



Hand Grip Strength as a Marker for Physical Fitness, Lung Function and Body Composition in School Students

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Abstract

Background and Study Aim: This study aimed to evaluate hand grip strength (HGS) as a non-invasive marker of physical fitness, lung function and body composition in school-aged children.

Material and Methods: A cross-sectional study was conducted on 350 healthy students (181 boys and 169 girls) aged 8–12 years. HGS was assessed using a dynamometer, peak expiratory flow (PEF) via a peak flow meter, and body composition (BMI, fat percentage and lean body mass) through bioelectrical impedance analysis. Physical fitness parameters including standing broad jump, and flexibility, were also measured. Data were analysed using descriptive statistics, correlation analyses, and age-specific percentiles curves were established for HGS.

Results: HGS increased progressively with age in both boys and girls and shown strong positive correlations ranged moderate degree to strong with height ($r = 0.459$ to $r = 0.929$), Weight ($r = 0.359$ to $r = 0.760$), BMI ($r = 0.202$ to $r = 0.639$) lean body mass ($r = 0.367$ to $r = 0.842$), SBJ ($r = 0.368$ to 0.745) and peak expiratory flow ($r = 0.348$ to $r = 0.752$), especially in boys. While the correlation values of girl's participants for same variables shown low to moderate degree of relationship. The correlation values of HGS and flexibility was inconsistent and shown negative relationship in both genders. In addition, HGS was moderately associated with fat percentage. Percentile curves indicated that muscular strength develops more rapidly in boys than girls during late childhood. The percentile cut points (3rd, 15th, 50th, 85th and 97th) provided key insights into muscular strength through chronological age. These findings support HGS as a useful indicator of muscular development and respiratory function as well as body composition in children.

Conclusions: Grip strength is a practical, reliable, and non-invasive tool for assessing physical development in children aged 8–12 years. It is significantly associated with physical fitness, lung function and body composition, making it a valuable screening measure in school-based health programs.

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1. Introduction

Grip strength is widely regarded as a simple, practical ^[1, 2], and reliable method for assessing muscular strength, particularly in paediatric populations ^[3]. It primarily reflects the functional capacity of the hand and forearm muscles but has also been recognized as a broader biomarker of overall health ^[4]. In school-aged children, grip strength has been significantly associated with critical physiological indicators such as body composition ^[5] including fat percentage and lean body mass as well as pulmonary function, especially peak expiratory flow ^[6].

As a non-invasive, low-cost, and easily administered test, grip strength provides a practical means of evaluating physical development and muscular health in children [7]. Early detection of reduced grip strength may indicate poor muscle function, imbalances in body composition, or even predict potential long-term health risks such as cardiometabolic diseases [8]. Consequently, incorporating grip strength assessments into school-based and paediatric health monitoring programs can be instrumental in tracking and improving the health and fitness status of children aged 8 to 12 years^[9, 10]. Although grip strength is a recognized marker of muscular strength, there is not sufficient literature available to establish its association with body composition and respiratory parameters, especially in children aged 8 to 12 years.

With reference to this gap into the literature, the present study has been attempted to fulfil this gap with identification of relationship HGS and variable of physical fitness, lung function and body composition as well as the reference points of HGS for age 8 to 12 years respectively.

Material and Methods

Participants

The study included a total of 350 school students (181 boys and 169 girls), aged between 8 to 12 years. Participants were selected from classes 2nd to 7th across selected schools. A systematic random sampling technique was used to ensure a representative and unbiased sample. The RAND() function in Microsoft Excel was applied to generate a random sequence of student roll numbers, followed by a fixed interval selection process to identify participants from class-wise student lists.

Measurement of variables

Grip Strength: Grip strength was assessed using a Camry handheld dynamometer. Participants were instructed to squeeze the dynamometer with maximum effort using their dominant hand while standing with the arm at their side, not touching the body^[11]. Two trials were conducted with a 30-second rest in between, and the highest value in kilograms (kg) was recorded.

Peak Expiratory Flow (Peak Flow): Peak flow was measured using a novel peak flow meter (Mini-Wright or similar)^[12]. Students were instructed to take a deep breath and blow as hard and fast as possible into the device. The test was repeated three times, and the highest value in litres per minute (L/min) was recorded. Separate mouthpiece was used for each child to maintain the individual hygiene and to avoid the spread of pathogens.

Fat Percentage and Lean Body Mass: Fat percentage was estimated using a Bioelectrical Impedance Analysis (BIA) device, which measures body composition based on the resistance of body tissues to a small, safe electrical current. Participants were asked to stand barefoot on the BIA device (Omron HBF 702T) with clean, dry feet and maintain a still posture during the measurement. The device provided a direct estimate of body fat percentage (Fat %) based on input parameters including age, sex, height, and weight. The measurement was conducted according to the manufacturer's standardized protocol to ensure consistency and accuracy^[13]. This means that measurements were taken before meals or at least 2-3 hours after the last food intake to minimize the influence of food and hydration on body composition

readings.

Lean Body Mass (LBM): was calculated using the following formula: $LBM = \text{Body Weight} - \text{Fat Mass}$, where $\text{Fat Mass} = (\text{Fat}\% \times \text{Body Weight}) / 100$.

Standing Broad Jump (SBJ): Explosive leg power was assessed using the Standing Broad Jump test. Participants stood behind a marked line with feet shoulder-width apart and jumped forward as far as possible using both feet simultaneously, swinging their arms for momentum^[14]. The distance from the starting line to the point where the back of the heels landed was measured in centimeters (cm) using a measuring tape. Each participant performed two trials, and the longest valid jump was recorded.

Flexibility (Sit and Reach Test): Flexibility of the lower back and hamstrings was measured using the Sit and Reach test. A standard sit-and-reach box was used. Participants sat on the floor with legs extended straight and feet flat against the box with hands overlapped and arms extended, they reached forward as far as possible without bending their knees^[15]. The farthest point reached (in centimeters) was recorded. Two trials were conducted, and the best score was used for analysis.

Height, Weight and Body Mass Index: Height was measured using a Cambia stadiometer, with the participant standing barefoot, upright, and with heels, buttocks, shoulders, and head touching the vertical surface. The measurement was recorded in centimetres (cm) to the nearest 0.1 cm^[16]. Weight was measured using a digital weighing scale with participants wearing school uniforms without shoes. The value was recorded in kilograms (kg) to the nearest 0.1 kg^[17]. Body Mass Index (BMI) was measured using a Bioelectrical Impedance Analysis (BIA) device (Omron HBF 702T), which provided BMI values based on the participant's entered age, sex, height, and weight. Participants were asked to stand barefoot on the BIA machine, and measurements were taken according to the manufacturer's standardized procedures. The device automatically calculated and displayed the BMI, along with other body composition parameters such as fat percentage and lean body mass^[13].

Inclusion and Exclusion criteria

Inclusion criteria: Participants included in the study were school students aged 8 to 12 years, enrolled in classes 2nd to 7th. Both boys and girls who were medically healthy and physically able to perform the required assessments were eligible for participation. Only students who were present on the day of data collection and whose participation was permitted by the school authorities were included in the study.

Exclusion criteria: Students with any known physical or medical conditions that could affect grip strength, lung function, or body composition were excluded from the study. Additionally, students who were absent on the day of data collection or did not receive permission from the school authorities were not included.

Ethical Consideration

Prior to data collection, ethical approval was obtained from

the relevant department to ensure the study met all institutional research standards. Written permission was also secured from the school authorities for conducting the study within their premises. Participation was voluntary, and all students took part only after receiving approval from the schools. Confidentiality of the participants' data was strictly maintained throughout the research process.

Statistical Application

All data were computed in SPSS 26.0 version. First, the obtained data were checked for missing values and normality.

Kolmogorov and Smirnov test was applied for normality assumptions. N (number) mean and standard deviation was used as descriptive statistics. Karl Pearson coefficient of correlation was applied for check the quantitative relationship between variables. The degree of correlation was considered as follow: 0.00 to 0.10 = negligible, 0.10 to 0.39 = weak correlation, 0.40 to 0.69 = moderate correlation, 0.70 to 0.89 = strong correlation and 0.90 to 1.00 = very strongly correlation [18]. The percentile cut point of HGS [3rd, 15th, 50th (Median), 85th and 97th] were computed as reference points for age 8 to 12 year's boys and girls [19].

Results

Table 1: Descriptive statistics of selected variables for boys aged 8 to 12 years

Age		Body Composition					Muscular Strength	Lung Function	Physical Fitness	
		Height	Weight	BMI	Fat %	LBM	HGS	PEF	SBJ	Flexibility
8 Y	N	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00
	Mean	125.75	23.99	15.13	15.33	20.01	10.82	198.86	119.43	23.97
	SD	5.56	6.31	3.47	5.24	3.69	3.18	39.43	20.57	4.51
9 Y	N	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
	Mean	131.41	27.73	15.92	15.54	23.24	14.18	204.33	136.73	23.16
	SD	6.28	5.88	2.22	3.36	3.89	3.50	36.55	19.79	4.99
10 Y	N	57.00	57.00	57.00	57.00	57.00	57.00	57.00	57.00	57.00
	Mean	138.01	30.49	15.89	14.79	25.73	15.87	256.23	138.18	22.97
	SD	6.09	6.99	2.57	3.88	4.30	3.18	44.10	12.89	5.04
11 Y	N	38.00	38.00	38.00	38.00	38.00	38.00	38.00	38.00	38.00
	Mean	138.89	30.48	15.60	13.66	25.96	16.34	252.11	139.48	22.39
	SD	8.83	8.71	3.05	4.61	5.58	3.65	47.37	22.72	5.64
12 Y	N	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00
	Mean	143.66	33.24	15.76	13.07	28.52	19.26	260.95	149.81	23.51
	SD	13.47	10.41	3.02	4.54	7.56	6.90	97.46	28.04	6.41
Total	N	181.00	181.00	181.00	181.00	181.00	181.00	181.00	181.00	181.00
	Mean	135.39	29.09	15.67	14.58	24.58	15.10	236.22	135.94	23.14
	SD	9.66	8.02	2.85	4.37	5.52	4.62	57.65	21.63	5.21

Y = Age in Years, HGS = Hand Grip Strength, BMI = Body Mass Index, PEF = Peak Expiratory Flow, SBJ = Standing Broad Jump, LBM = Lean Body Mass

Table 2: Descriptive statistics of selected variables for girls aged 8 to 12 years

Age		Body Composition					Muscular Strength	Lung Function	Physical Fitness	
		Height	Weight	BMI	Fat %	LBM	HGS	PEF	SBJ	Flexibility
8 Y	N	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00
	Mean	125.87	24.24	15.28	19.19	19.46	10.24	202.00	113.83	22.59
	SD	4.45	4.13	2.40	3.56	2.51	2.28	40.33	19.22	4.48
9 Y	N	34.00	34.00	34.00	34.00	34.00	34.00	34.00	34.00	34.00
	Mean	131.29	26.81	15.48	18.48	21.71	12.27	209.85	121.12	21.46
	SD	5.78	5.09	2.25	3.40	3.27	4.04	51.35	16.67	5.50
10 Y	N	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00
	Mean	137.18	29.03	15.37	17.61	23.76	12.74	216.91	120.96	23.49
	SD	6.74	5.53	2.34	3.53	3.60	3.32	53.67	16.12	4.30
11 Y	N	34.00	34.00	34.00	34.00	34.00	34.00	34.00	34.00	34.00
	Mean	141.59	32.23	15.88	17.68	26.26	14.52	231.71	124.64	22.70
	SD	7.12	7.88	2.48	3.75	5.10	3.42	57.37	20.13	4.60
12 Y	N	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
	Mean	143.93	32.65	15.70	16.59	27.18	14.02	249.17	133.38	26.92
	SD	7.46	4.55	1.31	2.07	3.40	5.54	40.30	12.33	3.29
Total	N	169.00	169.00	169.00	169.00	169.00	169.00	169.00	169.00	169.00
	Mean	134.44	28.22	15.49	18.14	22.95	12.46	216.08	120.48	22.83
	SD	8.54	6.33	2.32	3.55	4.41	3.65	51.58	18.11	4.71

Y = Age in Years, HGS = Hand Grip Strength, BMI = Body Mass Index, PEF = Peak Expiratory Flow, SBJ = Standing Broad Jump, LBM = Lean Body Mass

Table 1 presents descriptive statistics for various anthropometric, physiological, and fitness parameters among boys aged 8 to 12 years. The sample size (N) for each age group ranges from 21 to 57, with a total of 181 participants. The data includes mean and standard deviation (SD) for height, weight, BMI, hand grip strength (HGS), peak

expiratory flow (PEF), standing broad jump (SBJ), flexibility, fat percentage, and lean body mass (LBM). Results show a general increase in all variables with age, particularly in HGS, PEF, and LBM, indicating developmental progress. For example, mean HGS rises from 10.82 kg at age 8 to 19.26 kg at age 12, and PEF from 198.86

to 260.95 L/min. These trends reflect growth-related improvements in physical and functional capacities among school-aged boys.

Table 2 provides descriptive statistics for physical and physiological parameters among girls aged 8 to 12 years, with a total of 169 participants. For each age group, the table reports the mean and standard deviation (SD) of height, weight, BMI, hand grip strength (HGS), peak expiratory flow

(PEF), standing broad jump (SBJ), flexibility, fat percentage, and lean body mass (LBM). The data shows gradual increases in most variables with age, reflecting normal growth patterns. For instance, HGS increases from a mean of 10.24 kg at age 8 to 14.02 kg at age 12, and PEF from 202.00 to 249.17 L/min. Although the sample size for age 12 is smaller (N=6), overall trends indicate improved physical fitness and body composition with age among school-going girls.

Table 3: Correlation coefficient between HGS and variables of physical fitness, lung function and body composition of boys

Age (Y)		Height	Weight	BMI	Fat%	LBM	PEF	Flexibility	SBJ
8	HGS	.459	.359	.202	.204	.367	.348	.157	.368
9	HGS	.529	.689	.639	.639	.690	.160	-.036	.038
10	HGS	.556	.585	.445	.445	.603	.267	.039	.023
11	HGS	.539	.602	.505	.505	.616	.406	-.044	.383
12	HGS	.929	.760	.372	.357	.842	.752	.508	.745

Y = Age in Years, HGS = Hand Grip Strength, BMI = Body Mass Index, PEF = Peak Expiratory Flow, SBJ = Standing Broad Jump, LBM = Lean Body Mass

Table 4: Correlation coefficient between HGS and variables of physical fitness, lung function and body composition of girls

Age (Y)		Height	Weight	BMI	Fat%	LBM	PEF	Flexibility	SBJ
8	HGS	.030	.247	.265	.257	.244	.180	-.127	-.044
9	HGS	.375	.383	.257	.257	.405	.281	.053	.312
10	HGS	.366	.241	.061	.061	.280	.035	.452	.319
11	HGS	.450	.427	.355	.355	.434	.063	-.023	.460
12	HGS	.293	.374	.344	.379	.351	-.058	.011	-.382

Y = Age in Years, HGS = Hand Grip Strength, BMI = Body Mass Index, PEF = Peak Expiratory Flow, SBJ = Standing Broad Jump, LBM = Lean Body Mass

Table 3 presents the correlation coefficients between hand grip strength (HGS) and various physical and physiological variables in boys aged 8 to 12 years. Across all ages, HGS shows positive correlations with height, weight, BMI, fat percentage, lean body mass (LBM), peak expiratory flow (PEF), and standing broad jump (SBJ), with the strength of correlation generally increasing with age. Notably, at age 12, HGS has very strong correlations with height ($r = .929$), LBM (.842), and PEF (.752), indicating a close relationship between muscular strength and overall body development in older boys. Flexibility shows weaker and less consistent correlations with HGS, even negative at ages 9 and 11, suggesting it is less associated with grip strength. Overall, the table highlights that as boys grow, HGS becomes more strongly linked with other indicators of physical fitness and body composition.

Table 4 presents the correlation coefficients between hand grip strength (HGS) and various physical and physiological variables among girls aged 8 to 12 years. The strength of associations is generally weaker compared to boys. At younger ages, such as 8 and 9 years, HGS shows low to moderate positive correlations with body weight, BMI, fat percentage, and lean body mass (LBM), with the highest correlation at age 9 between HGS and LBM ($r = .405$). In contrast, HGS shows little or no significant relationship with peak expiratory flow (PEF), flexibility, or standing broad jump (SBJ) across most age groups. Interestingly, at age 10, flexibility shows a moderate positive correlation ($r = .452$) with HGS, unlike other age groups. Overall, the data suggest that in girls, HGS is moderately related to body composition but shows inconsistent or weak relationships with functional fitness parameters as they age.

Table 5: Percentile cut point of Grip Strength for Age (Boys)

Age (Y)	3 rd	15 th	Median	85 th	97 th
8	4.344	7.320	10.700	13.740	19.66
9	8.200	10.230	13.650	18.705	20.66
10	9.122	13.040	15.700	18.590	23.868
11	7.470	12.770	16.400	20.200	25.237
12	7.100	11.350	20.000	25.230	27.350

Table 6: Percentile cut point of Grip Strength for Age (Girls)

Age (Y)	3 rd	15 th	Median	85 th	97 th
8	6.846	8.030	9.550	12.385	15.562
9	6.010	8.650	11.450	16.450	19.340
10	6.608	9.500	12.350	16.700	20.560
11	7.410	10.050	13.500	17.325	21.930
12	7.900	8.005	15.500	20.885	23.800

Table 5 shows the distribution of hand grip strength (HGS) in boys aged 8 to 12 years across percentiles (3rd, 15th, median, 85th, and 97th). The data indicate a general increase in grip strength with age, particularly at the median and higher

percentiles. For example, the median HGS increases from 10.70 kg at age 8 to 20.00 kg at age 12, showing a significant growth in muscular strength. The upper percentiles (85th and 97th) demonstrate even more pronounced increases, reaching

25.23 kg and 27.35 kg at age 12, respectively. These percentile values can help identify children with lower or higher than average grip strength, useful for fitness assessment and developmental tracking.

Table 6 presents similar percentile-based data for grip strength in girls aged 8 to 12 years. Unlike boys, the progression in median grip strength is more gradual, rising from 9.55 kg at age 8 to 12.35 kg at age 12. Interestingly, there is less consistency in the lower percentiles across ages, with some fluctuations (e.g., the 3rd percentile drops slightly from age 8 to 9). However, the upper percentiles, especially the 97th, show strong grip potential in some girls, reaching as high as 25.34 kg at age 9 and 23.80 kg at age 12. Overall, girls demonstrate improvement in grip strength with age, though the increase is more moderate compared to boys.

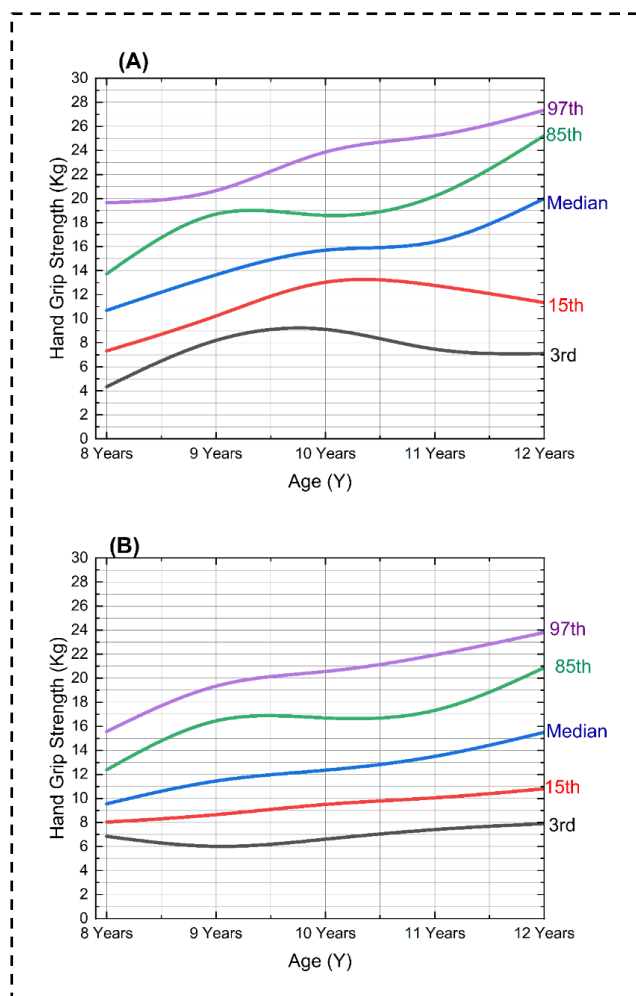


Fig 1: Percentile curves for Boys (A) and Girls (B) illustrating 3rd, 15th, 50th (Median), 85th and 97th cut points for hand grip strength to age

Discussion

The present study investigated the association between hand grip strength (HGS), peak expiratory flow (PEF), and body composition among school children aged 8 to 12 years. The findings revealed that grip strength increases consistently with age in both boys and girls, and shows a positive

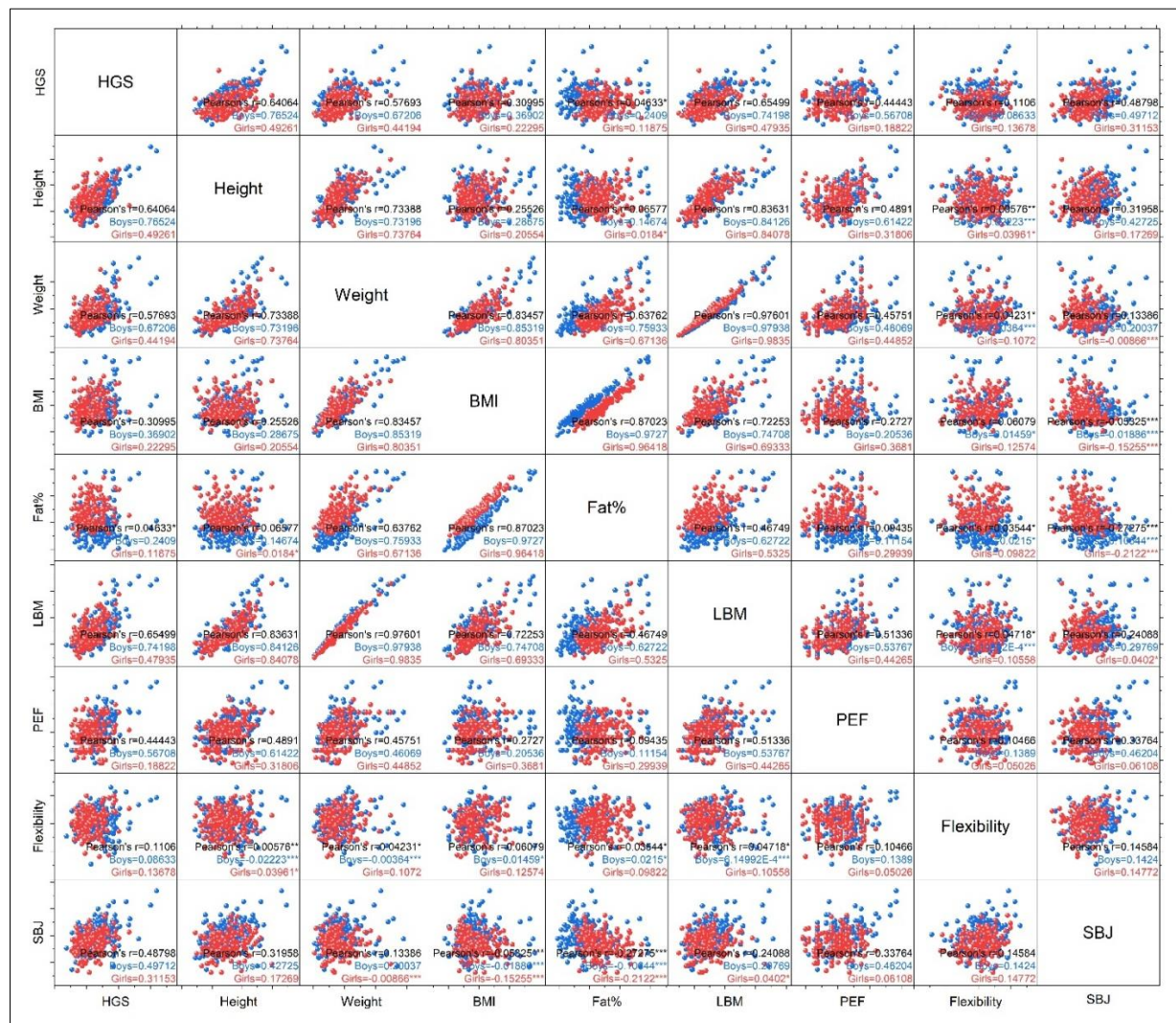
relationship with key health indicators such as lean body mass (LBM), fat percentage, and pulmonary function. In addition, reference cut points of HGS for age was also computed.

Among boys, grip strength showed strong positive correlations with LBM and PEF, especially at age 12. This indicates that as boys grow older, their muscular strength is more closely linked to both body composition and respiratory function. The increase in average grip strength and PEF values with age suggests normal physical development and highlights the usefulness of HGS as a simple measure of functional capacity. In girls, the relationship between grip strength and other variables was generally weaker and more inconsistent. While HGS did improve with age [20], its association with PEF and other fitness parameters was not as pronounced as in boys. This could be due to differences in growth patterns, levels of physical activity, or motivation during the testing process. The Figure 2 explore the relationship between HGS and variable of interest in form of a scatter plot matrix irrespective of the age.

Grip strength also showed a moderate association with fat percentage, which may indicate that children with higher fat mass also have more overall body mass, including muscle. However, this relationship needs to be interpreted carefully, as higher fat percentage does not always imply better health. The fat% of the subjects included the present study lies between the normal categories. Therefore, it may be a potential reason to reveal significant relationship with HGS. Flexibility showed weak or inconsistent associations with grip strength, supporting the idea that flexibility and strength are separate components of physical fitness.

The percentile charts developed in this study provide a practical reference for evaluating grip strength in school-aged children. The trend of increasing strength across age groups, especially among boys, reflects the expected pattern of muscular development. These benchmarks can help identify children who may be below or above average in muscular strength, allowing for early intervention when necessary. The normal range of HGS is still a matter of consideration due to the various covariate such as ethnicity, region, diet, physical activity etc. The present study followed the normal ranged between the 15th percentile to 85 percentiles as per the describe by WHO for body composition reference values [21]. Although the study provides important insights, it is limited by its cross-sectional design, which does not allow for conclusions about cause and effect. Additionally, while the tools used such as BIA and peak flow meters are suitable for field testing, they may be influenced by factors like hydration, body position, and effort during testing.

Overall, this study adds to the understanding of how grip strength relates to lung function and body composition in young children. It supports the inclusion of grip strength testing in school-based health assessments as a reliable and non-invasive method for monitoring physical development.



HGS= Hand Grip Strength, BMI = Body mass index, LBM = lean body mass, PEF = peak expiratory flow rate, SBJ = sanding broad jump

Fig 2: presents a visual correlation matrix highlighting the relationships between hand grip strength (HGS) and various physiological and body composition parameters in boys (blue) and girls (red).

Conclusion

This study highlights hand grip strength (HGS) as a practical and reliable indicator of physical development in school-aged children. HGS demonstrated a strong and consistent relationship with height, weight, and lean body mass (LBM), indicating that it effectively reflects overall body growth and muscular development. A moderate correlation was observed with BMI, while fat percentage showed a weak relationship, suggesting that HGS is more closely linked with muscle mass than with adiposity. Among physical fitness parameters, the standing broad jump (SBJ) showed a moderate positive correlation with HGS, supporting its role in assessing muscular power. In contrast, flexibility exhibited a weak and inconsistent association, reinforcing that it represents a distinct component of fitness not strongly linked to grip strength.

These findings suggest that HGS can serve as a valuable, non-invasive screening tool for evaluating strength, respiratory capacity, and body composition in children. The established percentile benchmarks further enhance its utility for identifying developmental norms and deviations, making it suitable for inclusion in school health programs.

Conflict of Interest: No conflict of Interest was declared among authors

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