

Article

Multidimensional Profiling of Physical Fitness and Behaviors among Rural Chinese Adolescents Aged 6-13: A Small-Sample Cross-Sectional Study

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Abstract: Purpose: To characterize the physical fitness and behavioral profiles of school-aged children in rural China and to examine associations between lifestyle factors and somatic as well as physiological health indicators. Methods: In a cross-sectional study, we conveniently sampled 26 students aged 6-13 years (16 boys, 10 girls) from Fucheng Subdistrict, Luoding, Guangdong. Multi-dimensional assessments covered four domains: body morphology, physiological function, physical fitness, and lifestyle behaviors. Data were analyzed and visualized in Python 3.12.3. Pearson correlations were used to construct a correlation matrix and a significance-annotated heat map (two-tailed; $P < 0.05$ were considered statistically significant, $P < 0.01$ were considered statistically highly significant). Results: Overall developmental status approximated age-matched norms, and no cases of overweight or obesity were identified. The Physical Activity Questionnaire for Older Children (PAQ-C) score averaged 2.65 ± 0.61 ; approximately 77% did not meet the recommended activity threshold. Non-learning screen time averaged 2.81 ± 0.64 hours/day, exceeding health guidance. Correlation analyses showed that physical activity level was positively associated with skeletal muscle percentage and negatively associated with weight, BMI, body-fat percentage, and systolic blood pressure; conversely, screen exposure time was positively associated with weight, BMI, and systolic blood pressure, and negatively associated with physical activity. Radar plots indicated relatively better flexibility but marked weaknesses in balance and physical activity dimensions. Conclusions: Rural adolescents face a clustering risk characterized by high screen time and low activity. Community and school interventions should adopt a dual strategy of "moving more and sitting less", strengthening support for physical activity and managing screen time across school and family settings to jointly improve physical fitness and health in school-aged children.

Keywords: adolescents; physical fitness; physical activity; behavioral profiling

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1. Introduction

Fucheng Subdistrict is located in the northern hilly zone of Luoding City, Guangdong Province, China, representing a typical urban-rural fringe area. Compared with urban centers, townships and administrative villages continue to experience persistent gaps in the availability of sports resources, coverage of health education, coordination between schools and families, and provision of facilities [1]. Within the framework of China's Rural Revitalization Strategy, which emphasizes improvements in education, health, and human capital, the physical fitness of school-aged children has emerged as a key indicator of a community's endogenous development capacity.

At the same time, the widespread penetration of digital media, including smartphones and short-video platforms, has exposed adolescents to modern health risks characterized by insufficient physical activity, increased sedentary time, and deteriorating

vision [2]. Although prior evidence indicates that urban-rural disparities are gradually narrowing, rural adolescents are increasingly confronting health challenges similar to those observed in urban settings [3].

In this context, the present study focuses on two primary dimensions-physical fitness, encompassing body morphology, physiological function, and physical performance, and behaviors, including physical activity and screen use-to construct a behavioral profile of school-aged children in Fucheng Subdistrict. This approach provides small-sample empirical evidence to inform grassroots interventions and guide policy implementation.

2. Methods

2.1. Participants

A cross-sectional survey was conducted in Fucheng Subdistrict using convenience sampling. Twenty-six school-aged children were enrolled (16 boys, 10 girls; mean age: 9.23 ± 2.02 years). Inclusion criteria included permanent residence in the jurisdiction, ability to cooperate with physical assessments, and written informed consent from parents or guardians. Exclusion criteria were any acute or chronic disease or injury that would limit participation in physical testing. The study adhered to the principles of the Declaration of Helsinki, and all data were anonymized. The protocol complied with the ethical standards of Zhaoqing University (approval No. 2025063; Zhaoqing, China).

2.2. Anthropometric Measurements

Body height (measured to the nearest 0.01 m) and weight (measured to the nearest 0.01 kg) were recorded, and body mass index (BMI) was calculated using the formula $BMI = \text{weight} / \text{height}^2$ (kg/m^2). Whole-body fat percentage and skeletal muscle percentage were assessed using bioelectrical impedance analysis (BIA). Waist circumference (to 0.01 m) and hip circumference (to 0.01 m) were measured, and the waist-to-hip ratio (WHR) was calculated as $WHR = \text{waist} / \text{hip}$.

2.3. Physiological Measurements

Resting systolic blood pressure (SBP), diastolic blood pressure (DBP), and heart rate (HR) were measured using an upper-arm automated electronic sphygmomanometer with participants seated at rest. Unaided visual acuity of each eye was assessed using an international standard logarithmic visual acuity chart (naked-eye; left eye L, right eye R).

To harmonize visual acuity for analysis, a 0-100 composite score was derived as follows. Let the base acuity be the binocular mean, $\text{Base} = (L + R)/2$, and define inter-ocular asymmetry as $\text{Asym} = |L - R| / ((L + R)/2)$. With the full-score reference set to $\text{Ref} = 1.2$ and the asymmetry weight $\alpha = 0.4$, the scaled visual score is $\text{Vision_Score}_{100} = 100 \times \min(\text{Base}/\text{Ref}, 1) \times (1 - \alpha \cdot \min(\text{Asym}, 0.3))$. This formula caps the acuity contribution at the reference level (no extra credit beyond 1.2) and applies a bounded penalty for inter-ocular asymmetry (maximum penalty at $\text{Asym} = 0.3$).

2.4. Physical Fitness Assessments

Strength (grip strength): Maximal handgrip strength of the dominant hand was measured using a calibrated dynamometer, following standard standing posture and verbal encouragement. Relative grip strength was computed as $\text{Relative Grip} = \text{grip}/\text{body-weight} \times 100\%$. To harmonize with a 0-100 scale, relative grip was normalized against the age-referenced benchmark for 9-10-year-olds [4]. Specifically, $\text{Grip_score}_{100} = \min(\text{Relative Grip}/45\%, 1) \times 100$. No bonus is granted beyond the benchmark; values above 45% are capped at 100.

Balance (single-leg stance, eyes closed): Balance was assessed using a 60 s eyes-closed single-leg stance test on both sides. Let L and R denote the best holding time (s) for the left and right legs, respectively; the time cap is $T = 60\text{s}$. Define the base stability and inter-

limb asymmetry as $\text{Base} = \min\left(\frac{L+R}{2T}, 1\right)$, $\text{Asym} = \frac{|L-R|}{\frac{L+R}{2}}$, With the asymmetry weight $\alpha = 0.4$, the 0-100 score is $\text{Balance_score_100} = 100 \times \text{Base} \times (1 - \alpha \cdot \min(\text{Asym}, 0.3))$. Performance is capped at 60 s; an asymmetry penalty up to $\text{Asym} = 0.3$ is applied.

Flexibility (range of motion, ROM): Cervical, shoulder, and hip ROM were measured bilaterally (left/right) using a goniometer under standardized positions. The per-side percentage score for a given motion with observed angle angle and reference cap T is $s = \min\left(\frac{\text{angle}}{T}, 1\right) \times 100$. Reference caps used were: cervical-flexion 45°, extension 60°, rotation 80°; shoulder-flexion 180°, extension 60°; hip-flexion 120°, extension 30°. For each bilateral pair, define a side-weighted base and asymmetry as $\text{Base} = 0.7\min(s_L, s_R) + 0.3\frac{s_L+s_R}{2}$, $\text{Asym} = \frac{|L-R|}{(L+R)/2}$, and apply an asymmetry weight $\alpha = 0.2$ to obtain the pair-level score: $\text{pair_100} = \text{Base} \times (1 - \alpha\min(\text{Asym}, 0.3))$. Composite region scores were then averaged across constituent motions to yield $\text{ROM}_{\text{cervical_100}}$, $\text{ROM}_{\text{shoulder_100}}$, $\text{ROM}_{\text{Hip_100}}$, and the overall flexibility score was computed as $\text{ROM_score_100} = \text{mean}(\text{ROM}_{\text{cervical_100}}, \text{ROM}_{\text{shoulder_100}}, \text{ROM}_{\text{Hip_100}})$.

2.5. Behavioral Assessments

Physical activity was assessed using the Physical Activity Questionnaire for Older Children (PAQ-C) and scored according to the official manual (item mean, 1-5). For consistency across domains, the total PAQ-C score was linearly rescaled to a 0-100 metric, with higher scores indicating greater activity.

Screen use was measured with a brief questionnaire quantifying daily non-academic screen exposure, including phones, tablets, computers, TVs, and gaming consoles, excluding classwork and homework. To align with health recommendations (≤ 2 hours/day), screen time was reverse-scored so that lower exposure corresponded to higher scores and then converted to a 0-100 scale for analysis and visualization.

2.6. Statistical Analysis

Results are presented as mean $\pm$ standard deviation (mean $\pm$ SD). Data processing and visualization were performed using Python 3.12.3. Pearson's correlation (two-tailed, pairwise deletion) was applied to construct the correlation matrix, and a significance-annotated heat map was generated, with $P < 0.05$ considered significant and $P < 0.01$ considered highly significant. A six-dimensional radar chart illustrated the cohort profile, using the group mean as the central line and the SD as a shaded band around the mean.

3. Results

3.1. Somatic Growth and Body Composition

Participants had a mean height of 134.69 ± 12.95 cm and a mean weight of 30.07 ± 9.74 kg, resulting in a BMI of 16.27 ± 3.21 kg/m². The mean body-fat percentage was $17.00\% \pm 5.69\%$, and the mean skeletal muscle percentage was $78.45\% \pm 5.49\%$. Central adiposity measures included a waist circumference of 61.06 ± 11.88 cm, hip circumference of 72.37 ± 12.90 cm, and a WHR of 0.84 ± 0.06 . Overall somatic development was consistent with age-specific norms, and no cases of overweight or obesity were observed (Table 1).

Table 1. Anthropometric and Body-Composition Characteristics of Participants (n=26).

Height (m)	Weight (kg)	BMI	Fat (%)	Muscle (%)	Waist (m)	Hip (m)	WHR
1.35 $\pm$ 0.13	30.07 $\pm$ 9.74	16.27 $\pm$ 3.21	17.00 $\pm$ 5.69	78.45 $\pm$ 5.49	0.61 $\pm$ 0.12	0.72 $\pm$ 0.13	0.84 $\pm$ 0.06

The results are expressed as mean $\pm$ SD.

Abbreviation: BMI body mass index, BMI = weight (kg) / [height (m)]², WHR waist to hip ratio, WHR = waist circumference / hip circumference.

3.2. Basic Physiological Function

Resting heart rate averaged 93.65 ± 12.31 bpm. Mean blood pressure was 104.30/64.54 mmHg (SBP/DBP), both within normative ranges for children. Uncorrected visual acuity averaged approximately 4.95 on the Chinese decimal scale, and the myopia detection rate was 34.6%, slightly lower than the national estimate for children and adolescents (52.7%) [5] (Table 2).

Table 2. Basic Physiological Measures of Participants (n=26).

RHR (bpm)	SBP (mmHg)	DBP (mmHg)	Vision left	Vision right
93.65±12.32	104.31±13.54	64.54±6.79	4.96±0.21	4.95±0.23

The results are expressed as mean $\pm$ SD.

Abbreviation: RHR resting heart rate, SPB systolic blood pressure, DBP diastolic blood pressure.

3.3. Physical Performance

Relative grip strength averaged 72.46 ± 12.47 , and range of motion (ROM) averaged 77.27 ± 7.95 , both indicating moderate performance levels. Balance scored 52.85 ± 21.66 , reflecting substantial interindividual variability and representing a key weakness in the cohort (Table 3).

Table 3. Physical Performance Scores of Participants (n=26).

Grip score	Balance score	ROM score
72.46±12.47	52.85±21.66	77.27±7.95

The results are expressed as mean $\pm$ SD.

Abbreviation: ROM range of motion.

3.4. Behavioral Characteristics

The PAQ-C score averaged 2.65 ± 0.61 . Based on prior validation studies, a PAQ-C score greater than 2.73-2.87 is commonly used as the threshold for adequate physical activity [5,6]; by this criterion, 76.92% or more of participants in the present sample did not reach the adequate activity level. Daily non-learning screen time averaged 2.81 ± 0.64 hours, exceeding the recommended limit of ≤ 1 hour/day [7,8] (Table 4).

Table 4. Physical Activity and Non-Learning Screen Time of Participants(n=26).

Physical activity	Screen(hours/day)
2.65±0.61	2.81±0.64

The results are expressed as mean $\pm$ SD.

3.5. Correlation Analysis and Integrated Profiling

As shown in Figure 1, Pearson correlations revealed consistent associations among growth- and physiology-related variables (height, weight, BMI, body fat and muscle composition, blood pressure, and heart rate), reflecting typical developmental patterns in youth [9]. Behavioral indicators were closely linked with somatic and physiological variation in this cohort. The PAQ-C physical activity score was negatively correlated with age ($r = -0.543$, $P < 0.01$), weight ($r = -0.495$, $P < 0.05$), BMI ($r = -0.429$, $P < 0.05$), body-fat percentage ($r = -0.416$, $P < 0.05$), and systolic blood pressure ($r = -0.422$, $P < 0.05$), and positively correlated with skeletal muscle percentage ($r = 0.576$, $P < 0.01$). In contrast, non-learning screen time (SCREEN) was positively correlated with age ($r = 0.413$, $P < 0.05$), weight ($r = 0.468$, $P < 0.05$), BMI ($r = 0.477$, $P < 0.05$), and systolic blood pressure ($r = 0.465$, $P < 0.05$), and negatively correlated with skeletal muscle percentage ($r = -0.405$, $P < 0.05$). As expected, SCREEN and PAQ-C were inversely related ($r = -0.474$, $P < 0.05$). Physical

performance scores, including balance, visual function, grip strength, and ROM, showed no statistically significant linear associations with most anthropometric, physiological, or lifestyle variables in this sample ($P > 0.05$).

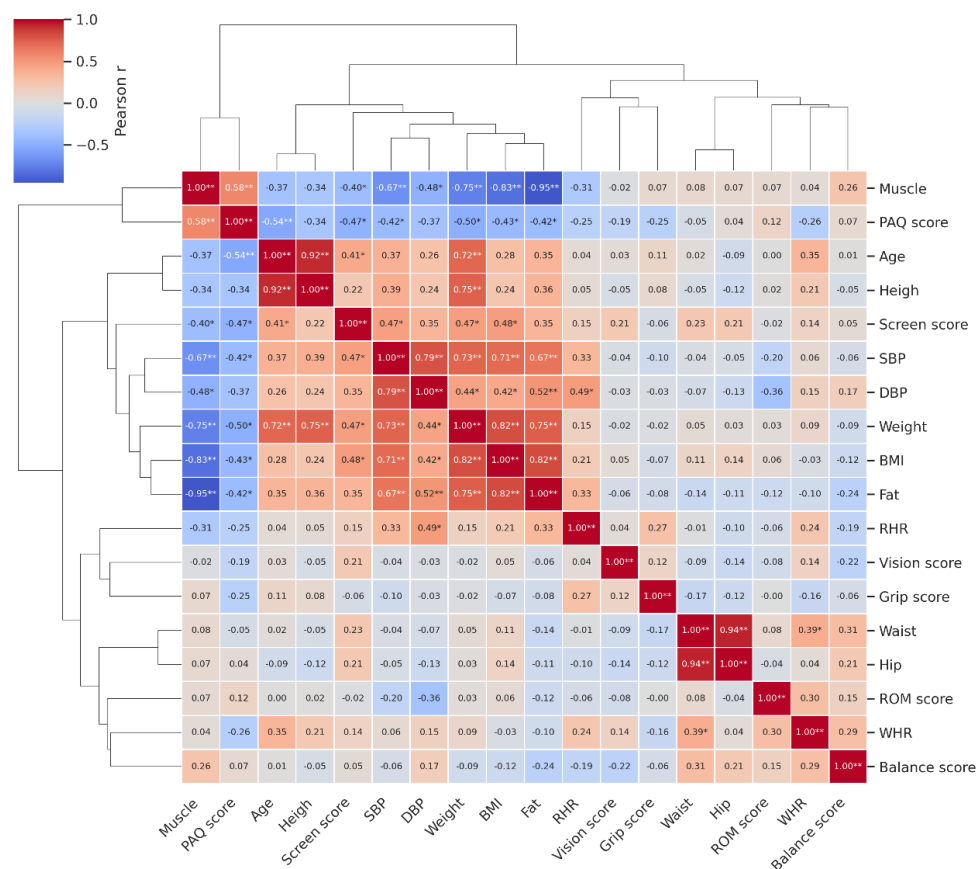


Figure 1. Pearson correlation matrix among anthropometric, physiological, physical performance, and behavioral measures ($n = 26$). Abbreviation: ROM range of motion, BMI body mass index, WHR waist to hip ratio, RHR resting heart rate, SPB systolic blood pressure, DBP diastolic blood pressure. * indicates $P < 0.05$; ** indicates $P < 0.01$.

Figure 2 presents the six-domain radar profile of the cohort. The overall polygon is irregular, indicating uneven development across domains. Flexibility/ROM extends farthest outward, reflecting relative strength, while grip strength occupies the mid-to-upper range. The weakest dimensions are balance and physical activity (PAQ-C), which retract noticeably inward. The screen-time dimension also lies closer to the inner ring, indicating higher exposure and lower scores under the reverse-scored metric.

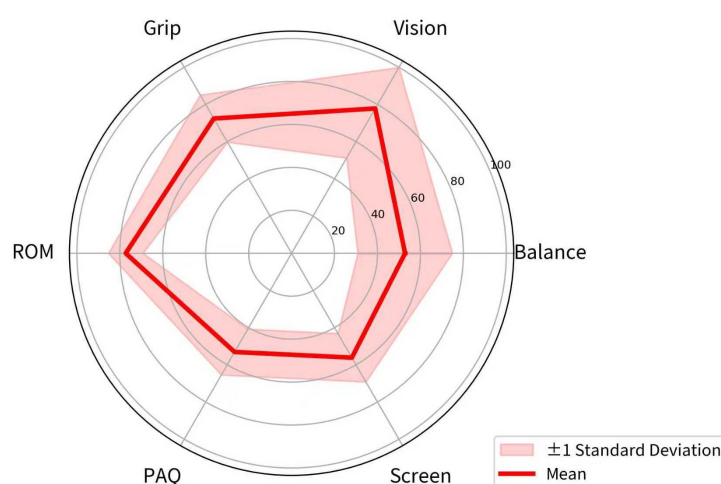


Figure 2. Six-domain radar profile of the cohort.

Abbreviation: ROM range of motion. The results are expressed as mean $\pm$ SD. The central line denotes the group mean, and the shaded band represents the SD.

4. Discussion

The study identified two lifestyle-related patterns among school-aged children in an urban-rural fringe community. First, physical activity level (PAQ-C) was moderately positively correlated with skeletal muscle percentage and negatively correlated with weight, BMI, body-fat percentage, and systolic blood pressure. This suggests that routine moderate-to-vigorous activity is associated not only with a more favorable body composition (lower fat, higher muscle) but also with lower weight, BMI, and blood pressure. Second, screen exposure time showed positive correlations with weight, BMI, systolic blood pressure, and age, and a negative correlation with PAQ-C, indicating a concurrent pattern of high screen time, low activity, and unfavorable body composition/elevated blood pressure. Consistent with the radar chart, the cohort profile retracts inward on balance and physical activity, while the screen-time dimension also lies closer to the center, reflecting prevalent sedentary behavior accompanied by insufficient activity. Functional fitness indices (balance, grip strength, flexibility, and vision) did not show stable linear associations with most anthropometric, blood pressure, or behavioral variables. This may be due to the modest sample size, score dispersion across domains, and measurement variability. Nevertheless, the radar chart's structural imbalance-highlighting relative strength in flexibility alongside weaknesses in balance and physical activity-provides a clear target for future interventions.

Based on these findings, two priority strategies are recommended at the community and school levels. First, "move more": implement during- and after-school programs aimed at increasing activity, such as tiered moderate-to-vigorous exercise, gamified fitness classes, and school-community sports clubs, with a focus on improving balance and aerobic/muscular fitness. Second, "sit less": establish screen-time management strategies through coordinated family-school-community agreements, provide alternative activity options, and use practical timing and feedback mechanisms. These measures should be coupled with health education and school-family collaboration to prevent the clustering of high screen time and low physical activity.

Methodologically, the study is limited by its small sample size ($n = 26$) and cross-sectional design, which precludes causal inference. PAQ-C and screen-time measures were partly self-reported, making them susceptible to recall bias. While converting fitness outcomes to a 0-100 composite scale facilitates integrated visualization, it may obscure differences among subtests. These limitations highlight the need for further validation in

larger samples with longitudinal follow-up and objective monitoring (e.g., wearable devices). Despite these constraints, the study demonstrates, in a grassroots context, a consistent association between lifestyle patterns and body composition/blood pressure and provides an operational framework with actionable insights for intervention prioritization.

5. Conclusion

This study conducted a multidimensional assessment of 26 school-aged children from a semi-rural community, revealing important insights into the interplay between lifestyle behaviors, physical fitness, and cardiometabolic health. Higher physical activity levels were consistently associated with more favorable body composition, including higher skeletal muscle percentage and lower body-fat proportion, as well as lower weight, BMI, and systolic blood pressure. In contrast, prolonged screen exposure was linked to higher weight, BMI, and systolic pressure, highlighting a co-occurring pattern of sedentary behavior and suboptimal physiological outcomes. The cohort also exhibited relative weaknesses in balance and general physical activity, underscoring specific domains that require targeted intervention.

These findings emphasize the need for comprehensive, community-level strategies to promote healthy behaviors among school-aged children. Interventions should adopt a dual approach of "move more and sit less," prioritizing the development of balance, aerobic endurance, and muscular strength through structured programs such as tiered physical activity classes, school-community sports initiatives, and gamified fitness activities. In addition, coordinated family-school-community strategies for screen-time management and health education are essential to mitigate excessive sedentary behavior, encourage active lifestyles, and foster a supportive environment for habit formation.

Beyond immediate behavioral modifications, these insights have broader implications for public health planning and education policy. Early intervention in semi-rural communities-where access to sports resources and structured physical activity may be limited-can contribute to long-term improvements in physical fitness, reduce the risk of cardiometabolic disorders, and help narrow urban-rural disparities in child health outcomes. Future research should validate these findings in larger, longitudinal cohorts, integrating objective monitoring tools to refine recommendations and optimize intervention strategies. Overall, this study provides an operational framework for profiling physical activity and sedentary behavior while offering actionable guidance for promoting holistic health among children in grassroots settings.

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Informed Consent Statement: Not applicable. All authors approved the final manuscript and the submission to this journal.

Data Availability Statement: The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest: The authors declare no competing interests.

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