Evaluating Body Composition, Grip Strength, Respiratory index, and Explosive Strength Among Children aged 8 to 12 years

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Abstract
Background and Aim: Childhood between the ages of 8 to 12 years is a critical period for physical growth and functional development. This study aimed to evaluate body composition, hand grip strength (HGS), respiratory function (Peak Expiratory Flow – PEFR), and explosive strength (Standing Broad Jump – SBJ) among school-going children to establish normative data and explore age and gender-based differences.
Materials and Methods: A cross-sectional study was conducted on 350 students (181 boys and 169 girls) aged 8 to 12 years, selected using systematic random sampling from various schools. Body composition (fat percentage, lean body mass), HGS, PEFR, flexibility, and explosive strength were assessed using standardized tools and protocols. Descriptive statistics and independent sample t-tests were used to evaluate developmental trends and sex-based differences across age groups.
Results: The findings revealed a consistent age-related increase in height, weight, lean body mass, grip strength, PEFR, and SBJ performance in both sexes. Girls demonstrated significantly higher fat percentages across all age groups, while boys outperformed girls in HGS, PEFR, and SBJ from age 9 [Fat% (MD = -2.93, p = .001), HGS (MD = 1.90, p = 0.50), SBJ (MD = 15.60, p = 0.001)] onward, with significant differences observed particularly at age 10 [Fat% (MD = -2.82, p = .000), LBM (MD = 1.97, p = 0.010), HGS (MD = 3.13, p = 0.000), PEF (MD = 39.31, p = 0.000), SBJ (MD = 17.22, p = 0.000)]. BMI and flexibility remained relatively stable with no consistent gender disparity.
Conclusions: The study highlights distinct growth trajectories and emerging gender differences in physical and functional fitness among children aged 8 to 12 years. These findings emphasize the importance of age and gender-specific benchmarks for early identification of health and performance trends, and the development of targeted interventions in school health and physical education programs.

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1. Introduction

Childhood, particularly between the ages of 8 to 12 years, is a crucial phase for physical growth and development (MARTIN *et al*., 2012) [8]. During this period, assessing health and fitness indicators such as body composition, grip strength, respiratory function, and explosive strength provides important insights into a child's physical well-being (Boraita *et al*., 2021) [1]. Body composition reflects the balance of fat and lean mass, which is linked to metabolic and cardiovascular health (Yan *et al*., 2019) [17]. Grip strength is a simple yet powerful measure of muscular fitness and has been associated with both current and future health outcomes (Garraza *et al*., 2023; Nara *et al*., 2022, 2023) [4, 9-10]. Respiratory indices, including peak expiratory flow rate (PEFR), are essential for evaluating lung function and aerobic capacity (Pedersen *et al*., 1996) [13]. Similarly, explosive strength, often measured through jump tests (Rahman, 2021) [14], reflects neuromuscular coordination and power critical for physical activity and sports performance (Kumar *et al*., 2025; Marlatt *et al*., 2022) [6, 7]. Despite the growing emphasis on physical fitness in children, there is a lack of comprehensive data on these parameters in the Indian context (Yamada *et al*., 2016) [16]. Understanding the prevalence and variations of these attributes across age groups can help identify early signs of developmental delays or health risks (Stefanaki *et al*., 2018) [15]. This study aims to examine the prevalence of body composition, grip strength, respiratory index and explosive strength among children aged 8 to 12 years, with the goal of establishing baseline values and supporting future health and fitness interventions (Chapman *et al*., 2019; MARTIN *et al*., 2012) [3, 8].

Although international studies have provided normative data for these indicators, there remains a scarcity of comprehensive, region-specific data, particularly within the Indian context (Chapman *et al*., 2019; Marlatt *et al*., 2022) [3, 7]. Furthermore, few studies have examined the simultaneous assessment of these variables in a unified framework across both genders and multiple age groups (Kaya & Çelenay, 2014; Yogesh *et al*., 2024) [5, 18]. Recognizing gender-based physiological differences is also vital, as boys and girls begin to diverge in muscle development, fat distribution, and strength-related capacities even before the onset of puberty (Brodner *et al*., 2020; Kaya & Çelenay, 2014) [2, 5].

Against this backdrop, the present study aims to evaluate and compare body composition, muscular strength, respiratory index, and explosive strength among Indian school-going children aged 8 to 12 years. The objectives include identifying age-related growth patterns, gender differences, and establishing baseline data that can serve as reference standards for educators, health professionals, and policy makers in physical education and child health development programs.

Research methodology:

Participants

The study comprised a total of 350 school students, including 181 boys and 169 girls, aged between 8 and 12 years. Participants were drawn from classes 2nd to 7th across selected schools. To ensure a representative and unbiased sample, a systematic random sampling technique was employed. Initially, the RAND() function in Microsoft Excel was used to assign random values to student roll numbers. Subsequently, participants were selected at fixed intervals from the class-wise lists based on the generated sequence.

Measurement of variables

Grip Strength: Grip strength was measured using a Camry Digital Hand Dynamometer. Participants were instructed to stand with their arms at their sides, ensuring the arm did not touch the body, and to squeeze the dynamometer with maximum effort using their dominant hand. Two trials were performed, with a 30-second rest interval between attempts. The highest reading, recorded in kilograms (kg), was used for analysis.

Peak Expiratory Flow (Peak Flow): Peak expiratory flow was measured using a Bos Medicare Surgical® peak flow meter (Mini-Wright or equivalent)(Nazir *et al*., 2005) [11]. Students were instructed to take a deep breath and exhale into the device as forcefully and rapidly as possible. The procedure was repeated three times, and the highest value, recorded in liters per minute (L/min), was taken for analysis. To ensure hygiene and prevent the spread of pathogens, a separate mouthpiece was used for each participant.

Fat Percentage and Lean Body Mass: Body fat percentage was determined with a bioelectrical impedance analyser (Omron HBF-702T) (Omron Healthcare, 2025) [12]. While standing barefoot on the device with clean, dry feet, participants remained still as a low, safe electrical current passed through the body. The analyser combined the measured impedance with the entered age, sex, height, and weight to calculate body-fat percentage. Following the manufacturer's standard protocol, all measurements were taken either before eating or at least 2–3 hours after the last meal to limit the effects of food intake and hydration on the result.

Lean Body Mass (LBM): was calculated using the following formula: LBM = Body Weight – Fat Mass, where Fat Mass = (Fat% × Body Weight) / 100.

Standing Broad Jump (SBJ): Explosive leg power was evaluated using the Standing Broad Jump test. Participants stood with their feet shoulder-width apart behind a marked line and jumped forward with both feet simultaneously, using arm swing to generate momentum. The distance from the take-offline to the point where the back of the heels landed was measured in centimetres (cm) using a measuring tape. Each participant completed two trials, and the longest valid jump was recorded for analysis.

Flexibility (Sit and Reach Test): Flexibility of the lower back and hamstrings was assessed using the Sit and Reach test with a standard sit and reach box. Participants sat on the floor with legs fully extended and feet placed flat against the box. With arms extended and hands overlapping, they reached forward as far as possible without bending the knees. The farthest point reached, measured in centimetres (cm), was recorded. Two trials were performed, and the highest score was used for analysis.

Height, Weight and Body Mass Index: Height was measured using a Cambia stadiometer, with participants standing barefoot in an upright position, ensuring that the heels, buttocks, shoulders, and head were in contact with the vertical surface. The height was recorded to the nearest 0.1 centimetre (cm). Weight was measured using a digital weighing scale, with participants dressed in school uniforms and without shoes, and recorded to the nearest 0.1 kilogram (kg). Body Mass Index (BMI) was assessed using a Bioelectrical Impedance Analysis (BIA) device (Omron HBF-702T) (Omron Healthcare, 2025) [12], which calculates BMI based on the participant's age, sex, height, and weight. Participants stood barefoot on the device, and measurements were taken following the manufacturer's standardized protocol. The device automatically displayed BMI along with additional body composition metrics, including body fat percentage and lean body mass.

Inclusion and Exclusion criteria

Inclusion Criteria: Participants in the study were school children aged 8 to 12 years, enrolled in classes 2nd to 7th. Eligibility was limited to medically healthy boys and girls who were physically capable of performing the required assessments. Only students who were present on the day of data collection and had received permission from school authorities were included.

Exclusion Criteria: Students with any known physical or medical conditions that could affect grip strength, lung function, or body composition were excluded. These included, but were not limited to, cardiovascular diseases, muscular dystrophy, joint or bone disorders, chronic respiratory conditions such as asthma or chronic obstructive pulmonary disease (COPD), and any history of allergic reactions that could interfere with participation. Students who were absent during data collection or did not receive the necessary school approval were also excluded from the study.

Ethical consideration:

Prior to data collection, ethical clearance was obtained from the relevant institutional department to ensure compliance with research standards. Written permission was also secured from the respective school authorities to conduct the study on their premises. Participation was voluntary, and only those students whose involvement was approved by the schools were included. Throughout the research process, the confidentiality of all participants' data was strictly maintained.

Statistical Analysis

Initially, participant data were categorized and tabulated by age and gender. We then checked for missing values and performed a Kolmogorov-Smirnov test to confirm normality. For descriptive statistics, arithmetic mean, and standard deviation were calculated to establish reference values for central tendency and dispersion. Subsequently, an independent t-test was employed to compare the different age and gender strata. All statistical procedures were conducted using SPSS 26.00, with significance determined at $p < 0.05$.

Results

Table 1: Descriptive Boys

Age (Years)	8			9			10			11			12		
Variables	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**
Height	35	125.74	5.56	30	131.41	6.27	57	138.01	6.09	38	138.88	8.82	21	143.65	13.46
Weight	35	23.98	6.30	30	27.72	5.88	57	30.48	6.98	38	30.47	8.71	21	33.24	10.41
BMI	35	15.13	3.47	30	15.92	2.22	57	15.88	2.56	38	15.60	3.05	21	15.76	3.02
Fat%	35	15.33	5.24	30	15.54	3.35	57	14.78	3.87	38	13.65	4.61	21	13.06	4.53
LBM	35	20.01	3.18	30	23.24	3.89	57	25.73	4.29	38	25.95	5.57	21	28.52	7.55
HGS	35	10.82	39.42	30	14.17	3.50	57	15.87	3.18	38	16.34	3.64	21	19.25	6.90
PEFR	35	198.85	39.42	30	204.33	36.54	57	256.22	44.10	38	252.10	47.37	21	260.95	97.46
Flexibility	35	23.97	4.50	30	23.16	4.98	57	22.96	5.04	38	22.39	5.64	21	23.51	6.40
SBJ	35	119.42	20.57	30	136.73	19.79	57	138.18	12.88	38	139.47	22.72	21	149.81	28.03

Table 1 presents the descriptive statistics of various physical fitness and body composition parameters among boys aged 8 to 12 years. The data shows a consistent age-related increase across most variables, indicating normal physical growth and development during this period. Height and weight both increase steadily with age. The mean height rises from 125.74 cm at age 8 to 143.65 cm at age 12, while mean weight progresses from 23.98 kg to 33.24 kg, reflecting healthy growth patterns. BMI values remain relatively stable across ages, ranging between 15.13 and 15.92, suggesting proportional increases in height and weight. Fat percentage shows a gradual decline from 15.33% at age 8 to 13.06% at age 12, indicating a shift in body composition as boys gain more lean mass. Correspondingly, lean body mass (LBM) increases significantly with age from 20.01 kg to 28.52 kg highlighting growing muscle development. Hand grip strength (HGS) improves with age, with a notable rise from 10.82 kg at age 8 to 19.25 kg at age 12, showing enhanced muscular strength. Similarly, peak expiratory flow (PEFR), a measure of lung function, increases from 198.85 L/min to 260.95 L/min, reflecting the development of respiratory capacity. Flexibility remains relatively stable across age groups, showing only minor fluctuations. Explosive strength, as measured by standing broad jump (SBJ), increases from 119.42 cm at age 8 to 149.81 cm at age 12, suggesting improved neuromuscular coordination and power with age. Overall, the table indicates progressive improvement in most health and fitness parameters from ages 8 to 12 in boys, with particularly marked gains in muscular strength, lung function, and lean body mass, while fat percentage declines slightly. These trends are consistent with normal male physiological development in pre-adolescence.

Table 2: Descriptive Girls

Age (Years)	8			9			10			11			12		
Variables	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**
Height	40	125.87	4.44	34	131.28	5.77	55	137.17	6.73	34	141.59	7.11	6	143.93	7.46
Weight	40	24.23	4.13	34	26.80	5.08	55	29.03	5.52	34	32.23	7.87	6	32.65	4.55
BMI	40	15.28	2.40	34	15.48	2.24	55	15.37	2.33	34	15.88	2.48	6	15.70	1.31
Fat%	40	19.18	3.55	34	18.47	3.39	55	17.61	3.52	34	17.68	3.74	6	16.59	2.07
LBM	40	19.45	2.51	34	21.70	3.27	55	23.75	3.59	34	26.26	5.09	6	27.17	3.40
HGS	40	10.24	2.27	34	12.27	4.04	55	12.73	3.31	34	14.52	3.41	6	14.01	5.54
PEFR	40	202	40.33	34	209.85	51.35	55	216.90	53.66	34	231.70	57.37	6	249.16	40.30
Flexibility	40	22.59	4.48	34	21.46	5.49	55	23.48	4.29	34	22.70	4.60	6	26.91	3.292
SBJ	40	113.82	19.21	34	121.12	16.66	55	120.95	16.12	34	124.63	20.13	6	133.38	12.33

SD=Standard deviation; BMI = Body Mass Index; LBM = Lean Body Mass; HGS = Hand grip strength; PEFR = Peal exploratory Flow Rate; SBJ = Standing broad Jump

Table 2 outlines the physical and fitness parameters of girls aged 8 to 12 years, showing gradual developmental trends across age groups. Height and weight steadily increase with age, with height rising from 125.87 cm at age 8 to 143.93 cm at age 12, and weight increasing from 24.23 kg to 32.65 kg, reflecting normal growth patterns. BMI remains relatively consistent across ages, ranging between 15.28 and 15.88, suggesting proportional development. Fat percentage shows a slight decrease with age, from 19.18% at age 8 to 16.59% at age 12, though overall fat levels remain higher in girls compared to boys. In contrast, lean body mass (LBM) increases with age, from 19.45 kg to 27.17 kg, indicating gradual muscular development. Hand grip strength (HGS) also improves over time, rising from 10.24 kg to 14.01 kg, though values are generally lower than those of boys at the same ages. Peak expiratory flow (PEFR) shows progressive enhancement from 202 L/min at age 8 to 249.16 L/min at age 12, indicating improving respiratory function with age. Flexibility values fluctuate slightly, with a notable peak at age 12 (26.91 cm), suggesting better joint and muscle flexibility in some older girls. Explosive strength, measured by standing broad jump (SBJ), increases modestly from 113.82 cm to 133.38 cm, though values remain lower than those observed in boys. In summary, the table reflects gradual age-related improvements in all parameters among girls. Compared to boys, girls generally show higher fat percentages, lower grip strength, and slightly less explosive power, with significant differences becoming more visible by ages 10 to 12, likely due to early pubertal changes and sex-based physiological differences.

Table 3: Mean difference between boys and girls

Age (Years)	8		9		10		11		12	
Variables	**MD**	**Sig.**	**MD**	**Sig.**	**MD**	**Sig.**	**MD**	**Sig.**	**MD**	**Sig.**
Height	-.12	.915	.12	.934	.83	.493	-2.70	.160	-.27	.962
Weight	-.24	.838	.91	.506	1.45	.226	-1.75	.375	.59	.894
BMI	-.14	.828	.44	.434	.51	.272	-.28	.669	.05	.964
Fat%	-.38	.000*	-2.93	.001*	-2.82	.000*	-4.02	.000*	-3.52	.079
LBM	-.55	.444	1.53	.092	1.97	.010*	-.307	.809	1.34	.679
HGS	-.58	.363	1.90	.050*	3.13	.000*	1.81	.033*	5.24	.101
PEFR	-3.14	.735	-5.51	.626	39.31	.000*	20.39	.103	11.78	.777
Flexibility	1.38	.187	1.70	.202	-.518	.560	-.30	.801	-3.40	.226
SBJ	5.60	.227	15.60	.001*	17.22	.000*	14.83	.005*	16.43	.179

MD = Mean Difference (Boys – Girls); * = significance at 0.05 level.

Table 3 summarizes the mean differences between boys and girls for various physical and fitness-related variables across the ages of 8 to 12 years, along with the statistical significance (Sig.) of these differences. At age 8, there are no significant differences between boys and girls in most parameters, except fat percentage, where girls have significantly higher values (MD = -0.38, $p < 0.001$). This early difference in fat % aligns with known gender-specific physiological traits. By age 9, gender-based differences become more noticeable. Girls continue to show a significantly higher fat percentage (MD = -2.93, p = 0.001) and boys begin to outperform in hand grip strength (HGS), with the difference nearing significance (MD = 1.90, p = 0.050). Standing broad jump (SBJ) also shows a significant advantage for boys (MD = 15.60 cm, p = 0.001), indicating early signs of greater explosive strength. At age 10, statistically significant gender differences are seen in multiple areas: boys outperform girls in lean body mass (LBM) (MD = 1.97, p = 0.010), HGS (MD = 3.13, $p < 0.001$), PEFR (MD = 39.31, $p < 0.001$), and SBJ (MD = 17.22, $p < 0.001$). Girls continue to have higher fat percentage (MD = -2.82, $p < 0.001$). This age appears to mark a turning point, where physical gender differences become clearly pronounced. At age 11, boys still have significantly better HGS (MD = 1.81, p = 0.033) and SBJ (MD = 14.83, p = 0.005), while fat % remains significantly higher in girls (MD = -4.02, $p < 0.001$). However, other variables show no significant difference, indicating that some aspects of growth may begin to stabilize or vary individually. At age 12, although mean differences remain in favour of boys across most parameters (especially HGS and SBJ), none reach statistical significance, possibly due to the smaller sample size (especially for girls, N = 6), which limits the power of statistical testing.

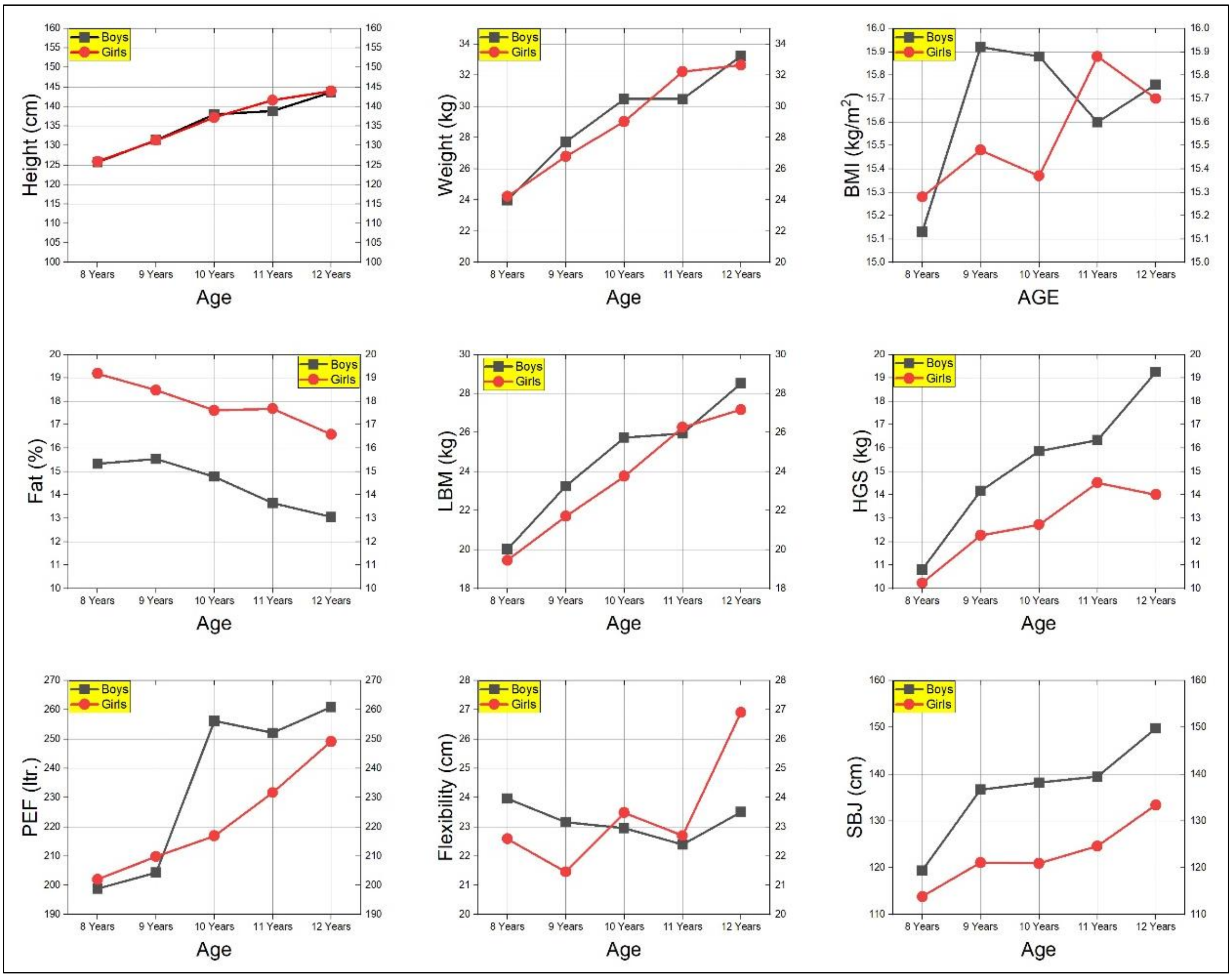

Fig 1: Line graph showing mean score of selected variables for boys and girls participants aged 8 to 12 years.

Discussion

The present study investigated age- and gender-related variations in body composition, muscular strength, respiratory function, flexibility, and explosive strength among Indian school children aged 8 to 12 years. The overall results indicate a progressive improvement in physical and physiological parameters with age, consistent with known patterns of childhood growth and development.

A key focus of this study was the gender-based differences, summarized in Table 3, which reveal important age-specific disparities between boys and girls. While no significant differences were observed at age 8 across most variables, gender-related trends begin to emerge from age 9 and become statistically significant by age 10, marking a developmental turning point.

One of the most consistent findings was the significantly higher fat percentage in girls across all age groups, with p-values ranging from <0.001 to 0.079. Girls had significantly higher fat mass from as early as age 8 (MD = -0.38, p < 0.001), and this difference widened through ages 9, 10, and 11 (p < 0.001 at each age). This reflects natural physiological differences influenced by hormonal changes, even before the onset of puberty, and is aligned with earlier findings in pediatric studies.

In contrast, boys demonstrated significantly greater muscular strength and explosive power starting from age 9 onward. Hand grip strength (HGS) was significantly higher in boys at ages 9 (p = 0.050), 10 (p < 0.001), and 11 (p = 0.033). Similarly, boys outperformed girls in standing broad jump (SBJ) with statistically significant differences at age 9 (p = 0.001), age 10 (p < 0.001), and age 11 (p = 0.005). These findings highlight that neuromuscular development and strength gains begin to diverge between sexes around age 9–10, possibly due to early androgenic effects and increased physical activity levels in boys.

Moreover, peak expiratory flow (PEFR) a measure of respiratory function was significantly higher in boys at age 10 (MD = 39.31, p < 0.001), suggesting stronger lung function development in boys during this phase. While boys also showed higher PEFR values at ages 11 and 12, the differences were not statistically significant, likely due to the reduced sample size, especially among 12-year-old girls (n = 6), which may have limited the statistical power.

Interestingly, lean body mass (LBM) was significantly greater in boys only at age 10 (p = 0.010), indicating a developmental window where muscle accumulation accelerates. No significant differences were found in BMI, height, weight, or flexibility between boys and girls at any age, emphasizing that absolute growth measures may not fully reflect the internal compositional or functional changes occurring during pre-adolescence.

Collectively, the data from Table 3 confirm that gender differences in physical performance and body composition become increasingly evident by age 10, particularly in muscular strength, lean mass, explosive power, and respiratory function, with boys generally outperforming girls in performance metrics and girls maintaining higher fat percentages. These findings underline the need for age- and gender-specific fitness benchmarks to inform physical education, talent identification, and health monitoring programs in schools.

In addition to age-related growth, gender variation plays an increasingly important role during this period. While boys and girls demonstrate relatively similar physical characteristics at ages 8 and 9, statistically significant differences begin to emerge around age 10, particularly in lean body mass, grip strength, peak expiratory flow, and explosive strength, with boys generally outperforming girls. Meanwhile, girls tend to maintain higher fat percentages, even from earlier ages. Recognizing these differences is essential for setting accurate benchmarks and designing age and gender appropriate health and fitness interventions.

Limitations and Future Directions

While the study provides crucial normative data, the reduced sample size in the 12-year-old female group may have affected the significance of differences at that age. Future research should focus on longitudinal tracking with balanced sex representation and examine the role of environmental, nutritional, and socio-cultural factors that may contribute to observed differences.

Conclusion

In conclusion, this study highlights clear patterns of physical development between ages 8 to 12, with emerging gender-based differences in strength, body composition, and lung function. These insights are valuable for educators, pediatric health professionals, and policymakers in tailoring interventions that support optimal growth, prevent early onset of obesity, and foster lifelong fitness habits in both boys and girls.

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