Research Article
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Development of a fitness index score: a normative framework for assessing health-related fitness in Lebanese adolescents

Abstract

Background: Adolescence is a pivotal stage for physical, emotional, and social development. Assessing health-related fitness during this period is essential for promoting well-being and identifying athletic potential. Despite its importance, no standardized fitness norms or battery tests exist for Lebanese adolescents. This study aimed to establish gender- and development-specific norms for key health-related fitness components and develop a tailored fitness index score.

Methods: A cross-sectional study involving 391 Lebanese adolescents (205 boys, 186 girls; aged 15–17 years) assessed health-related fitness components, including cardiorespiratory endurance (beep test), upper body strength (push-ups), core endurance (sit-ups), and flexibility (V sit-and-reach test). The 5D methodology was used to develop performance norms, and MANOVA was employed to analyze gender and developmental stage differences.

Results: Boys in late adolescence demonstrated significantly higher upper body strength ($p < 0.05$) compared to middle adolescents, while girls in late adolescence showed significantly lower cardiovascular endurance than their younger counterparts ($p < 0.01$). Flexibility showed no significant changes across genders or stages, while age-related improvements were observed in boys' strength and endurance.

Conclusion: This study provides the first standardized health-related fitness norms and fitness index score for Lebanese adolescents. The results offer a practical tool for assessing health status and identifying athletic talent, facilitating targeted interventions in educational and sports settings. Future studies should validate the index and explore broader applications.

Keywords: adolescent fitness norms, fitness index, health-related fitness assessment, lebanese adolescents, developmental stage fitness evaluation.

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Zahi Andraos, Mickael Abi Abdallah
Antonine university (UA) Faculty of sport sciences, Lebanon

Correspondence: Zahi Andraos, Antonine university (UA) Faculty of sport sciences, Lebanon,
Email Zahy.andraos@hotmail.com

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Introduction

Adolescence is a critical period of physical, emotional, and social development, highlighting the importance of prioritizing health through proper nutrition, regular exercise, and mental health support.[1] A holistic approach during this stage not only fosters growth and well-being but also equips adolescents with the tools necessary to navigate the challenges of adulthood successfully. Comprehensive healthcare services, including preventive care and education on healthy lifestyle choices, play a vital role in promoting long-term health outcomes for this population.

Health-related fitness encompasses components such as cardiovascular endurance, muscular strength, flexibility, and body composition, while skill-related fitness focuses on abilities like agility, balance, coordination, power, reaction time, and speed.[2] While both are essential for overall physical performance and well-being, health-related fitness forms the foundation for a healthy lifestyle, whereas skill-related fitness enhances athletic performance and functional abilities in daily life.[3] A variety of tests are available to assess health-related fitness components, each targeting specific physical attributes. For example, the beep test measures cardiovascular endurance by requiring participants to run between markers at increasing speeds, while push-ups evaluate muscular strength by engaging multiple muscle groups. Flexibility is assessed using the sit-and-reach test, which measures lower back and hamstring flexibility.[4–6] Additional tests include the 1-mile run for aerobic capacity,[7] handgrip strength measured with a dynamometer for overall muscle strength,[8] and the curl-up or sit-up test for core muscular endurance.[9]

Cardiovascular fitness and heart rate recovery are evaluated through the 3-minute step test.[10] Together, these assessments provide a comprehensive evaluation of an individual's physical capabilities and highlight areas for improvement. Body composition in adolescents is typically measured using techniques such as skinfold measurements, bioelectrical impedance analysis, or body mass index (BMI), which help determine fat distribution and overall health status.[11] Currently, there is no available data on health-related fitness norms specific to Lebanese adolescents, nor is there a standardized battery test designed to assess their fitness levels and overall health status. This study aims to address these gaps by establishing norms for four key components of health-related fitness: cardiorespiratory endurance, muscular strength, core muscular endurance, and flexibility. Additionally, it seeks to develop a fitness index score to provide a comprehensive health assessment for each adolescent.[12] The proposed norms and fitness index are specifically tailored to the unique characteristics of Lebanese adolescents, enabling a more accurate and culturally relevant evaluation of their health and fitness status.

Material and method

Participants

This study was conducted in collaboration with the administration and students of **College Central Jounieh (CCJ)** and received ethical approval from the **Antonine University (UA) Ethical Committee** (Code 470, Ref No. 679 - 2024). Following approval from the school principal, consent forms were distributed to parents, outlining the study's objectives, benefits, and potential risks. Participation was voluntary, and students who opted out were excluded without prejudice. The study included Grade 10 and Grade 11 students from both French and English sections. Eligibility criteria required students to be healthy, without injuries or other conditions preventing physical activity. Participants were from various regions of Lebanon and exhibited diverse training backgrounds. Students were divided into two grade-based groups: Grade 10 (mean age: 15.5±0.5 years) and Grade 11 (mean age: 16.6±0.4 years), with both genders represented.[13] A total of 391 students participated, including 205 boys and 186 girls. All participants underwent anthropometric measurements and physical fitness assessments. To ensure reliability, participants abstained from intense physical activity 48 hours prior to testing and fasted for at least 1.5 hours before assessments. The study complied with the Declaration of Helsinki.[14]

Procedure

The study was conducted over a four-week period (April 8 to May 3, 2024). Grade 11 students (aged 16–17) were tested on Mondays, and Grade 10 students (aged 15–16) on Fridays during their regular PE sessions. Testing was conducted in an indoor basketball court, with the beep test performed in the center and other assessments in designated corners. One week prior to the fitness assessments, a questionnaire was distributed to exclude participants with injuries or conditions preventing physical activity. Anthropometric measurements (height and weight) were conducted outside regular PE sessions during the same week. Participants were divided into four groups per grade, with boys and girls tested separately but simultaneously (Table 1). Each week, students performed one test, rotating through the assessments as outlined in Table 2. All the tests were conducted by certified PE teachers from a university recognized and approved by the Ministry of Education.

Table 1 presents the testing schedule for the four groups in each grade

Group	Group 1	Group 2	Group 3	Group 4
Beep test	Week 1	Week 4	Week 3	Week 2
Max Push up	Week 2	Week 1	Week4	Week 3
Max sit-up in 60sec	Week 3	Week 2	Week 1	Week 4
V sit and reach test	Week 4	Week 3	Week 2	Week 1

Table 2 Descriptive results of explored variables by gender

Gender	Test	Mean±SD	Standard Error of the Mean (%)	Coefficient of Variation (%)
Boys	Beep Test (m)	887.7±143.84	1.08%	16.02%
	Maximum Push-up Test (reps)	28±6.8	1.64%	24.28%
	Sit-up Test in 60 sec (reps)	40±8.5	1.43%	21.25%
	V Sit and Reach Test (cm)	85±5.2	0.41%	6.12%
Girls	Beep Test (m)	396±94.71	1.73%	23.92%
	Maximum Push-up Test (reps)	11±3.27	2.18%	29.72%
	Sit-up Test in 60 sec (reps)	31±3.54	0.83%	11.8%
	V Sit and Reach Test (cm)	90±5.67	0.45%	6.3%

Protocol

The physical fitness testing protocol included four assessments: the 20-meter shuttle run test (beep test), the maximum push-up test, the maximum sit-up test in 60 seconds, and the V sit-and-reach test. Testing began with a standardized five-minute warm-up consisting of jogging and dynamic stretches (e.g., high knees, butt kicks, open and close the gate, soldier walks, and hamstring kickbacks) to elevate body temperature and reduce injury risk. Instructions and demonstrations were provided before each test, and students were allowed one trial for familiarization, followed by the actual test.

Scores were recorded as follows:

1. **Beep test**: The highest level reached before elimination.
2. **Push-up test**: The maximum number of push-ups performed with correct form until failure.[15]
3. **Sit-up test**: The total number of sit-ups completed in 60 seconds with proper technique.[16]
4. **V sit-and-reach test**: The furthest distance reached without bending the knees or altering posture.

Instruments

Anthropometric measurements

1. **Body Mass**: Measured to 0.1 kg accuracy using a validated digital scale, with participants barefoot and in light clothing.[17]
2. **Body height**: Measured to 0.1 cm accuracy using a portable digital height scale (Camry, China).[18]
3. **Body mass index (BMI)**: Calculated using the formula BMI=Body Mass (kg)/Height (m^2).[19]

Physical fitness assessments

1. **Beep test**: Equipment: Cones to mark shuttle run distances and the Beep Test Leger App (App Store, ID: 1591739721) for auditory prompts and level tracking.
2. **Push-up test**: Equipment: Mat for support and comfort.
3. **Sit-up test**: Equipment: Ruler for range of motion, a chronometer for timing, and a mat for stability.

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4. **V sit-and-reach test**: Equipment: Protractor ruler for 90-degree positioning, marker and ruler for measuring reach, and cones to ensure proper leg positioning.

Data management

Data were recorded and analyzed using a dell laptop equipped with statistical software, ensuring efficient and accurate analysis.

Variable

The research aimed to evaluate both anthropometric and health-related fitness indicators in order to establish normative data and assess fitness levels among Lebanese adolescents. The anthropometric indicators encompassed body mass (quantified in kilograms) and body height (quantified in centimeters), which were utilized to compute the Body Mass Index (BMI) employing the formula BMI = Body Mass (kg) / Height (m^2). The health-related fitness indicators consisted of four fundamental components: cardiovascular endurance, quantified through the beep test (distance in meters); upper body strength, appraised by the maximum number of push-ups executed until muscular failure; core muscular endurance, evaluated via the number of sit-ups completed within a 60-second interval; and flexibility, assessed using the V sit-and-reach test (distance in centimeters). These indicators were meticulously chosen to facilitate a thorough evaluation of the participants' physical fitness and overall health status. Each indicator was recorded with exactitude, and descriptive statistics, including mean, standard deviation, coefficient of variation, and standard error of the mean, were computed for subsequent analysis.

Statistical analysis

Descriptive statistics, including the mean (Mean), standard deviation (SD), coefficient of variation (CV %), and the Standard Error of the Mean as a percentage of the mean (SEM %), were calculated to assess the precision and reliability of the measurements. A 95% confidence interval for the mean, including lower and upper bounds, was determined to establish significant ranges for the data under examination. To establish norms for health-related fitness components, the 5D methodology was used, categorizing results into five levels: Poor, Below Average, Average, Above Average, and Excellent. Similarly, for fitness index scores, the 5D methodology classified results into the categories: Optimal Health, Good Health, Moderate Health, Health Improvement Needed, and at Risk. These norms and classifications were derived using metrological procedures, as described by Zatsiorsky (1982). The grading system for health-related fitness components was based on a scale of 1 to 5, where Poor corresponded to 1/5, Below Average to 2/5, Average to 3/5, Above Average to 4/5, and Excellent to 5/5. This grading system provided a standardized framework for interpreting individual performance levels across all health-related fitness components. A Multivariate Analysis of Variance (MANOVA) was conducted to compare all variables related to health fitness components and fitness scores between two age categories (15–16 years and 16–17 years) and between boys and girls. Grade 10 their age was between 15 and 16 will be replaced by name of Middle Adolescents and the grade 11 their age is between 16 and 17 will be replaced by the name of Late Adolescents. Statistical analyses were performed using SPSS Statistics software (version 26.0) and Microsoft Excel (version 2016).

Results

The results in Table 2 indicate that the standard error of the mean was 1.14% for males and 1.30% for females, with a coefficient of variation of 6.12% for males and 17.94% for females. These values demonstrate a high level of precision in the measurement approach and tools utilized in the study, confirming the accuracy of the data collected and supporting its validity for scientific analysis and reliable conclusions. Table 3 compares body mass (BM), body height (BH), and body mass index (BMI) between middle adolescents (15–16 years) and late adolescents (16–17 years). Among boys, significant differences were observed in both BM ($p = 0.007$) and BH ($p = 0.004$), with late adolescents being heavier and taller. For girls, significant differences were found in BH ($p = 0.002$), with late adolescents being taller than their younger counterparts. However, BMI differences were not statistically significant across developmental stages for either gender ($p > 0.05$). These findings indicate age-related physical growth differences, particularly in height and body mass, without corresponding changes in BMI.[20]

Table 3 Anthropometric differences by developmental stage and gender (Mean±SD)

Variables	Boys Late Adolescents (n=81)	Boys Middle Adolescents (n=124)	P-value	Girls Late Adolescents (n=82)	Girls Middle Adolescents (n=104)	P-value
BM (kg)	78	71.8	0.007	60.9	59.06	NS
BH (cm)	176	173.3	0.004	163.4	160.5	0.002
BMI (kg/m^2)	25.1	23.76	NS	22.61	22.9	NS

BM = Body Mass; BH = Body Height; BMI = Body Mass Index; NS = Not Significant

Table 4 presents the grading system used to evaluate health-related fitness levels among Lebanese adolescent students, segmented by age, gender, and performance across various fitness metrics. The grading system categorizes performance into five levels-Excellent, Above Average, Average, Below Average, and Poor-scored out of 5 for each fitness component. For boy's middle adolescents, the highest performance was observed in the Excellent category, with thresholds beginning at 1526 meters for cardiovascular endurance, 47 repetitions for upper body strength, 58 repetitions for core muscular endurance, and 107 centimeters for flexibility. Conversely, thresholds for the Poor category were defined by values of 247 meters or lower, 6 repetitions or fewer, 22 repetitions or fewer, and 63 centimeters or less, respectively. Similar grading criteria were applied to girl's students of the same age group, albeit with modified threshold values reflecting typical gender differences in physical performance. Notably, Late Adolescents exhibited adjusted performance benchmarks, particularly with increased requirements for higher grades, indicating a progression in expected fitness levels with age. This grading system allows for a standardized assessment of adolescent fitness and provides a benchmark for evaluating physical health status across age and gender in the Lebanese adolescent population. Figure 1 illustrates the average scores for each component of a health-related fitness battery test, with individual scores displayed for the beep test, flexibility, push-up, and sit-up, each scored out of 5. The final column shows the total score out of 20, calculated as the sum of all fitness components, providing a better understanding of the participants' overall level of health-related

fitness. The error bars represent the standard deviation, reflecting the variability within each component score and offering insight into the consistency of fitness levels. The health-related fitness test scores for middle and late adolescents are summarized in Table 5. Boys in late adolescence performed significantly better in the push-up test (30.5±17.2 reps) than boys in middle adolescence (26.2 ± 13.0 reps, $p = 0.04$). Girls in middle adolescence achieved significantly higher scores in the beep test (452.9 ± 264.3 m) compared to late adolescents (341.6 ± 209.8 m, $p = 0.003$), indicating better cardiovascular endurance in younger girls. No significant differences were observed for flexibility or sit-ups across genders and developmental stages.

Table 4 Grading system for health-related fitness levels among adolescent lebanese students (Ages 15–17)

Test (Grade /5)	Excellent (5/5)	Above Average (4/5)	Average (3/5)	Below Average (2/5)	Poor (1/5)
Boys Middle Adolescents					
Beep Test (m)	≥1526	1101-1525	674-1100	248-673	≤247
Push-up Test (reps)	≥47	34-46	20-33	7-19	≤6
Sit-up Test (reps)	≥58	46-57	34-45	23-33	≤22
V Sit and Reach (cm)	≥107	93-106	78-92	64-77	≤63
Girls Middle Adolescents					
Beep Test (m)	≥850	586-849	321-585	56-320	≤55
Push-up Test (reps)	≥25	18-24	10-17	3-9	≤2
Sit-up Test (reps)	≥47	37-46	26-36	16-25	≤15
V Sit and Reach (cm)	≥116	101-115	85-100	70-84	≤69
Boys Late Adolescents (16 – 17 years)					
Beep Test (m)	≥1537	1095-1536	651-1094	208-650	≤207
Push-up Test (reps)	≥57	40-56	22- 39	5-21	≤4
Sit-up Test (reps)	≥64	50-63	35-49	21-34	≤20
V Sit and Reach (cm)	≥108	93-107	77-92	62-76	≤61
Girls Late Adolescents (16 – 17 years)					
Beep Test (m)	≥657	586-656	237-447	27-236	≤26
Push-up Test (reps)	≥26	19-25	11-18	4-10	≤3
Sit-up Test (reps)	≥45	36-44	26-35	17-25	≤16
V Sit and Reach (cm)	≥113	97-112	81-96	66-80	≤65

Table 5 Gender and developmental stage comparisons

Test/Grade	Boys middle adolescents	Boys late adolescents	p-value	Girls middle adolescents	Girls late adolescents	p-value
Beep test (m)	886.9±425.7	872.2±442.8	NS	452.9±264.3	341.6±209.8	**0.003**
Flexibility (cm)	84.9±13.9	84.3±14.9	NS	92.4±14.9	88.9±15.1	NS
Push-ups (reps)	26.2±13.0	30.5±17.2	**0.04**	13.2±7.1	11.4±7.0	NS
Sit-ups (Reps)	39.6±11.4	41.9±14.1	NS	30.5±10.0	30.4±8.8	NS

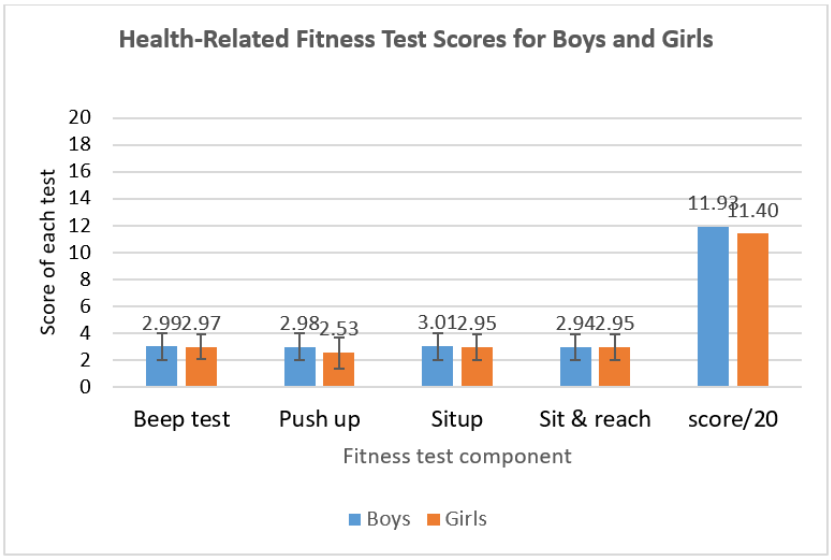

Figure 1 Test of health-related fitness component scores for boys and girls.

Table 6 presents the total fitness scores (out of 20) by gender and developmental stage. Boys in late adolescence had a slightly higher mean score (12.09 ± 4.21) than boys in middle adolescence (11.44 ± 3.82), although the difference was not statistically significant (p = 0.255). Conversely, girls in late adolescence scored significantly lower (9.69 ± 5.45) than girls in middle adolescence (11.66 ± 4.17, p = 0.006). When comparing genders within the same developmental stage, late adolescent boys scored significantly higher than late adolescent girls (p = 0.002), while no significant differences were observed between boys and girls in middle adolescence (p = 0.681). These findings emphasize the influence of developmental stage and gender on overall fitness.

Table 6 Total fitness scores by developmental stage and gender

Group Comparison	Gender	Mean ±SD	Mean ±SD	P-value
Boys Late Adolescents (n= 82) vs. Boys Middle Adolescents (n= 125)	Boys	12.09±4.21	11.44±3.82	NS
Girls Late Adolescents (n= 83) vs. Girls Middle adolescents (n= 103)	Girls	9.69±5.45	11.66±4.17	**0.006**
Boys Late Adolescents (n= 82) vs Girls Late Adolescents (n= 83)	Boys vs Girls	12.09±4.21	9.69±5.45	**0.002**
Boys Late Adolescents (n= 125) vs Girls Middle Adolescents (n= 103)	Boys vs Girls	11.44±3.82	11.66±4.17	NS

Discussion

This study aimed to establish normative data and a fitness index score tailored to assess health-related fitness levels among Lebanese adolescents, addressing the absence of standardized tools for this population. The study evaluated key health-related fitness components, including cardiorespiratory endurance, upper body strength, core muscular endurance, and flexibility. By providing a structured grading system and fitness index score, the findings offer valuable insights into the physical fitness status of adolescents, highlighting differences by gender and developmental stage. The analysis revealed significant age- and gender-related differences in health-related fitness components. For boys, late adolescents demonstrated superior upper body strength compared to middle adolescents, attributed to physiological maturation, increased muscle mass, and improved neuromuscular coordination during this developmental stage. In contrast, for girls, late adolescents exhibited significantly lower cardiovascular endurance than middle adolescents. This decline could be influenced by reduced physical activity levels or shifts in interests away from sports, which aligns with trends observed in similar populations.[21,22] Flexibility remained stable across both genders and developmental stages, suggesting that this component may not be as influenced by age-related physical or hormonal changes as strength and endurance. Additionally, while boys outperformed girls in strength and endurance, girls demonstrated comparable or slightly better flexibility. These findings emphasize the importance of age- and gender-specific considerations when assessing adolescent fitness levels and designing interventions.

One of the most significant contributions of this study is the development of a fitness index score, a composite measure designed to provide a holistic assessment of adolescent health-related fitness.[23] By assigning weights to each fitness component-cardiorespiratory endurance (40%), upper body strength (25%), core muscular endurance (25%), and flexibility (10%)-the index reflects the relative importance of each attribute in overall health and fitness.[24–28] Based on the results from the fitness index score, each adolescent's health status can be categorized using the normative ranges provided in Table 7. By comparing an individual's fitness index score to these normative categories, it is possible to determine whether the adolescent falls into the "Optimal Health," "Good Health," "Moderate Health," "Health Improvement Needed," or "At Risk" category. This classification allows for a quick assessment of the adolescent's overall health and fitness level, identifying those who may benefit from targeted interventions to improve their health outcomes.[29] Tables 7-9 provide normative ranges for categorizing fitness levels by age and gender, allowing PE teachers and coaches to assess adolescents' fitness levels and identify areas for improvement. For example, scores of 3 or below in table 8 or 9 indicates the need for targeted interventions, while scores of 4 or above highlight components that should be maintained. Evidence-based recommendations, such as resistance training,[30] respiratory muscle training, [31] and regular aerobic activities, [25,32] can be employed to improve these fitness components. Additionally, PE teachers and coaches can use Tables 8 and 9 as evaluation sheets to directly assign scores for each fitness test, leading to a total score out of 20.

Table 7 Normative fitness index score categories for health assessment by developmental stage and gender

Gender	Developmental stage	Optimal health	Good health	Moderate health	Health improvement needed	At risk
Boys	Late Adolescents	≥4.14	3.37-4.13	2.59-3.36	1.81-2.58	≤1.8
Boys	Middle Adolescents	≥4.06	3.35-4.05	2.63-3.34	1.92-2.62	≤1.91
Girls	Late Adolescents	≥4.22	3.08-4.21	1.93-3.07	0.79-1.92	≤0.78
Girls	Middle Adolescents	≥3.99	3.23-3.98	2.46-3.22	1.7-2.45	≤1.69

Table 8 Evaluation sheet of middle adolescent of both genders years

Name:						
Class/Age:						
Gender:						
Test name	**Beep test (in m)**	**Pushup test (in reps)**	**Sit-up Test(in reps)**	**V sit and reach (in cm)**	**Score**	**Overall grade**
Test Scale (boys)	≥1526	≥47	≥58	≥107	5/5	
	1101-1525	34-46	46-57	93-106	4/5	
	674-1100	20-33	34-45	78-92	3/5	
	248-673	7-19	23-33	64-77	2/5	
	≤247	≤6	≤22	≤63	1/5	

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Table 8 Continued...

Test name	Beep test (in m)	Pushup test (in reps)	Sit-up Test(in reps)	V sit and reach (in cm)	Score	Overall grade
Test Scale (girls)	≥850	≥25	≥47	≥116	5/5	
	586-849	18-24	37-46	101-115	4/5	
	321-585	10-17	26-36	85-100	3/5	
	56-320	3-9	16-25	70-84	2/5	
	≤55	≤2	≤15	≤69	1/5	
Grade	/5	/5	/5	/5		/20

Table 9 Evaluation sheet of late adolescent of both genders

Name:						
Class/Age:						
Gender:						
Test name	**Beep test (in m)**	**Pushup test (in reps)**	**Sit-up test(in reps)**	**V sit and reach (in cm)**	**Score**	**Overall grade**
Test scale (boys)	≥1537	≥57	≥64	≥108	5/5	
	1095-1536	40-56	50-63	93-107	4/5	
	651-1094	22- 39	35-49	77-92	3/5	
	208-650	5-21	21-34	62-76	2/5	
	≤207	≤4	≤20	≤61	1/5	
Test Scale (girls)	≥657	≥26	≥45	≥113	5/5	
	586-656	19-25	36-44	97-112	4/5	
	237-447	11-18	26-35	81-96	3/5	
	27-236	4-10	17-25	66-80	2/5	
	≤26	≤3	≤16	≤65	1/5	
Grade	/5	/5	/5	/5		/20

Practical applications

The fitness index score is a versatile tool for educators, health professionals, and policymakers. Its implementation in schools enables PE teachers to monitor progress, identify at-risk students, and tailor fitness programs to individual needs. Additionally, it serves as an initial screening tool for identifying athletic talent, contributing to talent selection programs in competitive sports. In public health contexts, the fitness index can inform community-level interventions by providing data on fitness trends and identifying populations at risk. For instance, regions with high proportions of students classified as "At Risk" can implement targeted initiatives, such as structured physical activity programs or awareness campaigns promoting active lifestyles.

Validation and future research

While the fitness index score is a novel contribution, its validation against established fitness batteries is necessary to confirm its reliability and generalizability. Comparing the index with international tools will ensure its credibility and allow for cross-cultural adaptations. Future research should also explore the predictive value of the index in determining long-term health outcomes, such as obesity, cardiovascular health, or academic performance, and its role in identifying future athletic talent. Furthermore, socio-economic and environmental factors, such as dietary habits and access to sports facilities, should be considered in future studies to better understand their impact on fitness levels. Expanding this research to include adolescents from diverse regions and age groups will enhance the index's applicability and generalizability.

Limitations

Several limitations of this study should be acknowledged. First, the reliance on chronological age to define developmental stages (middle and late adolescents) does not account for variations in sexual maturation, a critical determinant of physical fitness during adolescence. Future studies should incorporate assessments of sexual maturation to provide more nuanced interpretations of fitness differences. Second, the sample was limited to a specific geographic region in Lebanon, which may not fully represent the diversity of the adolescent population. Including participants from various regions, accounting for lifestyle differences, economic situation and environmental factors such as altitude, would strengthen the findings.

Conclusion

This study provides a culturally relevant and scientifically robust framework for assessing health-related fitness in Lebanese adolescents. By establishing normative data and a fitness index score, it offers a practical tool for evaluating health status and athletic potential. The findings highlight the importance of age- and gender-specific approaches in fitness assessments and interventions, laying the groundwork for healthier lifestyles and the identification of athletic talent. Further validation and expansion of this index will enhance its applicability and contribute to improving adolescent health outcomes on a broader scale.

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None.

Conflicts of interest

The authors declare that there is no conflict of interest.

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