health behaviours through institutional policies, supportive environments, and opportunities that facilitate healthier choices [26]. Consequently, women's participation in PA may depend not only on individual characteristics but also on features of the educational contexts in which they study [7,27].

The exclusive focus on university women was intentional. Previous studies consistently demonstrate that women report lower PA participation, greater perceived barriers, and higher psychosocial vulnerability than men during emerging adulthood [18,28,29].

Analysing women separately may therefore facilitate the identification of patterns that could remain obscured in mixed-sex samples and support the development of more targeted health-promotion strategies.

Despite growing recognition of the multidimensional determinants of PA, relatively few studies have examined how behavioural, dietary, psychosocial, and contextual characteristics combine to form distinct PA-related profiles among university women. Decision-tree procedures such as Classification and Regression Trees (CART) and Exhaustive Chi-square Automatic Interaction Detection (CHAID) offer a useful means of exploring hierarchical interactions and context-sensitive subgroup patterns that may not emerge through conventional analytical approaches. These methods generate transparent segmentation structures that facilitate interpretation and the identification of potentially vulnerable groups within health-promotion contexts.

Accordingly, the aim of this study was to identify hierarchical behavioural profiles associated with differing levels of PA participation among university women using CART and Exhaustive CHAID segmentation methods. Specifically, the study examined PA participation in relation to perceived barriers to PA, dietary quality, and selected contextual characteristics within a multicentre sample of university women from Chile, Spain, Italy, and Mexico. These countries participated through established academic collaborations, enabling the implementation of a common research protocol across diverse university settings. Figure 1 presents the conceptual framework informing the study. This framework serves solely as a theoretical illustration of associations reported in the literature and does not imply causal relationships among the variables examined.

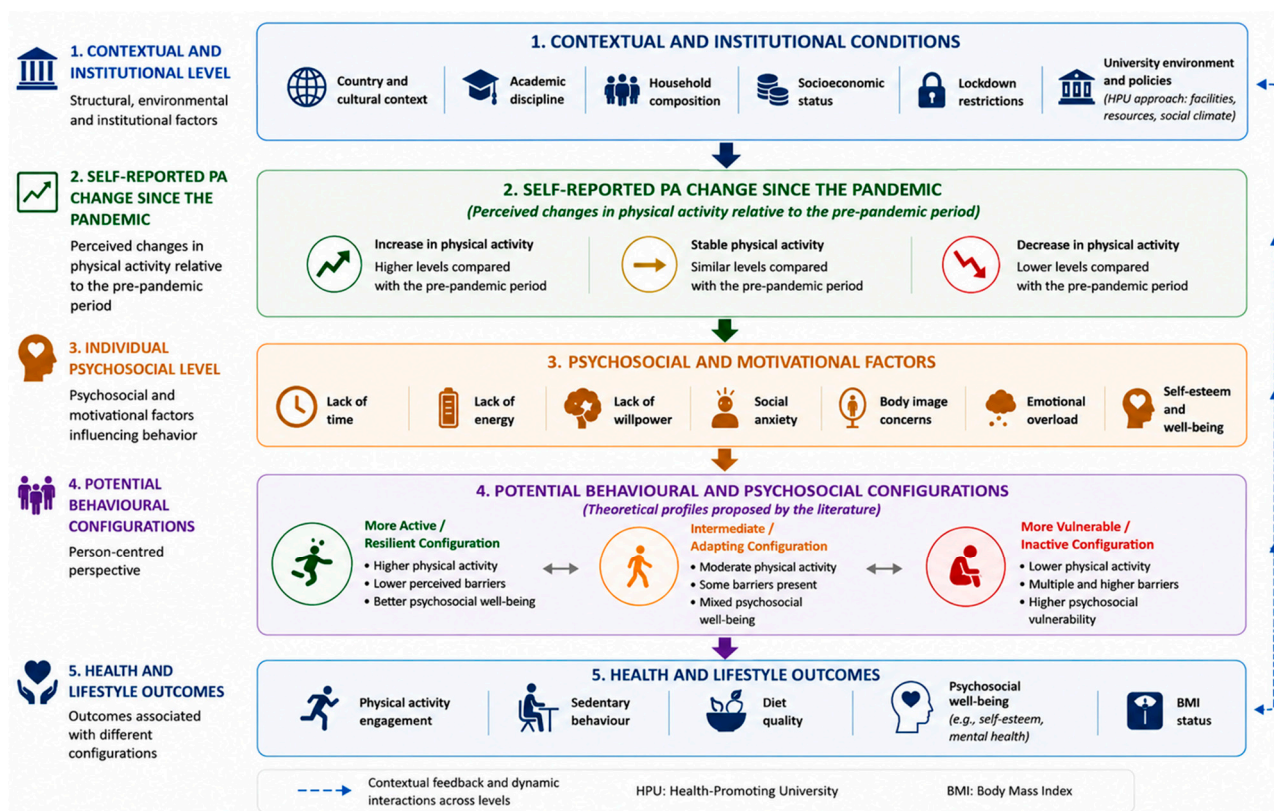


Figure 1. Conceptual framework derived from the reviewed literature. The framework summarises theoretically informed associations derived from the literature and is intended solely for conceptual illustration. The present study was not designed to test causal pathways among the proposed constructs. Solid downward arrows indicate conceptual flow, double-headed arrows indicate continua between theoretical profiles, and dashed arrows indicate potential feedback across levels.

2. Materials and Methods

2.1. Research Design and Participants

This multicentre cross-sectional study adopted a person-centred analytical approach to identify behavioural profiles associated with physical activity (PA) among university women. The study was conducted through an international collaboration involving universities in Chile, Spain, Italy, and Mexico and was conceived as an exploratory multicentre investigation rather than an attempt to obtain nationally representative samples.

Participants were recruited between November 2023 and April 2024 using institution-based convenience sampling. Recruitment reflected the academic programmes accessible to each participating research team and did not seek strict equivalence of disciplines across countries. Consequently, the academic composition of the national subsamples varied according to the organisational characteristics of the participating institutions. Additional information regarding recruitment settings, target populations, and approximate response rates is provided in Supplementary Table S1.

Eligibility criteria included: (i) being enrolled as an undergraduate student, (ii) being 18 years of age or older, (iii) self-identifying as female, and (iv) providing informed consent before participation.

A total of 808 questionnaires were initially received through the online platform. Following data screening, 686 complete questionnaires were retained for eligibility assessment. Cases were excluded when substantial missing information affected key study variables (e.g., IPAQ-SF, BBAQ-21, or self-reported anthropometric data), when duplicate submissions were identified through timestamp and IP verification, or when inconsistencies across critical variables compromised data interpretation. Male respondents were excluded from the present analyses.

The final analytical sample comprised 417 women from Chile ($n = 57$, 13.7%), Spain ($n = 109$, 26.1%), Italy ($n = 134$, 32.1%), and Mexico ($n = 117$, 28.1%). The academic composition of the sample differed across countries, reflecting the disciplinary profiles of the participating institutions. Detailed information on academic programmes and sociodemographic characteristics is presented in Supplementary Tables S1 and S3.

The study was conducted and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) recommendations for cross-sectional research [30].

2.2. Data Collection Instruments

Data were collected using a self-administered online questionnaire developed in Google Forms. The survey was originally prepared in Spanish and subsequently translated into Italian through forward–backward translation procedures involving bilingual experts to ensure semantic and contextual equivalence.

Although forward–backward translation procedures were used when required, formal tests of cross-cultural measurement invariance were not conducted. Therefore, the translated instruments were assumed to be semantically equivalent for descriptive and exploratory purposes, but strict metric equivalence across countries cannot be guaranteed.

2.2.1. Sociodemographic and Contextual Variables

Participants reported their age, country, academic programme, year of study, employment status, living arrangement, perceived financial autonomy, and perceived socioeconomic status.

Sex was assessed using a binary response option (“male” or “female”), and only respondents identifying as female were included in the present analyses. Accordingly, the term women refers to the sex-based composition of the sample, whereas gender-

related terminology is used when discussing psychosocial and sociocultural influences on PA behaviours.

Country was included as a contextual segmentation variable rather than as a direct indicator of national culture. Given the differences in institutional settings, academic composition, and recruitment contexts across participating universities, country was interpreted as a composite contextual indicator encompassing sociocultural, educational, and environmental influences.

2.2.2. Health-Related Variables

Participants self-reported their height and weight, which were used to calculate body mass index (BMI) and classify weight status according to World Health Organization criteria [31]. Additional health-related variables included current medical or psychological treatment, adherence to a medically prescribed diet, previous COVID-19 diagnosis, perceived restrictions on PA participation during the pandemic period, and self-reported PA change since the pandemic. For the latter, participants retrospectively reported whether they perceived their current PA levels as higher than, lower than, or similar to their PA levels before the COVID-19 pandemic. Consistent with the exploratory nature of the study, this variable was interpreted as a subjective perception of behavioural change rather than an objectively verified longitudinal trajectory.

2.2.3. Habitual Physical Activity

Habitual PA was assessed using the International Physical Activity Questionnaire–Short Form (IPAQ-SF) [32], which evaluates the frequency and duration of walking, moderate-intensity PA, and vigorous-intensity PA performed during the previous seven days.

Weekly PA volume was calculated as metabolic equivalent minutes per week (MET-min/week) following established scoring procedures. Participants were classified as having low (<600 MET-min/week), moderate (600–1500 MET-min/week), or high (>1500 MET-min/week) PA levels [32,33]. Previous studies have reported acceptable reliability and validity of the IPAQ-SF among adult and university populations [32,34]. Given the known limitations of self-report measures, IPAQ-SF scores were interpreted as epidemiological indicators suitable for behavioural profiling rather than as objective estimates of energy expenditure [35].

Within the present study, IPAQ-SF categories were used in the hierarchical segmentation analyses. CART models examined compliance with World Health Organization PA recommendations, whereas CHAID models explored differences across low, moderate, and high PA levels. Because measurement invariance across countries was not assessed, cross-national comparisons should be considered exploratory.

2.2.4. Perceived Barriers to Physical Activity

Perceived barriers to PA were assessed using the Barriers to Being Active Questionnaire (BBAQ-21) [36]. The instrument comprises 21 items distributed across seven domains: lack of time, social influences, lack of energy, lack of willpower, fear of injury, lack of skills, and lack of resources.

Items are rated on a four-point Likert scale ranging from 0 (“not very likely”) to 3 (“very likely”), yielding domain scores between 0 and 9. Scores ≥ 5 indicate the presence of a meaningful perceived barrier according to the original scoring guidelines [36].

The BBAQ-21 has demonstrated acceptable psychometric properties in university populations [37], and subsequent cross-cultural research supports its applicability in educational settings [38]. Each domain was analysed as an independent predictor to preserve conceptual specificity.

2.2.5. Dietary Quality

Dietary quality was assessed using the Healthy Eating Index (HEI) adapted for Spanish-speaking populations [39]. For the Italian subsample, the questionnaire was translated using the same forward–backward procedure applied to the remaining study materials; however, formal cross-cultural validation and measurement invariance across countries were not assessed.

The HEI evaluates adherence to healthy eating recommendations across nine food groups and generates a total score ranging from 0 to 100. Scores were classified as indicating an unhealthy diet (<50), a diet requiring improvement (50–80), or a healthy diet (>80). Previous studies support the validity and sensitivity of the HEI for differentiating dietary patterns among university students [40,41].

2.3. Procedures and Ethical Considerations

Data collection was conducted between November 2023 and April 2024. The questionnaire was distributed electronically through institutional communication channels, including university email systems, virtual learning environments, and classroom announcements. Teaching staff at each participating institution provided standardised instructions regarding study participation and questionnaire completion.

Participation was anonymous and voluntary, and no incentives were offered. Before accessing the questionnaire, participants received information regarding the study objectives, participation requirements, confidentiality safeguards, and data protection procedures. Electronic informed consent was obtained from all participants prior to participation.

The questionnaire required approximately 12 min to complete. Responses were stored in secure databases accessible only to authorised members of the research team. Duplicate submissions were screened through timestamp and IP verification procedures. Following data cleaning, missing data accounted for less than 2% of the dataset and were handled using pairwise deletion where appropriate.

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki [42] and was approved by the Ethics Committee of the Institute of Agricultural and Rural Sciences (ICAR), Autonomous University of the State of Mexico (UAEMex) (approval code: 01-SEP-2023; approved on 14 July 2023).

2.4. Statistical Analysis

Data were analysed using IBM SPSS Statistics version 29.0 (IBM Corp., Armonk, NY, USA). Statistical significance was established at $p < 0.05$. Continuous variables are presented as means and standard deviations (SD), whereas categorical variables are reported as frequencies and percentages.

Preliminary analyses indicated that several continuous variables did not satisfy assumptions of normality and homogeneity of variance. Accordingly, cross-national comparisons involving continuous outcomes were conducted using Kruskal–Wallis tests with epsilon-squared coefficients (ϵ^2) as measures of effect size. When significant differences were detected, Dunn–Bonferroni post hoc tests were performed.

Associations between categorical variables and habitual PA levels were examined using Pearson's chi-square tests (χ^2) and Cramer's V coefficients. Adjusted standardized residuals (ASR, ± 1.96) were inspected to identify cells contributing significantly to observed associations. Linear-by-linear association tests were additionally performed for ordinal variables.

To explore whether differences in PA levels across countries might be influenced by variations in academic composition, an exploratory ordinal logistic regression analysis was conducted with country and academic programme entered simultaneously as predictors of

PA level (low, moderate, high). Additional ordinal logistic regression models examined associations between perceived barriers and habitual PA levels. Model adequacy was evaluated using likelihood-ratio chi-square statistics, Pearson and deviance goodness-of-fit indices, pseudo- R^2 coefficients (Cox and Snell, Nagelkerke, and McFadden), and the test of parallel lines. Regression coefficients (β), odds ratios (OR), 95% confidence intervals (CI), and Wald statistics were calculated.

The complete output of the exploratory ordinal logistic regression examining the simultaneous contribution of country and academic programme is reported in Supplementary Table S2, including parameter estimates, standard errors, Wald statistics, odds ratios, 95% confidence intervals, and pseudo- R^2 indices.

Potential multicollinearity among the seven BBAQ domains was examined using Pearson correlation coefficients. Although all domains were significantly interrelated ($p < 0.001$), correlation magnitudes (0.169–0.542) remained below commonly accepted thresholds for problematic overlap, supporting their inclusion as separate predictors.

The principal analytical focus was to explore hierarchical behavioural profiles associated with PA participation using Classification and Regression Trees (CART) and Exhaustive Chi-square Automatic Interaction Detection (CHAID). These decision-tree methods were selected because they facilitate the exploration of interactions among multiple predictors and the identification of context-sensitive subgroup profiles.

Predictor selection was informed by socioecological models of health behaviour [16] and the Health-Promoting Universities framework [26]. Candidate variables included demographic, academic, health-related, behavioural (including self-reported PA change since the pandemic), and psychosocial indicators.

The CART procedure employed the CRT growing method with the Gini impurity criterion to distinguish between participants who met and those who did not meet World Health Organization PA recommendations. The category ‘not meeting WHO PA recommendations’ was specified as the target category to facilitate the identification of subgroup profiles characterised by insufficient PA. Maximum tree depth was limited to five levels, with minimum node sizes of 50 cases for parent nodes and 25 cases for child nodes. Ten-fold cross-validation was applied to enhance model stability.

Exhaustive CHAID analyses were subsequently performed to identify hierarchical profiles across low-, moderate-, and high-PA categories. Bonferroni-adjusted chi-square splitting criteria were applied at each stage. The CHAID model was limited to three levels while maintaining the same minimum node-size criteria and cross-validation procedures used in the CART analyses. These parameters were selected to balance model interpretability and subgroup stability while reducing the risk of overfitting, consistent with established recommendations for decision-tree modelling [43–45].

Model performance was evaluated using classification accuracy, resubstitution and cross-validation risk estimates, gain-index analyses, and classification matrices. Consistent with the exploratory aims of the study, decision-tree procedures were interpreted primarily as segmentation and hypothesis-generating tools rather than predictive models intended for individual-level classification.

Decision-tree diagrams were generated using the visualisation functions available in IBM SPSS Statistics version 29.0. Parent and terminal nodes display the distribution of PA categories within each subgroup, whereas branch splits represent the predictor variables producing the greatest statistically significant reductions in node impurity according to the respective CART and Exhaustive CHAID algorithms.

3. Results

3.1. Sample Characteristics

Significant differences were observed across countries for several demographic, behavioural, and health-related characteristics (Table 1). Age varied substantially, with Italian participants representing the oldest subgroup and Spanish and Mexican students comprising the youngest groups ($p < 0.001$, $\epsilon^2 = 0.18$). Healthy Eating Index (HEI) scores also differed significantly ($p < 0.001$, $\epsilon^2 = 0.09$), with Italian and Spanish students reporting more favourable dietary patterns than Mexican students, who exhibited the lowest dietary quality scores.

Table 1. Descriptive characteristics of the sample according to country.

Variable	Total (<i>n</i> = 417)	Chile (<i>n</i> = 57)	Spain (<i>n</i> = 109)	Italy (<i>n</i> = 134)	Mexico (<i>n</i> = 117)	<i>p</i> -Value	Effect Size (ϵ^2)
Age (years)	22.2 ± 5.1	22.4 ± 3.1	20.5 ± 2.1	25.1 ± 7.3	20.3 ± 2.5	<0.001	0.18
Healthy Eating Index	63.9 ± 12.9	61.9 ± 13.5	66.0 ± 11.9	67.5 ± 12.4	58.7 ± 12.4	<0.001	0.09
Vigorous PA (MET-min/week)	1621.8 ± 2238.4	2147.1 ± 2214.6	1437.1 ± 2056.0	1822.7 ± 2234.5	1307.9 ± 2372.1	<0.001	0.07
Moderate PA (MET-min/week)	688.8 ± 988.7	795.1 ± 985.8	467.9 ± 640.0	837.9 ± 1146.3	672.2 ± 1035.2	0.084	—
Walking PA (MET-min/week)	1388.5 ± 1281.8	1447.7 ± 1301.3	1268.9 ± 1169.9	1670.7 ± 1483.8	1147.9 ± 1053.7	0.061	—
Total PA (MET-min/week)	3748.9 ± 3325.7	4389.9 ± 3637.9	3364.3 ± 2587.4	4331.3 ± 3559.1	3128.0 ± 3376.1	0.002	0.05
Perceived barriers (n)	2.0 ± 1.9	1.3 ± 1.8	1.5 ± 1.6	1.9 ± 1.6	2.9 ± 2.2	<0.001	0.16
BMI (kg/m ²)	22.6 ± 3.8	23.9 ± 3.0	21.5 ± 2.9	21.9 ± 4.0	23.9 ± 4.1	<0.001	0.11

Note. Values are presented as mean (M) and standard deviation (SD). HEI = Healthy Eating Index; MET = metabolic equivalent of task.

Differences in PA were identified for vigorous ($p < 0.001$, $\epsilon^2 = 0.07$) and total PA volume ($p = 0.002$, $\epsilon^2 = 0.05$), although effect sizes remained small. Chilean and Italian women demonstrated the highest overall PA volumes, whereas Mexican students reported the lowest levels. No significant differences were observed for moderate-intensity or walking-related PA.

Perceived barriers to PA differed significantly across countries ($p < 0.001$, $\epsilon^2 = 0.16$). Mexican participants reported the highest number of barriers, whereas Chilean and Spanish students tended to report fewer barriers overall. Significant differences in BMI were also observed ($p < 0.001$, $\epsilon^2 = 0.11$), with higher mean values identified among Chilean and Mexican participants than among their Spanish and Italian counterparts.

Several categorical variables differed by country. The strongest association emerged for academic programme ($\chi^2(21) = 1053.47$, $p < 0.001$, $V = 0.92$), reflecting differences in the institutional and disciplinary composition of the participating universities. Significant associations were also observed for living arrangement ($\chi^2(3) = 19.63$, $p < 0.001$, $V = 0.22$), household size ($\chi^2(12) = 40.04$, $p < 0.001$, $V = 0.18$), perceived socioeconomic status ($\chi^2(15) = 174.99$, $p < 0.001$, $V = 0.37$), employment status ($\chi^2(3) = 24.49$, $p < 0.001$, $V = 0.24$), and treatment status ($\chi^2(6) = 29.90$, $p < 0.001$, $V = 0.19$). Collectively, these find-

ings indicate that the participating national subsamples differed across several contextual characteristics relevant to the interpretation of subsequent analyses.

Significant variation was also observed in self-reported COVID-19 history ($\chi^2(6) = 59.79$, $p < 0.001$, $V = 0.27$), perceived restrictions affecting PA participation during the pandemic ($\chi^2(9) = 66.46$, $p < 0.001$, $V = 0.23$), and self-reported PA change since the pandemic ($\chi^2(12) = 23.99$, $p = 0.020$, $V = 0.14$). Chilean participants more frequently reported increases in PA, whereas Italian students more commonly described stable activity patterns.

Finally, habitual PA levels differed significantly between countries ($\chi^2(6) = 34.50$, $p < 0.001$, $V = 0.20$). Chilean students were overrepresented in the high-PA category (64.9%, ASR = 2.7), whereas Italian participants were more frequently classified within the low-PA category (35.1%, ASR = 4.4). Mexican students were overrepresented in the moderate-PA category. Detailed distributions for academic, sociodemographic, health-related, and behavioural characteristics are provided in Supplementary Tables S3–S5.

Because measurement invariance across countries was not formally assessed, cross-country differences in self-reported PA, dietary quality, and perceived barriers should be interpreted as observed subgroup differences rather than as definitive evidence of equivalent behavioural contrasts across national contexts.

3.2. Physical Activity Levels According to Behavioural and Contextual Characteristics

Habitual PA levels varied according to several behavioural and contextual characteristics. Significant associations were observed between PA level and country ($\chi^2(6) = 34.50$, $p < 0.001$, $V = 0.20$). Chilean students were overrepresented in the high-PA category (64.9%, ASR = 2.7), whereas Italian participants were overrepresented in the low-PA category (35.1%, ASR = 4.4).

Academic programme was also associated with PA level ($\chi^2(14) = 39.27$, $p < 0.001$, $V = 0.22$). Students enrolled in Physical Education Pedagogy showed the most favourable PA distribution, with 64.9% classified in the high-PA category (ASR = 2.7). In contrast, Lifespan Psychology students exhibited the highest proportion of low PA levels (42.6%, ASR = 3.9). Given the substantial overlap between participating countries and academic programmes, these findings should be interpreted as descriptive subgroup differences rather than evidence of independent disciplinary effects.

Perceived socioeconomic status was modestly associated with PA level ($\chi^2(10) = 19.22$, $p = 0.038$, $V = 0.15$). Participants reporting lower socioeconomic status were more frequently represented in the high-PA category, whereas those reporting upper-middle socioeconomic status were more frequently represented in lower PA categories.

Self-reported PA change since the pandemic demonstrated one of the strongest associations with current PA levels ($\chi^2(8) = 44.97$, $p < 0.001$, $V = 0.23$). Participants reporting substantial increases in PA were predominantly classified within the high-PA category (73.7%, ASR = 4.1), whereas those reporting reductions in PA were more frequently represented in the low-PA category (34.9%, ASR = 3.7). A significant linear trend ($\chi^2(1) = 36.87$, $p < 0.001$) suggested a graded relationship between perceived behavioural changes and current PA participation.

Dietary quality was also associated with PA level ($\chi^2(4) = 14.98$, $p = 0.005$, $V = 0.13$). Students reporting healthier dietary patterns were more frequently classified within the high-PA category (70.0%, ASR = 2.9), whereas participants whose diets required improvement were more commonly represented within the moderate-PA category (32.5%, ASR = 2.4). A significant linear trend ($\chi^2(1) = 5.89$, $p = 0.015$) further supported the clustering of healthier dietary habits with more favourable PA profiles.

No significant associations were identified between PA level and the remaining categorical variables examined ($p > 0.05$).

To explore whether the differences in PA levels observed across countries might be influenced by the academic composition of the participating subsamples, an exploratory ordinal logistic regression analysis was conducted with country and academic programme entered simultaneously as predictors. The model provided a statistically significant improvement over the intercept-only solution ($\chi^2(9) = 22.51, p = 0.007$), although the amount of explained variance was small (Cox and Snell $R^2 = 0.053$, Nagelkerke $R^2 = 0.060$, McFadden $R^2 = 0.026$).

After accounting for country, academic programme was not significantly associated with PA level (all $p > 0.25$). Among the country comparisons, only Chile differed significantly from the reference category (Mexico), with Chilean participants showing greater odds of belonging to higher PA categories ($\beta = 1.09$, OR = 2.98, Wald = 6.13, $p = 0.013$, 95% CI for OR [1.25, 7.06]). No significant effects were observed for Spain ($\beta = 0.27, p = 0.518$) or Italy ($\beta = -0.33, p = 0.636$). Full model estimates are presented in Supplementary Table S2.

Taken together, these results suggest that the country-related patterns identified in the CART and CHAID analyses are unlikely to be explained solely by differences in academic discipline. At the same time, the modest explanatory capacity of the model indicates that both country and academic programme accounted for only a limited proportion of the variability in PA levels. In addition, the proportional odds assumption was not fully satisfied ($\chi^2(9) = 25.99, p = 0.002$). For these reasons, the findings should be regarded as exploratory and interpreted cautiously, particularly given the overlap between country, institution, and academic programme within several of the participating subsamples.

3.3. Associations Between Perceived Barriers and Physical Activity

Several perceived barriers to PA were associated with habitual PA levels (Table 2). Overall, students reporting fewer barriers tended to exhibit more favourable PA profiles, although the magnitude and consistency of these associations varied across domains.

Table 2. Distribution of habitual physical activity levels according to perceived barriers to performing desired physical activity.

Barrier	Group	Low PA Level f_i (%) [ASR]	Moderate PA Level f_i (%) [ASR]	High PA Level f_i (%) [ASR]
	Total	92 (22.1)	123 (29.5)	202 (48.4)
Lack of time *	No	49 (20.0) [−1.2]	63 (25.7) [−2.0]	133 (54.3) [2.9]
	Yes	43 (25.0) [1.2]	60 (34.9) [2.0]	69 (40.1) [−2.9]
Lack of social support *	No	65 (22.1) [0.0]	75 (25.5) [−2.8]	154 (52.4) [2.5]
	Yes	27 (22.0) [0.0]	48 (39.0) [2.8]	48 (39.0) [−2.5]
Lack of energy ***	No	43 (17.9) [−2.4]	59 (24.6) [−2.6]	138 (57.5) [4.3]
	Yes	49 (27.7) [2.4]	64 (36.2) [2.6]	64 (36.2) [−4.3]
Lack of willpower ***	No	42 (17.1) [−2.9]	58 (23.6) [−3.2]	146 (59.3) [5.3]
	Yes	50 (29.2) [2.9]	65 (38.0) [3.2]	56 (32.7) [−5.3]
Fear of injury	No	87 (22.1) [0.1]	116 (29.5) [0.0]	190 (48.3) [−0.2]
	Yes	5 (20.8) [−0.1]	7 (29.2) [0.0]	12 (50.0) [0.2]
Lack of skills *	No	85 (23.5) [1.9]	99 (27.4) [−2.4]	177 (49.0) [0.6]
	Yes	7 (12.5) [−1.9]	24 (42.9) [2.4]	25 (44.6) [−0.6]
Lack of resources	No	65 (21.2) [−0.7]	87 (28.3) [−0.9]	155 (50.5) [1.4]
	Yes	27 (24.5) [0.7]	36 (32.7) [0.9]	47 (42.7) [−1.4]

Notes: f_i = absolute frequency; % = row percentage; ASR = adjusted standardised residual. *** $p < 0.001$ /* $p < 0.05$.

Perceived lack of time was associated with PA level ($\chi^2(2) = 8.21, p = 0.016, V = 0.14$). Students who did not identify time constraints as a barrier were overrepresented in the high-PA category (54.3%, ASR = 2.9), whereas those reporting this barrier were more

frequently classified within the moderate-PA category (34.9%, ASR = 2.0). A significant linear trend further supported this association ($\chi^2(1) = 5.83, p = 0.016$).

Perceived lack of social support also differed according to PA level ($\chi^2(2) = 8.56, p = 0.014, V = 0.14$). Students who did not perceive inadequate social support as a barrier were overrepresented in the high-PA category (52.4%, ASR = 2.5), whereas those reporting this barrier were more frequently classified within the moderate-PA category (39.0%, ASR = 2.8). However, the corresponding linear trend was not statistically significant ($\chi^2(1) = 2.37, p = 0.124$).

The strongest associations emerged for lack of energy and lack of willpower. Students who did not perceive lack of energy as a barrier were substantially overrepresented in the high-PA category (57.5%, ASR = 4.3), whereas those reporting this barrier were more frequently represented in the low- (27.7%, ASR = 2.4) and moderate-PA categories (36.2%, ASR = 2.6) ($\chi^2(2) = 18.61, p < 0.001, V = 0.21$). Similarly, lack of willpower demonstrated the largest association among all barrier domains examined ($\chi^2(2) = 28.63, p < 0.001, V = 0.26$). Students not reporting this barrier were strongly overrepresented in the high-PA category (59.3%, ASR = 5.3), whereas those perceiving lack of willpower were more frequently represented in the low- (29.2%, ASR = 2.9) and moderate-PA categories (38.0%, ASR = 3.2). Significant linear trends were observed for both lack of energy ($\chi^2(1) = 15.48, p < 0.001$) and lack of willpower ($\chi^2(1) = 23.80, p < 0.001$).

Perceived lack of skills was also associated with PA level ($\chi^2(2) = 6.79, p = 0.034, V = 0.13$). Students endorsing this barrier were more frequently represented in the moderate-PA category (42.9%, ASR = 2.4), although no clear gradient emerged across PA levels. Consistent with this pattern, the linear trend was not statistically significant ($\chi^2(1) = 0.34, p = 0.561$).

No significant associations were identified between PA level and either fear of injury ($\chi^2(2) = 0.03, p = 0.985, V = 0.01$) or lack of resources ($\chi^2(2) = 1.95, p = 0.377, V = 0.07$).

To examine the independent contribution of the barrier domains, an ordinal logistic regression model was estimated using PA level (low, moderate, high) as the dependent variable. The model significantly improved upon the intercept-only solution ($\chi^2(7) = 38.16, p < 0.001$), although its explanatory power was modest (Nagelkerke $R^2 = 0.10$). The proportional odds assumption was satisfied ($\chi^2(7) = 12.64, p = 0.082$). After adjustment for the remaining barriers, the absence of perceived lack of energy ($\beta = 0.541, OR = 1.72, 95\% CI [1.09, 2.72], p = 0.021$) and lack of willpower ($\beta = 0.922, OR = 2.51, 95\% CI [1.63, 3.87], p < 0.001$) were associated with greater odds of belonging to higher PA categories. Conversely, students not reporting lack of skills showed lower odds of higher PA levels ($\beta = -0.648, OR = 0.52, 95\% CI [0.28, 0.99], p = 0.046$). Despite the model's limited explanatory power, these findings highlight the importance of motivational and energy-related barriers in differentiating PA profiles among university women.

3.4. Hierarchical Segmentation Profiles Identified Through CART and CHAID Analyses

The decision-tree analyses identified differentiated behavioural profiles associated with PA participation among university women.

3.4.1. CART Segmentation Profiles Associated with Compliance with WHO Recommendations

Overall, 77.9% of participants met WHO PA recommendations, whereas 22.1% did not (Figure 2). The CART procedure identified self-reported PA change since the pandemic as the primary segmentation variable (normalised importance = 100%; Figure 3). Participants who retrospectively reported stable or increased PA since the pandemic were more likely to meet WHO recommendations (85.8%; Node 1), whereas those reporting a perceived

reduction in PA showed lower compliance (62.7%; Node 2). These categories should be interpreted as subjective retrospective reports rather than objectively verified trajectories.

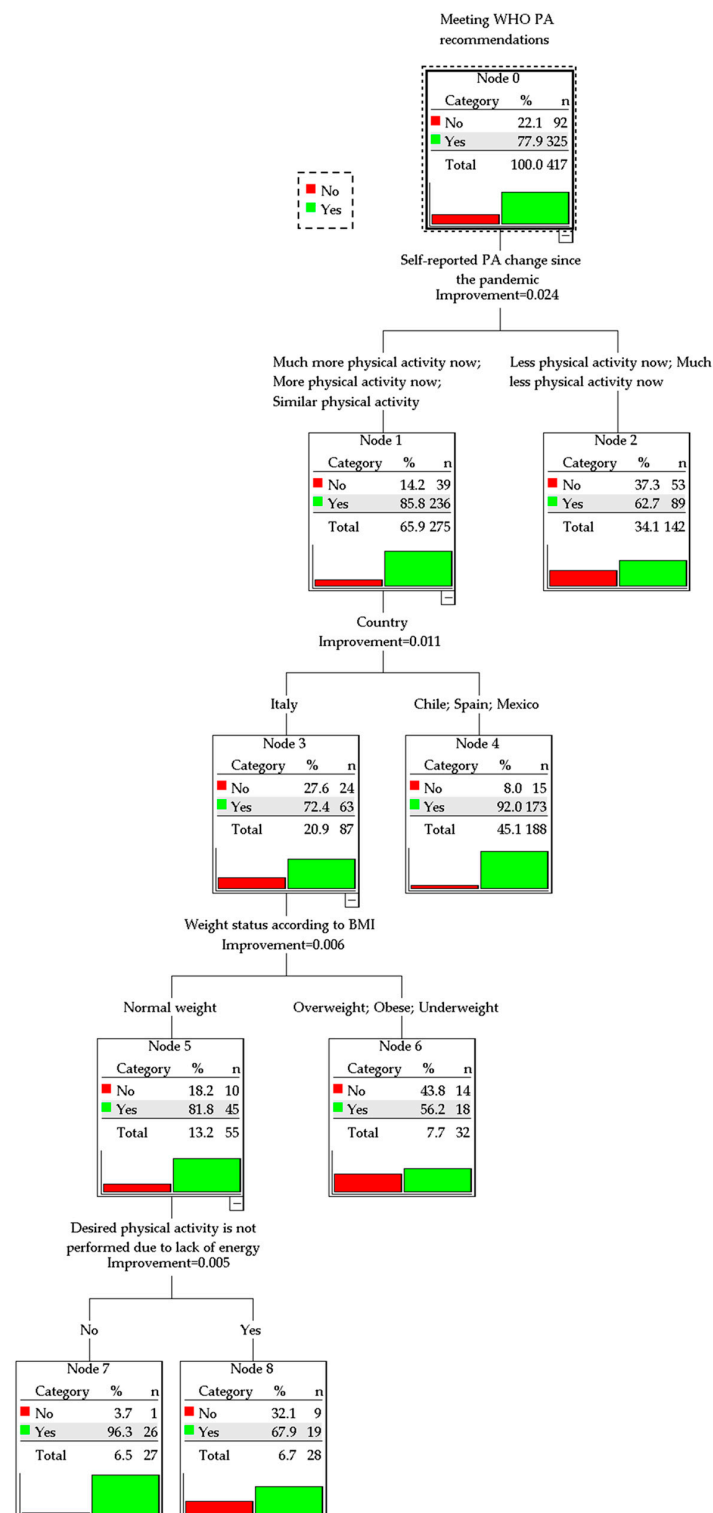


Figure 2. CART model identifying hierarchical profiles associated with compliance with WHO physical activity recommendations among university women. Nodes display subgroup sample sizes and proportions meeting versus not meeting WHO PA recommendations. Branch splits are the predictor variables that generate the greatest reduction in node impurity according to the Gini criterion. Terminal nodes indicate final behavioural profiles identified by the segmentation procedure. The tree was generated using IBM SPSS Statistics version 29.0.

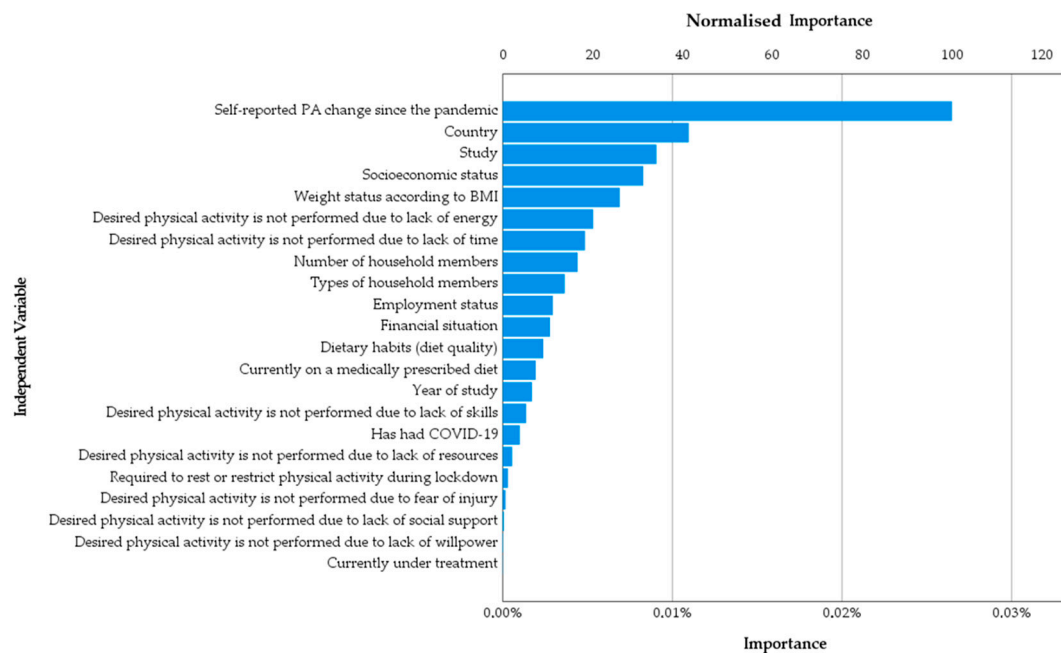


Figure 3. Normalised predictor importance derived from the CART model for compliance with WHO physical activity recommendations. Values represent the relative contribution of each predictor variable to the hierarchical segmentation structure generated by the CART procedure in IBM SPSS Statistics version 29.0.

Among participants reporting stable or increased PA, country provided further segmentation. Women from Chile, Spain, and Mexico displayed the most favourable profile, with 92.0% meeting WHO recommendations (Node 4), whereas Italian students showed comparatively lower adherence (72.4%; Node 3).

Within the Italian subgroup, BMI provided additional differentiation. Students classified as having normal weight demonstrated higher adherence (81.8%; Node 5) than those classified as underweight, overweight, or obese (56.2%; Node 6). Among normal-weight Italian students, perceived lack of energy further distinguished compliance profiles, with those not reporting this barrier exhibiting the highest adherence observed in the model (96.3%; Node 7).

Terminal-node gain analysis identified Italian students with non-normal BMI as the subgroup with the highest concentration of insufficient PA (Node 6: 43.8%; gain index = 198.3%), followed by participants who reported a reduction in PA since the pandemic (Node 2: 37.3%; gain index = 169.2%).

Model performance indicated moderate segmentation stability, with resubstitution and cross-validation risk estimates of 0.221 (SE = 0.020) and 0.235 (SE = 0.021), respectively. However, classification performance was highly unbalanced. Although the model correctly classified participants who met WHO recommendations, it failed to identify those who did not, resulting in an overall accuracy of 77.9% and 0% sensitivity for the insufficient-PA category. Accordingly, the CART model should be interpreted as an exploratory segmentation tool for describing subgroup patterns within the analysed sample, not as a screening procedure for identifying individual women at risk of insufficient PA.

3.4.2. CHAID Segmentation Profiles Across PA Levels

The Exhaustive CHAID analysis generated an 11-node structure, including seven terminal nodes, and identified self-reported PA change since the pandemic as the primary segmentation variable differentiating low-, moderate-, and high-PA profiles ($\chi^2(4) = 42.64$, adjusted $p < 0.001$; Figure 4).

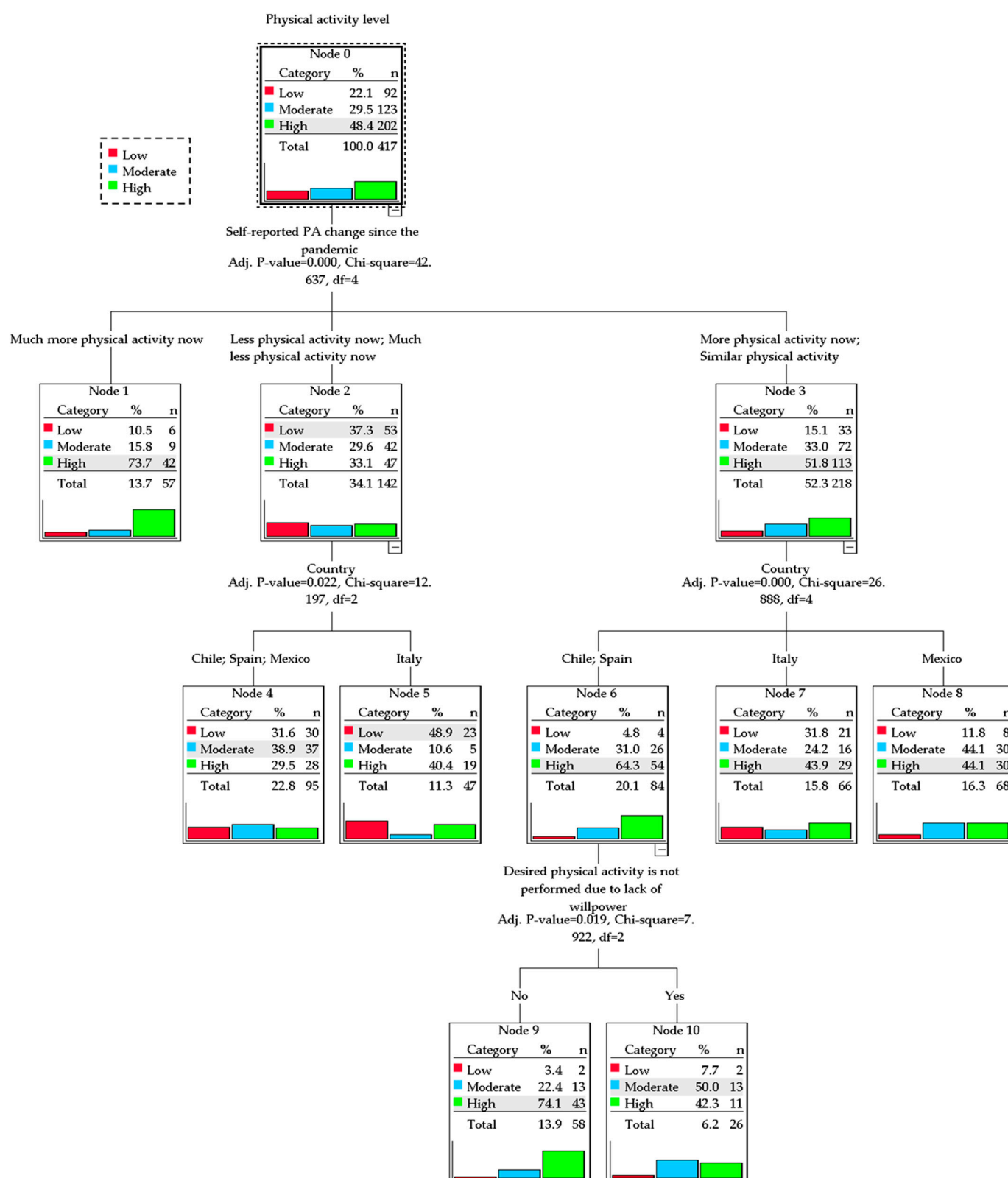


Figure 4. Exhaustive CHAID classification tree illustrating hierarchical differentiation of low, moderate, and high physical activity profiles among university women. Nodes display subgroup distributions across physical activity categories, whereas branch splits represent statistically significant segmentation criteria based on Bonferroni-adjusted chi-square tests. Terminal nodes indicate the final behavioural profiles identified by the model. The tree was generated using IBM SPSS Statistics version 29.0.

Participants reporting substantial increases in PA exhibited the most favourable profile, with 73.7% classified within the high-PA category and only 10.5% within the low-PA category (Node 1). In contrast, those reporting reduced PA showed a less favourable pattern, with a higher prevalence of low PA (37.3%; Node 2).

Country further differentiated these profiles. Among students reporting reduced PA, Italian participants exhibited the highest prevalence of low PA (48.9%; Node 5), whereas those from the remaining countries showed more balanced distributions (Node 4). Among participants reporting stable or increased PA, Chilean and Spanish students displayed the most favourable profile, with 64.3% classified within the high-PA category and only 4.8% within the low-PA category (Node 6).

Within this subgroup, perceived lack of willpower provided additional refinement. Students not reporting this barrier exhibited the most favourable terminal profile in the CHAID model (74.1% high PA; 3.4% low PA; Node 9), whereas those reporting it were more frequently classified within the moderate-PA category (50.0%; Node 10).

Gain-index analyses identified Italian students reporting reduced PA as the subgroup with the greatest concentration of low-PA profiles relative to the overall sample prevalence (Node 5: 48.9%; gain index = 221.8%).

Model performance was moderate. Resubstitution and cross-validation risk estimates were 0.480 (SE = 0.024) and 0.540 (SE = 0.024), respectively. Overall classification accuracy reached 52.0%, with greater discriminative capacity for highly active students (71.3%) than for moderate-PA (40.7%) or low-PA (25.0%) profiles. Consequently, the CHAID model should be interpreted primarily as a segmentation tool rather than a predictive classification model.

3.4.3. Comparative Synthesis of Segmentation Findings

Despite differences in outcome definition, the CART and CHAID procedures revealed broadly similar segmentation structures (Table 3). Self-reported PA change since the pandemic consistently emerged as the primary segmentation factor, whereas country contributed to subsequent contextual differentiation. Health-related characteristics (BMI) and selected barrier domains, particularly lack of energy and lack of willpower, provided additional refinement within specific subgroups.

Table 3. Summary of terminal nodes and hierarchical risk profiles identified by CART and Exhaustive CHAID models.

Model	Terminal Node	Hierarchical Profile Description	n	Main PA Distribution/Compliance	Risk Interpretation	Gain Index
CART	Node 7	Italian students reporting stable or increased PA since the pandemic, normal BMI, and no lack of energy	27	96.3% meeting WHO recommendations	Most favourable compliance profile	–
CART	Node 8	Italian students reporting stable or increased PA since the pandemic, normal BMI, but perceiving lack of energy	28	67.9% meeting WHO recommendations	Intermediate-risk profile characterised by energy-related barriers	–

Table 3. Cont.

Model	Terminal Node	Hierarchical Profile Description	n	Main PA Distribution/Compliance	Risk Interpretation	Gain Index
CART	Node 6	Italian students reporting stable or increased PA since the pandemic with non-normal BMI (underweight/overweight/obesity)	32	56.2% meeting WHO recommendations	Highest-risk subgroup for non-compliance with WHO PA recommendations	198.3%
CART	Node 4	Chilean, Spanish, and Mexican students reporting stable or increased PA since the pandemic	175	92.0% meeting WHO recommendations	Highly favourable self-reported PA change profile	–
CART	Node 2	Students reporting reduced PA since the pandemic (all countries)	142	62.7% meeting WHO recommendations	Elevated-risk profile associated with reported PA reductions since the pandemic	169.2%
CHAID	Node 9	Chilean and Spanish students reporting stable or increased PA since the pandemic and no lack of willpower	58	3.4% low PA; 74.1% high PA	Most favourable high-PA behavioural profile	–
CHAID	Node 10	Chilean and Spanish students reporting stable or increased PA since the pandemic but perceiving lack of willpower	26	7.7% low PA; 42.3% high PA	Moderate-risk profile characterised by motivational vulnerability	–
CHAID	Node 7	Italian students reporting stable or increased PA since the pandemic	66	31.8% low PA; 43.9% high PA	Heterogeneous PA profile with elevated low-PA prevalence	144.2%
CHAID	Node 8	Mexican students reporting stable or increased PA since the pandemic	68	11.8% low PA; 44.1% moderate PA; 44.1% high PA	Balanced moderate-to-high-PA profile	–
CHAID	Node 5	Italian students reporting reduced PA since the pandemic	47	48.9% low PA	Highest-risk low-PA profile identified in CHAID	221.8%
CHAID	Node 4	Chilean, Spanish, and Mexican students reporting reduced PA since the pandemic	95	31.6% low PA; 29.5% high PA	Unfavourable profile associated with reported PA reductions since the pandemic	143.1%

Note. PA = physical activity; BMI = body mass index; WHO = World Health Organization. Relative risk index values correspond to gain-index statistics generated by segmentation procedures and indicate the relative concentration of low physical activity or non-compliance cases within each terminal node compared with the total sample. Higher index values indicate greater relative vulnerability.

Taken together, these findings suggest that hierarchical segmentation approaches can identify distinct configurations of behavioural and contextual characteristics associated with PA participation among university women. Consistent with the exploratory aims of

the study, these subgroup profiles should be interpreted as descriptive patterns that may inform future hypothesis generation and targeted health-promotion initiatives rather than as predictive models of individual behaviour.

4. Discussion

4.1. Principal Findings

The present study examined behavioural profiles associated with PA participation among university women using complementary decision-tree approaches within an international multicentre sample. Overall, the findings suggest that PA participation is embedded within a broader constellation of behavioural, psychosocial, and contextual characteristics rather than being determined by isolated factors, consistent with socioecological and multi-level perspectives of health behaviour [5,7,16,17,24]. In particular, self-reported PA change since the pandemic emerged as one of the most salient variables differentiating the profiles identified through both CART and Exhaustive CHAID procedures. Women reporting stable or increased PA since the pandemic tended to exhibit more favourable activity profiles, whereas those reporting reduced PA since the pandemic were more frequently represented within less active configurations. Importantly, given the cross-sectional nature of the study and the retrospective assessment of these changes, these findings should be interpreted as perceived behavioural configurations rather than evidence of longitudinal continuity or causal influence.

Self-reported PA change since the pandemic emerged as the strongest discriminator in both models. Because this measure was based on retrospective self-perception, it was potentially influenced by recall bias, current activity status, and individual response tendencies. The resulting segmentation structure is best understood as reflecting participants' perceived changes in PA rather than objectively documented longitudinal trajectories.

Another important finding concerns the contextual role of country within the segmentation structures. Although country emerged as a relevant discriminator in both decision-tree models, this result should not be interpreted as reflecting independent national or cultural effects. The participating subsamples differed substantially in their institutional settings, recruitment procedures, and academic composition. Consequently, country functioned primarily as a contextual segmentation variable encompassing overlapping educational, sociocultural, and organisational influences, consistent with ecological approaches that emphasise the role of institutional contexts in shaping health behaviours [16,26,27]. Complementary sensitivity analyses further reinforced this interpretation, indicating that neither country nor academic programme independently accounted for a substantial proportion of variability in PA levels once both factors were considered simultaneously. Rather than supporting discrete national explanations, the identified subgroup differences appear more appropriately understood as context-dependent configurations arising from the interaction of multiple influences operating within university environments.

The convergence observed between CART and Exhaustive CHAID strengthens confidence in the stability of the identified segmentation patterns. Despite relying on different analytical principles, both procedures highlighted similar organising variables and differentiated subgroups according to self-reported PA change since the pandemic and selected contextual characteristics. At the same time, the modest classification performance observed—particularly the limited sensitivity of the CART model and the moderate accuracy of the CHAID procedure—suggests that these approaches should be interpreted primarily as exploratory segmentation tools rather than as predictive frameworks. This limitation is particularly important for the CART model, which did not correctly classify participants who did not meet WHO recommendations and therefore cannot be used to identify vulnerable individuals in practice.

Their principal contribution lies in identifying potentially vulnerable behavioural profiles and generating hypotheses regarding the interplay between PA participation, perceived barriers, and contextual conditions, consistent with the exploratory role of decision-tree methods in public health research [45].

Measurement comparability across countries should also be considered. Although the instruments were administered using translated versions and standardised procedures, formal measurement invariance was not tested. Consequently, some differences between national subsamples may reflect variation in the interpretation of questionnaire items, response categories, or culturally embedded constructs such as perceived barriers, energy, willpower, or dietary quality. Because country contributed to the segmentation structures, the resulting profiles are more appropriately understood as context-specific patterns within the study sample than as direct representations of national behavioural differences.

The segmentation patterns identified in this study add to growing evidence that PA participation among university women cannot be adequately explained through isolated correlates alone [4,9,25]. Instead, behavioural, contextual, and psychosocial influences appeared to cluster within identifiable profiles, suggesting that activity patterns emerge from the way these factors combine rather than from any single determinant acting independently [4,9,22,25]. This perspective helps explain why women with apparently similar circumstances may display markedly different levels of engagement in PA and highlights the value of approaches that acknowledge behavioural complexity when designing research and health-promotion initiatives [7,15,16,46].

4.2. Psychosocial and Behavioural Correlates of Physical Activity

Among the perceived barriers examined, lack of energy and lack of willpower emerged as the domains most consistently associated with lower PA participation. These findings align with previous research identifying motivational difficulties, emotional burden, low perceived energy, and self-regulatory challenges as common obstacles to maintaining active lifestyles during emerging adulthood [7,14,18,19]. In contrast, barriers related to fear of injury and limited resources appeared less relevant within the present sample, suggesting that the determinants of PA participation among university women may be more strongly linked to motivational and self-regulatory processes than to structural constraints alone [7,14,46,47].

From an intervention-design perspective, the prominence of energy- and willpower-related barriers suggests that these constructs should not be treated merely as descriptive obstacles. Rather, they may indicate difficulties in motivational regulation, perceived behavioural control, and the translation of intentions into action. Interventions for university women may therefore benefit from combining motivational strategies with concrete self-regulatory techniques, including graded goal-setting, action planning, coping planning, self-monitoring, and feedback. Such components may help students transform general intentions to be active into more stable and feasible routines.

An unexpected finding emerged for the lack-of-skills domain. Although students who did not report this barrier showed slightly lower odds of belonging to higher PA categories, the small effect size, borderline statistical significance, and inconsistency with prior evidence suggest that this result should be interpreted with caution and treated as exploratory, pending replication in future studies.

Self-Determination Theory provides a useful framework for interpreting these findings. According to this perspective, sustained engagement in PA is facilitated by intrinsic motivation, perceived competence, and autonomy-supportive environments, which support the internalisation and maintenance of health-related behaviours [48]. Women experiencing lower energy levels or difficulties in maintaining behavioural regulation may

therefore encounter greater challenges in initiating and sustaining regular PA participation, a pattern consistent with previous research on motivational influences among university students [7,47]. Importantly, these barriers should not be interpreted simply as indicators of individual deficits. Rather, they may reflect broader psychosocial processes involving academic demands, emotional well-being, competing responsibilities, and perceptions of personal capability, factors that have been consistently associated with PA participation among university students and particularly among women [7,19,49–51].

PA participation appears to be shaped by combinations of experiences that extend beyond exercise behaviour itself [4,15,25,46]. Studies have linked lower participation to body-image concerns, social anxiety, and poorer emotional well-being [9,49–51], suggesting that active and inactive lifestyles often develop within broader psychosocial contexts. Viewed from this perspective, barriers such as low energy or low willpower may represent only part of a more complex pattern influencing how women engage with PA during university years.

Previous research indicates that women's engagement in PA is influenced by psychosocial factors including body-image concerns, social evaluation, and emotional well-being [14,18,28,29,49,50,52]. The profiles identified in the present study align with evidence showing that PA behaviours among university women emerge from multiple interacting influences.

These findings have practical implications for intervention design. The prominence of barriers related to lack of energy and lack of willpower suggests that these factors may reflect difficulties in motivational regulation and in translating intentions into sustained behaviour rather than simple deficits in knowledge about the benefits of PA [7,46–48]. From this perspective, interventions may benefit from combining motivational support with self-regulatory strategies such as graded goal-setting, action planning, self-monitoring, feedback, and behavioural activation techniques designed to facilitate the initiation and maintenance of activity routines [7,46–48]. In parallel, the relevance of psychosocial barriers underscores the importance of creating exercise environments that are emotionally supportive, socially inclusive, and sensitive to body image and social evaluation concerns [6,19,20]. Taken together, these findings reinforce the need for multidimensional approaches that address the broader processes shaping women's engagement in PA during university years [6,7,19,20,46–48].

4.3. Implications for Health-Promoting Universities

The practical implications of these findings should be considered in light of the modest classification performance of the decision-tree models. In particular, the CART model was unable to correctly identify women who did not meet WHO PA recommendations, which substantially limits its use for individual screening or risk classification. Therefore, the profiles identified here should not be used to assign students to interventions or to diagnose vulnerability at the individual level. Their value is more appropriately located in informing hypothesis generation, guiding institutional reflection, and supporting the design of flexible health-promotion strategies that can be adapted and evaluated in future intervention studies.

A notable implication of the present study is the considerable variability among women who shared the same university stage yet differed in their PA participation patterns. This variability suggests that broad health-promotion messages may not resonate equally across all students. Instead, programmes may be more effective when they recognise that inactivity can arise from different combinations of motivational challenges, psychosocial circumstances, and everyday constraints [4,7,17,24,25,46].

The Health-Promoting Universities framework offers a useful way of interpreting these results because it places health behaviour within the wider university environment [26]. From this perspective, opportunities for PA are influenced not only by individual motivation but also by institutional conditions, social norms, and the extent to which healthy choices are supported in everyday campus life [16,26,27]. The diversity of profiles observed in the present study is consistent with the idea that effective health promotion requires action at multiple levels rather than reliance on individual behaviour change alone.

In practical terms, the identified profiles point towards intervention components that could be tested within Health-Promoting University initiatives. For students reporting low energy, programmes may incorporate behavioural activation principles, beginning with low-threshold, enjoyable, and easily accessible activities that reduce the perceived effort required to start. For students reporting low willpower, intervention design may focus less on exhortation and more on self-regulation: implementation intentions, scheduled activity prompts, peer accountability, and habit-formation strategies linked to existing daily routines. These approaches may be more appropriate than generic messages encouraging students to exercise more, particularly when inactivity is embedded in academic fatigue, stress, or competing responsibilities. Given the exploratory nature and modest classification performance of the segmentation models, these implications should be understood as directions for intervention development and evaluation rather than as ready-to-use decision rules for assigning individual students to specific programmes.

The prominence of barriers related to lack of energy and lack of willpower points towards intervention components that may be particularly relevant within Health-Promoting University initiatives [7,46–48]. Rather than viewing these barriers solely as obstacles to participation, they may also reflect challenges in motivational regulation, perceived competence, and the translation of intentions into sustained action [47,48]. Consequently, programmes incorporating graded goal-setting, action planning, self-monitoring, personalised feedback, and behavioural activation strategies may help students establish more manageable and sustainable PA routines within the demands of university life [7,46]. In parallel, approaches informed by Self-Determination Theory emphasise the importance of supporting autonomy, competence, and relatedness as foundations for more self-determined and enduring forms of exercise motivation [47,48].

The findings also highlight the role of the social and emotional context in shaping women's engagement in PA [19,20,26,27]. Students experiencing body image concerns, social anxiety, or heightened psychosocial stress may perceive conventional exercise settings as intimidating, evaluative, or insufficiently supportive [9,14,49–51]. For this reason, university-based initiatives may benefit from prioritising emotionally safe and socially inclusive environments, including peer-support programmes, women-oriented recreational opportunities, non-competitive activity formats, and opportunities for gradual participation [19,20,27]. Such approaches may help enhance enjoyment, perceived belonging, and long-term adherence during the transitional period of emerging adulthood [3,6,10].

These implications should be viewed in light of the segmentation models' exploratory nature and modest classification performance. The identified profiles are most useful for informing the development of flexible, context-sensitive strategies that can be prospectively evaluated and refined within university health-promotion programmes, rather than for individual-level classification or intervention allocation.

At the same time, the contextual variability observed across participating institutions suggests that health promotion initiatives should remain sensitive to the specific characteristics of each university environment [16,26,27]. Although country-related patterns identified in the present study should not be interpreted as independent national effects, they nevertheless underscore the potential influence of broader institutional and sociocul-

tural contexts on women's experiences of PA [16,17,27]. Flexible scheduling opportunities, accessible facilities, and policies that acknowledge the diversity of students' academic and personal responsibilities may help reduce barriers to participation and support more equitable engagement in active lifestyles [7,17,27].

Overall, the present findings support the view that universities represent important settings for fostering sustainable and health-oriented behaviours among women students [26,27]. By recognising the heterogeneity of behavioural profiles [4,25,46] and addressing the motivational, psychosocial, and contextual factors associated with PA participation, Health-Promoting Universities may be better positioned to develop interventions that are responsive to the diverse needs of their student populations.

Since the main segmentation factor reflected perceived rather than objectively measured PA change, intervention implications should not be based on assuming verified post-pandemic behavioural trajectories. Instead, this variable may be useful for identifying how students currently make sense of changes in their activity habits, which can inform supportive conversations and programme design at an institutional level.

4.4. Methodological Considerations, Strengths, and Limitations

Several methodological considerations should be taken into account when interpreting the present findings. First, the cross-sectional design precludes causal inference. Because all variables were assessed at a single time point through self-report questionnaires, it is not possible to establish the temporal ordering of perceived barriers, dietary behaviours, contextual factors, and PA participation. Consequently, the relationships identified throughout the study should be interpreted as contemporaneous associations rather than causal pathways.

Second, all key variables relied on self-reported information. Although instruments such as the IPAQ-SF are widely used in epidemiological research, previous studies have shown that they may overestimate PA levels, particularly vigorous-intensity activity, owing to recall difficulties and social desirability tendencies [32,34,35]. Therefore, the relatively high levels of PA observed in some subgroups should be interpreted with caution. Future investigations incorporating objective monitoring techniques, such as accelerometry or wearable activity trackers, would strengthen confidence in the measurement of PA behaviours.

A related concern involves the retrospective assessment of changes in self-reported PA since the pandemic. This variable relied on participants' subjective comparison between their current activity and their recollection of pre-pandemic behaviour, and may therefore be affected by recall bias, current behavioural status, and response tendencies. Its prominence as the primary segmentation factor in both CART and CHAID models should consequently be interpreted with caution. The identified structures do not demonstrate objectively verified longitudinal changes in PA; rather, they describe profiles organised around participants' perceived changes in activity. Future longitudinal studies using repeated and objective PA measurements are needed to determine whether these perceived configurations correspond to actual behavioural trajectories over time.

Several issues related to sample composition also warrant consideration. Participants were recruited through convenience sampling, and substantial overlap existed between country, institutional setting, and academic discipline. Although complementary sensitivity analyses indicated that neither country nor academic programme independently accounted for a substantial proportion of variability in PA levels, the partial confounding among these factors limits the interpretation of fully independent contextual effects. Consequently, the subgroup patterns identified in the present study are more appropriately interpreted as contextually embedded configurations rather than isolated national or disciplinary influences. This limitation also restricts the direct applicability of the profiles for identifying

individual students who require support; any use of interventions should therefore be preceded by prospective validation and evaluation in independent samples.

Measurement-related limitations should also be acknowledged. Although previously validated instruments were used and translation procedures implemented when necessary, formal measurement invariance across countries was not assessed. Consequently, it cannot be ruled out that some cross-country differences reflected variations in item interpretation, response styles, or cultural meanings attached to constructs such as perceived barriers, energy, willpower, and dietary quality, rather than equivalent behavioural differences. This limitation is especially relevant for interpreting country-related splits in the CART and CHAID models. The identified profiles should therefore be understood as exploratory, context-sensitive configurations within the analysed sample, not as evidence of fully comparable cross-national behavioural patterns.

Finally, limitations associated with the decision-tree procedures themselves should be recognised. Although cross-validation procedures and minimum node-size restrictions were implemented to reduce overfitting, the resulting terminal nodes reflected hierarchical partitioning within the analysed sample rather than independent explanatory effects. Furthermore, the models' classification performance was modest. The CART procedure demonstrated limited sensitivity in identifying women who did not meet WHO recommendations, whereas the CHAID model achieved only moderate overall classification accuracy. These findings reinforce the view that the primary value of decision-tree approaches lies in subgroup characterisation and hypothesis generation rather than in high-precision individual prediction [43–45].

Despite these limitations, the present study possesses several noteworthy strengths. It focused exclusively on university women, a population that has received increasing attention in recent person-centred research [4,9,46]. The multicentre design allowed the examination of behavioural heterogeneity across diverse university contexts, while the integration of behavioural, psychosocial, dietary, and contextual indicators provided a more comprehensive perspective on PA participation. Moreover, the use of complementary segmentation approaches generated convergent evidence regarding the existence of differentiated behavioural profiles among university women, an approach increasingly advocated in lifestyle and health-behaviour research [4,25,43–45].

4.5. Methodological Contributions and Future Directions

One contribution of this study lies in illustrating how person-centred methods can reveal patterns that may remain hidden in conventional variable-centred analyses [4,9,25,46]. By examining how behavioural, psychosocial, and contextual characteristics co-occur within the same individuals, the analyses provided a more nuanced picture of PA participation among university women. Such approaches may be particularly valuable in populations where behavioural diversity is substantial and where multiple influences operate simultaneously [15,16,24].

Methodologically, the complementary use of CART and Exhaustive CHAID provided distinct yet convergent perspectives on subgroup organisation. Whereas CART generated more detailed hierarchical differentiation centred on compliance with WHO recommendations, CHAID offered a broader overview of patterns across low, moderate, and high PA levels. The consistency observed across both procedures supports the potential utility of segmentation-oriented approaches for exploring variability within university populations, even when predictive performance remains modest.

Future research would benefit from adopting longitudinal designs capable of examining how behavioural profiles evolve over time and clarifying the temporal relationships among perceived barriers, motivational processes, and PA participation. The inclusion of

objective measures of PA, together with repeated assessments of psychosocial variables, may provide a more nuanced understanding of behavioural trajectories during university years [32,34,35]. Future studies should examine whether interventions targeting motivational regulation, self-efficacy, behavioural activation, and habit formation are effective for women presenting different perceived barrier profiles.

Additional attention should also be devoted to contextual influences. Although the present study was conceptually informed by socioecological perspectives and the HPU framework [16,26,27], direct measures of institutional policies, environmental characteristics, and sociocultural conditions were not incorporated into the analyses. Future multicentre investigations that integrate explicit contextual indicators may help disentangle the mechanisms by which university environments shape women's opportunities and motivations to engage in PA [7,17,27].

Finally, further research employing more balanced sampling strategies across institutions and academic disciplines is needed to clarify the extent to which the subgroup patterns identified here generalise to other university populations. Replication studies conducted in larger and more diverse samples would strengthen confidence in the stability of these profiles and enhance the translational value of segmentation approaches for informing health promotion initiatives targeting university women [4,25,45].

5. Conclusions

Distinct patterns of PA participation were observed among university women, reflecting different combinations of perceived barriers, behavioural characteristics, and contextual conditions. Women reporting more favourable activity profiles generally differed from their less active counterparts in factors related to perceived post-pandemic activity change and selected motivational and psychosocial characteristics. These results emphasise that PA participation during university years is embedded within a broader lifestyle context rather than representing an isolated health behaviour.

The findings further support the value of person-centred segmentation approaches for capturing heterogeneity in women's experiences of physical activity. The CART and Exhaustive CHAID procedures were useful for describing subgroup patterns and generating hypotheses regarding behavioural configurations. Their modest classification performance indicates that their primary value lies in understanding behavioural diversity rather than in individual-level screening or risk identification.

From a practical perspective, the results highlight the importance of gender-sensitive and context-responsive health-promotion strategies within higher education settings. Universities may benefit from initiatives that address the factors underlying barriers related to lack of energy and lack of willpower, particularly among women reporting less favourable activity profiles. Although the findings should be interpreted in light of the study's methodological limitations—including its cross-sectional design, reliance on self-reported measures, and contextual overlap between country and academic composition—they contribute to the growing evidence supporting context-sensitive and equity-oriented approaches to promoting active lifestyles during emerging adulthood.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/women6030044/s1>. Table S1: Female target population, recruitment settings, and approximate response rates across participating countries; Table S2: Sensitivity analysis: ordinal logistic regression examining the joint contribution of country and academic programme to physical activity level; Table S3: Academic and sociodemographic characteristics by country; Table S4: Health-related, anthropometric, and pandemic-related characteristics by country; Table S5: Physical activity, dietary, and barrier-related characteristics by country.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the Institute of Agricultural and Rural Sciences (ICAR), Autonomous University of the State of Mexico (UAEMex) (approval code: 01-SEP-2023; approved on 14 July 2023).

Informed Consent Statement: Informed consent was obtained from all participants.

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Abbreviations

The following abbreviations are used in this manuscript:

BBAQ-21	Barriers to Being Active Questionnaire
BMI	Body Mass Index
CART	Classification and Regression Trees
CHAID	Chi-square Automatic Interaction Detection
COM-B	Capability, Opportunity, Motivation–Behavior Model
COVID-19	Coronavirus Disease 2019
HEI	Healthy Eating Index
HPU	Health-Promoting Universities
ICAR	Instituto de Ciencias Agropecuarias y Rurales
IPAQ-SF	International Physical Activity Questionnaire—Short Form
MET	Metabolic Equivalent of Task
PA	Physical Activity
SES	Socioeconomic Status
STROBE	Strengthening the Reporting of Observational Studies in Epidemiology
WHO	World Health Organization

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