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Physical Fitness, Body Composition and Metabolic Risk in First-Year Medical Sciences Students from Western Cuba

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Abstract
Physical fitness and body composition are central health determinants; in medical students they also influence their future work as promoters of healthy habits. In western Cuba, a diagnosis of their status at university entry is lacking. This descriptive, cross-sectional study characterized the level of basic physical abilities and the anthropometric profile of 8,116 first-year medical sciences students (58.9% male, mean age 18.4 years) from four provinces. Standardized physical tests (800 m, 60 m, push-ups, sit-ups) were applied, and body mass index (BMI) and waist circumference (WC) were measured. Only 9.2% reached the Talent category, and arm strength was the most deficient ability (11.5% in level V). Mean BMI was 25.8 kg/m² (SD = 3.5), and 14.5% had abdominal obesity. Correlations between BMI/WC and performance were moderate (r between .29 and .51; p < .001). A proportion of 24.1% showed high metabolic risk. According to functional health criteria, 36.7% had insufficient arm strength and 32.2% insufficient abdominal strength. Cluster analysis identified three profiles: healthy (38.2%), moderate risk (41.5%), and high risk (20.3%). Province of residence was a significant predictor of risk profile membership: compared with Havana, students from Artemisa were 2.81 times more likely to belong to the high-risk profile (OR = 2.81; p < .001). It is concluded that a low-to-medium physical condition predominates, one in three students is overweight, one in four has high metabolic risk, and significant territorial gaps exist, which justifies early curricular interventions.

Keywords: Physical Fitness, Body Composition, Medical Students, Metabolic Risk, Health Profile

Introduction
The association between physical fitness and health is solidly documented. A high level of physical fitness is linked to lower cardiovascular risk, better mental health, and greater functionality across the life span [1,2]. However, in the case of health professionals, physical fitness acquires an additional dimension: a physician with healthy habits is more convincing when recommending lifestyle changes to patients, and various studies have confirmed the relationship between the health of the physician and their counseling practices [3].

University entry represents a critical stage. Medical sciences students face an intense academic load, psychosocial stress, and modifications in daily routines—factors that can rapidly deteriorate their health profile [4,5]. Evidence exists of a decline in physical and mental well-being during the degree program, but less information is available on the starting point: what is the health status of these young people when they enter higher education? This phenomenon is not exclusive to Cuba. Studies in Latin America and globally document a deterioration in physical fitness during the transition to university life, associated with changes in eating patterns, decreased physical activity, and increased sedentary behavior [4,6]. The present research provides evidence on the magnitude of this problem in the Cuban context.

In Cuba, the National Health System incorporates promotion and prevention among its principles. However, there is no comprehensive diagnosis characterizing the health profile of future professionals. The physical assessments carried out at universities usually adhere to INDER (2020) regulations, although their application is irregular and analyses are fragmentary [7]. Generally, body composition indicators—such as BMI or waist circumference—which are key to properly interpreting physical performance, are not integrated. Nor has the existence of differences between provinces been explored, a pertinent aspect in a country with heterogeneous territorial realities.

It should be noted that this study is limited to the physical dimension of health, without evaluating the psychological and social domains that comprise the broader construct of quality of life, which constitutes a necessary complementary line of research.

The specific objectives were:
- to describe the distribution of physical performance and anthropometric classification;
- to examine the internal homogeneity of performance categories;
- to analyze correlations between anthropometric indicators and physical capacity;
- to identify combined risk profiles; and
- to explore geographic inequalities. The hypothesis was that a risk-prone profile, high heterogeneity, and territorial gaps would be found.

Materials and Methods

Design and Population

An observational, descriptive, cross-sectional study was conducted during the first semester of 2024. The target population comprised all first-year students enrolled in Medical Sciences programs (Medicine, Dentistry, Nursing, Health Technology) at universities in Pinar del Río, Artemisa, Havana, and Mayabeque, the four provinces that make up the western region of Cuba. The 8,567 students registered, 8,116 (94.7%) completed all evaluations, constituting the final participating population. The mean age was 18.4 years (SD = 1.1), and 58.9% were male. Since nearly all enrolled students in the region were included, the results are representative of western Cuba, though not necessarily generalizable to the rest of the country.

Assessment of Physical Abilities

Standardized tests from INDER (2020) were administered [7]. Twenty-four certified Physical Education teachers participated, having previously attended a procedure standardization workshop to unify application criteria. The tests were:
- Cardiorespiratory endurance: 800-meter run. Time was recorded in minutes and seconds and converted to seconds for analysis.
- Speed: 60-meter sprint. Time recorded in seconds and hundredths.
- Arm muscular endurance: maximum number of push-ups performed with correct technique, no time limit.
- Abdominal muscular endurance: maximum number of sit-ups performed in one minute.

Raw scores were classified into six levels (Talent, I, II, III, IV, V) according to INDER normative tables, which consider sex and age.

Anthropometric Measurements

International Society for the Advancement of Kinanthropometry (ISAK) protocols were followed. Weight was measured with a digital scale (SECA 874, precision 0.1 kg) and height with a stadiometer (SECA 213, precision 0.1 cm). Body Mass Index (BMI) was calculated as weight (kg) / height² (m²). Cutoff points adapted for the Cuban adult population according to Berdasco (2002) were used: underweight (< 19.7 kg/m²), normal weight (19.8–26.0 kg/m²), overweight (26.1–29.0 kg/m²), and obesity (> 29.0 kg/m²) [8].

Waist circumference (WC) was measured at the midpoint between the lower rib and the iliac crest, at the end of a normal expiration, with a flexible, inextensible tape measure (SECA 201). WHO criteria were applied: normal (< 80 cm women, < 94 cm men), increased risk (80–88 cm women, 94–102 cm men), and abdominal obesity (> 88 cm women, > 102 cm men).

Statistical Analysis

Data were processed with SPSS version 28.0 (IBM Corp., Armonk, NY). Frequencies, percentages, means, standard deviations (SD), skewness coefficients, and 95% confidence intervals (95% CI) were calculated. To compare proportions between provinces, the chi-square test (χ^2) was used, and to compare means, one-way ANOVA with Bonferroni post-hoc tests. Effect sizes were estimated using Cramer's V for contingency tables and eta squared (η^2) for ANOVA, interpreted according to conventional cutoffs.

Bivariate correlations (Pearson coefficient) between anthropometric indicators and physical performance were explored, stratified by sex. To identify risk profiles, a two-step cluster analysis was performed with the variables: BMI, WC, 800 m time, 60 m time, push-ups, and sit-ups. The number of clusters was determined by the change in BIC criterion.

Additionally, functional health criteria for muscle strength were applied: arm strength was considered insufficient if push-ups < 10 repetitions and abdominal strength insufficient if sit-ups < 20 repetitions in 1 minute [9,10]. High combined metabolic risk was defined as the simultaneous presence of overweight or obesity (BMI ≥ 26.1) and increased WC or abdominal obesity according to sex.

Furthermore, a multinomial logistic regression analysis was performed to identify predictors of belonging to risk profiles (moderate and high vs. healthy), using province of origin and sex as independent variables. Odds ratios (OR) with 95% confidence intervals were calculated.

The significance level was set at $p < .05$.

Results

General Physical Performance

Of the total evaluated students, only 9.2% (n = 750) were classified as Talent overall. The modal category was level III (27.2%, n = 2205), followed by level II (20.4%, n = 1658). Low levels (IV and V) together comprised 25.5% of the cohort (n = 2073). When analyzed by specific ability, arm strength showed the most deficient performance: 11.5% (n = 931) in level V and only 9.0% (n = 734) in Talent.

Intra-Level Variability

Statistics of raw scores revealed considerable internal heterogeneity within all levels of each ability. In the 60 m test for level III (n = 2224), the mean was 9.32 seconds (SD = 1.84), ranging from 8.02 to 11.16 seconds. In arm strength within the Talent group (n = 734), the mean was 26.4 repetitions (SD = 8.2). Skewness coefficients were positive and high for all abilities (between 1.61 and 1.73), indicating that within each category the distribution is skewed toward lower values.

General Anthropometric Profile

Overall mean BMI was 25.8 kg/m² (SD = 3.5; 95% CI: 25.7–25.9). A proportion of 34.5% of students were overweight (26.7%, n = 2167) or obese (7.8%, n = 633). Mean waist circumference was 82.1 cm (SD = 9.8; 95% CI: 81.9–82.3). According to WHO criteria, 14.5% (n = 1177) fell into the abdominal obesity category.

Sex Differences

Men had higher mean BMI and higher prevalence of overweight and general obesity, whereas abdominal obesity was more frequent in women. Table 1 presents anthropometric indicators broken down by sex. Differences in BMI and WC were statistically significant ($p < .001$), although effect sizes were small ($\eta^2 = .018$ and $.021$, respectively).

Sex	n	BMI mean (SD)	% Overweight	% Obesity	WC mean (SD)	% Abdominal obesity
Male	4789	26.2 (3.3)	28.4	8.9	84.7 (9.2)	12.8
Female	3327	25.2 (3.7)	24.3	6.2	78.3 (8.9)	16.9
Total	8116	25.8 (3.5)	26.7	7.8	82.1 (9.8)	14.5

Note. BMI = body mass index (kg/m²); WC = waist circumference (cm).
Supplementary note: Applying standard WHO criteria (< 18.5; 18.5–24.9; 25.0–29.9; ≥ 30.0 kg/m²), overweight prevalence would be 31.2% and obesity 5.8%. The difference in obesity compared to Cuban criteria is due to the lower threshold for this cutoff in the national classification (≥ 29.0 vs. ≥ 30.0 kg/m²).

Table 1: Anthropometric Indicators by Sex

Correlations Between Anthropometry and Performance

Moderate and statistically significant correlations ($p < .001$) were found between all anthropometric indicators and physical tests (Table 2). Higher BMI and WC were associated with worse performance in all tests (longer times in running, fewer repetitions). Correlations were slightly stronger in women and for WC than for BMI.

Variable	BMI (men)	BMI (women)	WC (men)	WC (women)
800 m (time)	.38*	.41*	.42*	.45*
60 m (time)	.29*	.33*	.31*	.36*
Push-ups (n)	-.44*	-.47*	-.48*	-.51*
Sit-ups (n)	-.36*	-.39*	-.40*	-.43*
Note. *p < .001.				

Table 2: Correlations Between Anthropometric Indicators and Physical Performance

Combined Metabolic Risk

Combining BMI and WC, 24.1% of students presented high metabolic risk (overweight or obesity together with increased WC or abdominal obesity). A proportion of 33.2% were classified as moderate risk, and only 42.7% as no risk (Table 3). No substantial differences between sexes were observed in the distribution of these categories ($\chi^2 = 2.34$; $p = .311$).

Category	Men	Women	Total
No risk	41.2	44.8	42.7
Moderate risk	34.6	31.2	33.2
High risk	24.2	24.0	24.1

Table 3: Combined Metabolic Risk Categories (Percentages)

Muscle Strength According to Health Criteria

Applying health-based cutoffs, 36.7% of students had insufficient arm strength and 32.2% insufficient abdominal strength. A proportion of 22.4% presented insufficiency in both tests (Table 4). Women showed significantly higher percentages of insufficiency in both tests ($p < .001$), with a small-to-moderate effect size (Cramer's V = .12).

Test	Men	Women	Total
Push-ups < 10 reps	31.4	44.2	36.7
Sit-ups < 20 reps	27.8	38.5	32.2
Both insufficient	18.3	28.1	22.4

Table 4: Students With Insufficient Strength According to Health Criteria (Percentages)

Risk Profiles (Cluster Analysis)

Cluster analysis identified three differentiated profiles:

- Profile 1 – Healthy (38.2%): Normal BMI and WC (BMI < 24.5; WC < 78 cm women, < 88 cm men), good performance in all tests (800 m < 220 s, push-ups > 20, sit-ups > 30).
- Profile 2 – Moderate risk (41.5%): Upper-limit BMI (24.5–27.5), increased WC (78–85 cm women, 88–98 cm men), low-to-medium performance (800 m 220–260 s, push-ups 10–20, sit-ups 20–30).
- Profile 3 – High risk (20.3%): BMI > 27.5, WC > 85 cm women or > 98 cm men, very low performance (800 m > 260 s, push-ups < 10, sit-ups < 20).

Predictors of Risk Profile

Multinomial logistic regression analysis showed that, adjusting for sex, province of origin was a significant predictor of risk profile membership. Taking Havana as reference, students from Artemisa were 2.81 times more likely to belong to the high-risk profile (OR = 2.81; 95% CI: 2.32–3.41; $p < .001$), while in Mayabeque the OR was 2.45 (95% CI: 1.98–3.02; $p < .001$). Pinar del Río occupied an intermediate position (OR = 1.68; 95% CI: 1.42–1.99; $p < .001$). Female sex was associated with a higher probability of belonging to the high-risk profile (OR = 1.34; 95% CI: 1.18–1.52; $p < .001$).

Territorial Inequalities

Province-wise analysis showed statistically significant differences in all indicators. Havana presented the best results: lower BMI and WC, higher proportion of talents and healthy profile, and lower prevalence of high risk. At the opposite extreme were Artemisa and Mayabeque, while Pinar del Río occupied an intermediate position (Table 5). ANOVA confirmed significant differences for BMI, $F(3, 8112) = 87.4$; $p < .001$; $\eta^2 = .031$, and for WC, $F(3, 8112) = 112.6$; $p < .001$; $\eta^2 = .040$; both effect sizes are considered small. Post-hoc tests (Bonferroni) indicated that Havana differs significantly from Artemisa and Mayabeque in both indicators ($p < .001$).

Province	n	BMI mean (SD) [95% CI]	WC mean (SD) [95% CI]	% Talent	% High risk	% Healthy profile [95% CI]
Havana	3892	25.1 (2.9) [24.9–25.3]	80.2 (8.1) [79.9–80.5]	11.8	15.2	46.3 [44.7–47.9]
Pinar del Río	1856	25.6 (3.2) [25.4–25.8]	81.7 (9.0) [81.3–82.1]	8.9	22.6	37.8 [35.6–40.0]
Artemisa	1243	26.5 (3.8) [26.3–26.7]	85.1 (10.2) [84.5–85.7]	6.2	32.4	24.1 [21.7–26.5]
Mayabeque	1125	26.3 (3.7) [26.1–26.5]	84.3 (9.9) [83.7–84.9]	6.6	30.8	26.7 [24.1–29.3]

Total	8116	25.8 (3.5) [25.7–25.9]	82.1 (9.8) [81.9–82.3]	9.2	24.1	38.2 [37.1–39.3]
Note. BMI = body mass index (kg/m²); WC = waist circumference (cm). Interprovincial differences were significant for all indicators ($p < .001$).						

Table 5: Anthropometric and Risk Indicators by Province

Discussion

The present study, the largest scale to date in medical sciences students in western Cuba, reveals a health profile that deserves attention. The main findings can be summarized as follows: only one in ten students reaches a Talent level; one in three is overweight; one in four has high metabolic risk; more than one third have insufficient muscle strength according to health criteria; and there are marked differences between provinces, with Havana showing a consistently more favorable profile.

The Double Burden: Low Physical Performance and Excess Weight

The most concerning finding is the coexistence of low physical fitness and excess adiposity, particularly abdominal obesity. Abdominal obesity, present in 14.5% of the cohort, is a marker of metabolic dysfunction and an independent predictor of cardiovascular diseases [11]. Correlations between BMI/WC and physical performance (r between .29 and .51) confirm that higher adiposity is associated with poorer performance, especially in tests that require moving body mass.

When overweight/obesity is combined with increased WC, the risk multiplies. A proportion of 24.1% of students already presents this combination, configuring what the literature terms "metabolically unhealthy obese," associated with the worst prognosis in terms of morbidity and mortality [12,13]. It is significant that these risk factors are present before students receive their first clinical class.

Muscle Strength and Functional Health Criteria

Applying health-based cutoffs offers a complementary perspective. That more than one third of students do not reach minimum arm strength (36.7%) or abdominal strength (32.2%) has concrete functional implications. Muscle strength is related to the ability to perform activities of daily living, prevent musculoskeletal injuries, and preserve functionality throughout life [11]. In medical training, where procedures requiring strength and endurance are performed (patient mobilization, chest compressions, prolonged surgeries), these deficits may translate into practical limitations and increased risk of occupational injuries.

Risk Profiles and Population Heterogeneity

Cluster analysis identified three clearly differentiated groupings. The fact that only 38.2% are classified as healthy profile, while 20.3% are in high risk, provides a more integrative view than analysis of isolated variables. These profiles may be useful for designing tiered interventions: high-risk students would require more intensive and personalized programs, while moderate-risk students could benefit from preventive group interventions.

An additional relevant finding is the high variability found within each level of the INDER normative classification. That within the same level III, 60 m times range from 8.0 to 11.2 seconds, or that in arm strength the Talent group presents a standard deviation of 8.2 repetitions on a mean of 26.4, suggests that these categories have limited discriminative capacity when applied to heterogeneous populations such as university entrants. A student at the lower limit of level III may have a metabolic risk profile similar to that of one classified as level IV. Therefore, it is recommended to complement this classification with: (a) functional health criteria such as those applied here for muscle strength, (b) individualized longitudinal follow-up (ipsative assessment), and (c) routine incorporation of anthropometric indicators that contextualize physical performance.

Territorial Inequalities

The differences found between provinces, confirmed by multinomial logistic regression analysis, require careful examination. Havana, the capital and most urbanized province, concentrates better anthropometric indicators, a higher proportion of physical talents, and a lower prevalence of high risk. Artemisa and Mayabeque, on the contrary, present a mean BMI in the overweight range, WC in the risk category, lower physical performance, and a higher proportion of risk profiles. The probability of belonging to the high-risk profile was 2.8 times higher in Artemisa and 2.5 times higher in Mayabeque compared to Havana, even after adjusting for sex.

These gaps are not random. They likely underlie inequalities in social determinants of health that operate from early ages: access to sports facilities, availability of extracurricular activities, dietary patterns, and family socioeconomic level [14,15]. The university receives a cohort already stratified in terms of health capital. If specific policies are not implemented, these gaps will tend to persist or even widen during the degree program.

Implications for Performance and Professional Practice

Medical training is physically demanding. Long working hours, on-call duties, and procedures requiring strength and endurance demand a minimum level of physical fitness. A student with low cardiorespiratory capacity and poor muscle strength will likely fatigue more quickly, present a higher risk of injuries, and perform less well in activities involving sustained effort. Frajerman et al. (2019) have documented the high prevalence of burnout in medical students, and it is plausible that a deficient physical profile contributes to this vulnerability [5].

There is also a dimension that transcends the individual. The effectiveness of medical counseling on healthy lifestyles depends, at least in part, on the professional's credibility. Frank et al. (2010) found that physicians who practice healthy habits are more likely to counsel their patients effectively [3]. Therefore, training physicians with an optimal health profile should be considered an integral and unavoidable component of the professional training curriculum, with direct implications for the quality of future healthcare.

Limitations

This study has limitations that must be recognized. Its cross-sectional design precludes establishing causal relationships. The study is restricted to western Cuba; socioeconomic, cultural, and access-to-sports-infrastructure realities may differ in the central and eastern regions, so nationwide studies are required. Variables such as dietary habits, perceived stress, sleep quality, extracurricular physical activity level, or individual socioeconomic conditions were not assessed, which would help better understand the underlying factors. The absence of measurement of the quality of life construct in its psychological and social dimensions constitutes another relevant limitation; future research should incorporate instruments such as SF-36 or WHOQOL-BREF. The cutoffs for BMI, although validated for the Cuban population, differ from international WHO standards, which should be considered when comparing these results with studies from other countries [8]. Finally, the insufficient muscle strength criteria were taken from the international literature and require validation in the Cuban context.

Conclusions

First-year students entering Medical Sciences programs in western Cuba present, as a whole, a health profile with warning signs. Low-to-medium levels of physical fitness predominate, excess weight affects more than one third of the cohort, one in four presents high metabolic risk, more than one third have insufficient muscle strength according to health criteria, and significant territorial gaps exist that place Artemisa and Mayabeque at a disadvantage relative to Havana. Province of origin is an independent predictor of risk profile, even after adjusting for sex. This panorama justifies the implementation of early curricular interventions, differentiated according to risk profile and territorial realities, as part of a comprehensive strategy that conceives the future professional's health as an essential component of their training.

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Annex. SUPPLEMENTARY TABLES by Physical Ability and Level

Endurance (800 m)							
Level	**n**	**Mean (s)**	**SD (s)**	**95% CI**	**Min**	**Max**	**Skewness**
Talent	647	178.3	24.7	176.4–180.2	142	215	1.65
I	1284	198.6	28.4	197.1–200.1	165	238	1.62
II	1658	217.5	31.2	216.0–219.0	182	259	1.68
III	2205	238.4	34.8	237.0–239.8	200	285	1.71
IV	1402	261.7	38.5	259.7–263.7	222	312	1.69
V	920	289.3	42.1	286.6–292.0	248	348	1.73

Table A1

Speed (60 m)							
Level	**n**	**Mean (s)**	**SD (s)**	**95% CI**	**Min**	**Max**	**Skewness**
Talent	702	7.48	0.92	7.41–7.55	6.21	8.45	1.63
I	1352	8.15	1.18	8.09–8.21	6.98	9.32	1.66
II	1724	8.79	1.42	8.72–8.86	7.55	10.18	1.64
III	2224	9.32	1.84	9.24–9.40	8.02	11.16	1.71
IV	1318	9.98	2.21	9.86–10.10	8.67	12.45	1.68
V	796	10.85	2.58	10.67–11.03	9.33	14.20	1.72

Table A2

Arm Strength (Push-ups)							
Level	**n**	**Mean (rep)**	**SD (rep)**	**95% CI**	**Min**	**Max**	**Skewness**
Talent	734	26.4	8.2	25.8–27.0	18	42	1.67
I	1418	19.7	6.8	19.3–20.1	13	32	1.64
II	1682	14.8	5.4	14.5–15.1	9	25	1.61
III	2152	10.5	4.7	10.3–10.7	6	19	1.69
IV	1199	6.9	3.5	6.7–7.1	3	13	1.72
V	931	3.2	2.1	3.1–3.3	0	7	1.73

Table A3

Abdominal Strength (Sit-ups/min)							
Level	**n**	**Mean (rep)**	**SD (rep)**	**95% CI**	**Min**	**Max**	**Skewness**
Talent	712	42.5	9.8	41.8–43.2	32	58	1.62
I	1396	35.2	8.4	34.8–35.6	26	47	1.65
II	1703	29.6	7.7	29.2–30.0	21	40	1.68
III	2188	24.1	7.2	23.8–24.4	16	34	1.71
IV	1285	18.7	6.5	18.3–19.1	11	28	1.66
V	832	12.4	5.3	12.0–12.8	4	21	1.70

Table A4