

Research Article

Strength Endurance and Power: Developmental Patterns of Middle Childhood and Early Adolescent Girls in Bangladesh

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Abstract

Strength endurance is the ability to sustain repeated muscle contractions or maintain a level of muscular force over an extended period. Power is the ability to generate maximum force quickly to propel the body as far as possible in a single explosive movement. Both components develop progressively from childhood to adulthood. This study aims to analyze and understand the development of power and strength endurance across different age groups. A total of 270 schoolgirls (aged 6-14 years; $n = 30$ per age group) from primary and secondary schools in Jashore, Bangladesh, participated in the study. Strength endurance was assessed via the 30-second sit-up test, and power was measured using the standing broad jump. Data were analyzed using SPSS v25, with means, standard deviations, and standard errors calculated. One-way ANOVA, correlation analysis, and LSD post hoc tests were conducted at a 0.05 significance level. Significant age-related differences were observed in both strength endurance and power. ANOVA results showed that age had a significant effect on standing broad jump performance, $F(8, 261) = 25.07$, $p < .001$, and sit-up performance, $F(8, 261) = 11.74$, $p < .001$. Post hoc analyses revealed that younger children, particularly those aged 6, performed significantly lower than older peers, with improvements leveling off in the later age groups. Age significantly influences physical performance in children, with older age groups showing better explosive power and core muscular endurance. Tailoring fitness programs to developmental stages and considering biological maturation, sex differences, and environmental influences is crucial.

Keywords

Strength Endurance, Power, Schoolgirls, Physical Performance, Development

1. Introduction

Maintaining children's physical fitness is essential for their overall well-being, athletic performance, and the prevention

of obesity. Effective physical education programs can be developed by understanding how key fitness compo-

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nents—such as endurance and explosive strength—change with age [1]. These programs should include exercises targeting the lower back, abdomen, upper body, and lower body muscles [2].

Physical fitness is the capacity to perform daily activities with energy and stamina [3], is closely linked to motor skills, metabolism, and cardiovascular health in children. Therefore, it has been recognized as a critical health indicator. Related to health, physical fitness components are generally categorized into body composition, musculoskeletal, motor, and cardiorespiratory fitness [4].

Muscular endurance is the capacity to sustain physical activity over an extended period without excessive fatigue [5]. Abdominal muscular endurance, in particular, is widely recognized by sports medicine experts and exercise scientists as a vital aspect of both athletic performance and general health. It is essential for keeping the axial skeleton properly aligned and enabling coordinated movement of the lower and upper limbs during daily tasks, occupational duties, and sports. Strong and enduring abdominal muscles are essential for the stabilization and alignment of the pelvic girdle [6].

The four main muscles in the abdomen are the rectus abdominis, external and internal obliques, and transverses abdominals—work together to support and protect internal organs [7]. There are several ways to evaluate the endurance of the abdominal muscles, with data available for both adults and children, including specific athletic populations [8]. One of the most often used standardized activities to assess abdominal strength and endurance is the sit-up [9]. While sit-ups are a fundamental tool for strengthening core muscles, they may increase the risk of lumbar spine injury due to repetitive spinal flexion [10]. Core training involves specialized exercises aimed at improving the strength and coordination of muscles involved in trunk stability. The core, comprising dorsal and sub-abdominal muscles, plays a key role in transmitting force between the upper and lower body. These muscles are essential for spinal stabilization during resistance training and everyday activities, particularly in the lower back region [11].

It is widely acknowledged that the core is vital for maintaining spinal stability and generating force during most sports and daily physical activities [12]. Efficient mobility and peak performance across various movements depend on core strength. A strong core diminishes the chance of injury while also improving athletic performance [13]. Strengthening both small and large core muscles improves control, balance, and the efficiency of internal and external force transmission [14, 15].

Power and strength are two fundamental components of motor fitness. Muscular power is the ability to generate a significant amount of force rapidly, while muscular strength refers to the maximum force a muscle or group of muscles can produce in a single action [16]. Muscular fitness is recognized as a crucial element of health-related physical fitness. It plays an important role in maintaining strength, stability, and over-

all physical function [3, 17]. It includes the muscles' capacity to produce force at their maximum level (strength), explosively (power or explosive strength), or constantly without becoming tired (endurance) [18]. Numerous tests have been developed to evaluate the distinct aspects of muscular fitness, each typically focusing on one type of strength and specific body parts—for example, the standing broad jump evaluates the explosive power of the lower body, while sit-ups assess abdominal muscular endurance [19].

Explosive power, as assessed through the standing broad jump, refers to the capacity to quickly generate maximal muscle contraction in a single burst of movement [20]. The SBJ is a practical, reliable, and valid field-based test for evaluating lower-limb explosive power and overall physical fitness [21]. It is strongly connected with children's overall health and serves as a valuable functional indicator of lower-body explosive strength [22]. The SBJ has been widely used to assess children's general fitness levels and monitor improvements following training interventions [23]. Moreover, it can help identify athletic talent and is used for progress tracking and pre-recruitment evaluations in contexts where other assessment tools may not be feasible [24].

This study aims to assess abdominal muscular endurance and lower-body explosive strength in school-going 6-14 years children to better understand their physical fitness levels. These two components are critical for core stability, movement efficiency, and injury prevention. Despite their importance, limited research has examined both variables simultaneously in non-athlete children. Findings from this study will help inform physical education programs and support this helps in creating focused programs that can improve both fitness levels and overall health for people in this group.

2. Methodology

2.1. Subject

A total of $N = 270$ subjects, schoolgirls aged 6 to 14 years, were selected for the study. The subjects were equally distributed ($n = 30$) across nine age groups: 6, 7, 8, 9, 10, 11, 12, 13, and 14 years. These girls were students from primary and secondary schools in the Jashore district of Bangladesh.

2.2. Criteria Measure and Test Procedure

Strength endurance and power were the criterion measures for the present study, with endurance and power assessed through components such as the standing broad jump for leg power and the 30-second sit-up test for abdominal strength endurance.

The standing broad jump test was administered on a sand pit, with athletes in a standing stance and their feet parallel. The participants were instructed by the tester to jump as far forward as they could in a horizontal direction. There were no instructions on how the athletes should move their arms or

legs, allowing them to perform a free-arm swing and a self-determined depth counter-movement of the legs. To block the jump without moving forward, participants had to land with both feet together. After a brief break, each participant performed the test three times. A tape measure was used to measure the distance, in meters, between the starting line and the heel of the landing foot closest to the starting line. The best result from the three attempts was retained for the final evaluation [21]. The participant was instructed to complete as many sit-ups as they could in 30 seconds as part of this test, which gauges the endurance of the abdominal muscles. The individual should be lying supine on the floor with their knees bent 90 degrees, their elbows pointing straight forward, and their fingers interlaced behind their heads. When performing a proper sit-up, the elbows should make contact with the knees

before moving back till the shoulders make contact with the floor. The subject's legs and feet were supported by the test leader [25].

2.3. Statistical Analysis

IBM SPSS software (version 25) was used to analyze the data and calculate the mean, standard deviation, and standard error of the mean for each group. A one-way analysis of variance (ANOVA) test was used to find any significant group differences. Significant differences were subsequently identified using the least significant difference (LSD) post hoc test. A significance level of 0.05 was used to these investigations [26].

3. Results

Table 1. Descriptive statistics for different age groups.

Variables	Age	n	Mean	Std. Deviation	Std. Error	Minimum	Maximum
Standing Broad Jump	6	30	85.90	9.54	1.74	71	110
	7	30	111.93	19.10	3.49	60	152
	8	30	114.93	14.28	2.61	87	143
	9	30	128.87	19.64	3.59	98	189
	10	30	127.63	16.73	3.06	93	162
	11	30	142.00	18.48	3.37	95	185
	12	30	125.10	20.84	3.81	86	168
	13	30	131.83	23.80	4.35	90	200
	14	30	138.80	21.11	3.85	108	185
Sit ups	6	30	7.400	24.36	1.48	2.0	11.0
	7	30	11.267	2.16	0.39	5.0	18.0
	8	30	13.000	3.04	0.55	5.0	17.0
	9	30	11.667	2.82	0.51	4.0	21.0
	10	30	11.367	3.81	0.70	5.0	16.0
	11	30	15.733	3.34	0.61	5.0	27.0
	12	30	15.000	5.24	0.96	2.0	23.0
	13	30	14.400	5.46	1.00	3.0	23.0
	14	30	15.733	5.82	1.06	4.0	27.0

Table 2. One-Way ANOVA of strength endurance, and power across different age groups.

Variables	Groups	Sum of Squares	df	Mean Square	F	Sig.
Standing Broad	Between Groups	69387.467	8	8673.433	25.071	0.000

Variables	Groups	Sum of Squares	df	Mean Square	F	Sig.
Jump	Within Groups	90294.533	261	345.956		
	Between Groups	1784.519	8	223.065		
Sit ups	Within Groups	4959.633	261	19.002	11.739	0.000

* Significant at 0.05 level

Table 3. LSD Post-hoc test for different age groups.

Age	Age groups	Standing Broad Jump		Sit ups	
		Mean Difference	Sig.	Mean Difference	Sig.
6	7	-26.033*	.000	-3.8667*	.001
	8	-29.033*	.000	-5.6000*	.000
	9	-42.967*	.000	-4.667*	.000
	10	-41.733*	.000	-3.9667*	.001
	11	-56.100*	.000	-8.3333*	.000
	12	-39.200*	.000	-7.6000*	.000
	13	-45.933*	.000	-7.0000*	.000
	14	-52.900*	.000	-8.3333*	.000
7	6	26.033*	.000	3.8667*	.001
	8	-3.000	.533	-1.7333	.125
	9	-16.933*	.000	-.4000	.723
	10	-15.700*	.001	-.1000	.929
	11	-30.067*	.000	-4.4667*	.000
	12	-13.167*	.007	-3.7333*	.001
	13	-19.900*	.000	-3.1333*	.006
	14	-26.867*	.000	-4.4667*	.000
8	6	29.033*	.000	5.6000*	.000
	7	3.000	.533	1.7333	.125
	9	-13.933*	.004	1.3333	.237
	10	-12.700*	.009	1.6333	.148
	11	-27.067*	.000	-2.7333*	.016
	12	-10.167*	.035	-2.0000	.077
	13	-16.900*	.001	-1.4000	.215
	14	-23.867*	.000	-2.7333*	.016
9	6	42.967*	.000	4.2667*	.000
	7	16.933*	.000	.4000	.723
	8	13.933*	.004	-1.3333	.237
	10	1.233	.798	.3000	.790

Age	Age groups	Standing Broad Jump		Sit ups	
		Mean Difference	Sig.	Mean Difference	Sig.
10	11	-13.133*	.007	-4.0667*	.000
	12	3.767	.434	-3.3333*	.003
	13	-2.967	.537	-2.7333*	.016
	14	-9.933*	.040	-4.0667*	.000
	6	41.733*	.000	3.9667*	.001
	7	15.700*	.001	.1000	.929
	8	12.700*	.009	-1.6333	.148
	9	-1.233	.798	-.3000	.790
	11	-14.367*	.003	-4.3667*	.000
	12	2.533	.598	-3.6333*	.001
	13	-4.200	.383	-3.0333*	.007
	14	-11.167*	.021	-4.3667*	.000
	6	56.100*	.000	8.3333*	.000
	7	30.067*	.000	4.4667*	.000
11	8	27.067*	.000	2.7333*	.016
	9	13.133*	.007	4.0667*	.000
	10	14.367*	.003	4.3667*	.000
	12	16.900*	.001	.7333	.515
	13	10.167*	.035	1.3333	.237
	14	3.200	.506	.0000	1.000
	6	39.200*	.000	7.6000*	.000
12	7	13.167*	.007	3.7333*	.001
	8	10.167*	.035	2.0000	.077
	9	-3.767	.434	3.3333*	.003
	10	-2.533	.598	3.6333*	.001
	11	-16.900*	.001	-.7333	.515
	13	-6.733	.162	.6000	.594
	14	-13.700*	.005	-.7333	.515
13	6	45.933*	.000	7.0000*	.000
	7	19.900*	.000	3.1333*	.006
	8	16.900*	.001	1.4000	.215
	9	2.967	.537	2.7333*	.016
	10	4.200	.383	3.0333*	.007
	11	-10.167*	.035	-1.3333	.237
	12	6.733	.162	-.6000	.594
14	14	-6.967	.148	-1.3333	.237
	6	52.900*	.000	8.3333*	.000

Age	Age groups	Standing Broad Jump		Sit ups	
		Mean Difference	Sig.	Mean Difference	Sig.
	7	26.867*	.000	4.4667*	.000
	8	23.867*	.000	2.7333*	.016
	9	9.933*	.040	4.0667*	.000
	10	11.167*	.021	4.3667*	.000
	11	-3.200	.506	.0000	1.000
	12	13.700*	.005	.7333	.515
	13	6.967	.148	1.3333	.237

* The mean difference is significant at the 0.05 level.

The results (Table 2) of the one-way analysis of variance (ANOVA) indicated a statistically significant effect of age on Standing Broad Jump performance, $F(8, 261) = 25.071$, $p < .001$. Similarly, a significant effect of age was observed for Sit-ups, $F(8, 261) = 11.739$, $p < .001$. These findings suggest that age is a significant factor influencing both jumping ability and core endurance in children.

Table 3 presents the results of the LSD post hoc test for Standing Broad Jump and Sit-ups across different age groups. For both tests, significant differences were found between

younger and older age groups, with children aged 6 performing significantly worse than children in all older groups. The Mean Differences between age groups were highest between age 6 and age 7 and gradually decreased as age increased. While most differences were statistically significant ($p < .05$), the differences between the oldest age groups (e.g., ages 13 and 14) were smaller and not always significant. These results suggest that age significantly influences both explosive power and core endurance, with performance improving as children age.

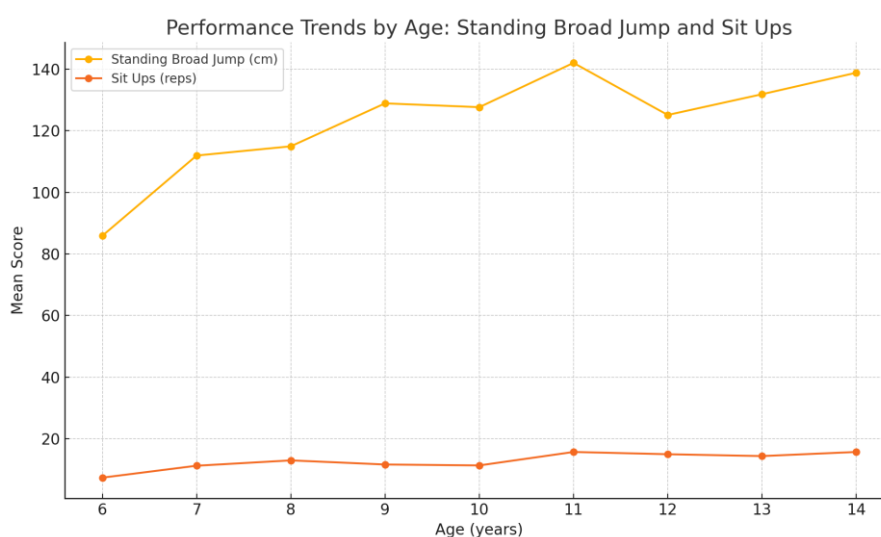


Figure 1. Age-wise performance progression.

4. Discussion

The present study examined age-related differences in physical performance among children aged 6 to 14, specifically focusing on explosive leg power (Standing Broad Jump)

and core muscular endurance (Sit-ups). Results demonstrated statistically significant differences across age groups, with older children consistently outperforming younger ones. These findings align with established developmental trends in physical fitness, where improvements in neuromuscular coordination, muscle mass, and skeletal maturity contribute to enhanced performance during childhood and early adoles-

cence [27]. Post hoc LSD tests revealed the most notable differences between the youngest participants (age 6) and those in older groups, indicating that significant physical development occurs particularly between ages 6 and 11. This supports earlier studies suggesting rapid gains in muscular strength and motor skill acquisition during early and middle childhood [28, 29].

Interestingly, while performance continued to improve with age, the rate of improvement diminished among the oldest children (ages 13 and 14), with several comparisons showing non-significant differences. This leveling off might happen because kids go through puberty at different times—even if they're the same age, their bodies may be developing at different rates [30]. Additionally, differences in habitual physical activity, nutrition, or training background—factors not measured in this study—may also explain the reduced performance gains in the older groups. These results align with previous findings that strength and endurance development begins to plateau during early adolescence as the effects of growth alone wane, and lifestyle or environmental factors play a larger role [31, 32].

Further comparison with existing literature supports these findings. Studies have shown that the most rapid improvement in standing broad jump performance typically occurs between ages 6 and 8, likely due to early neuromuscular development and increases in lean muscle mass [33, 34]. A similar trend was observed for sit-ups, where core endurance increased steadily from age 6 to 11 before stabilizing. Research also shows that while boys tend to continue improving until around 16-17 years, girls often plateau by age 12-13, likely due to hormonal differences during puberty [35, 36]. Additionally, studies in younger children (ages 5-7) report similar age-related gains in jump performance without significant gender differences at that stage [37]. These results reinforce the need for developmentally appropriate physical education classes that introduce formal strength and endurance training in middle childhood and early adolescence and focus on motor skills in early childhood [22, 38]. Physical education should align with developmental stages, emphasizing motor skills in early years and strength training from middle childhood. The period between ages 6 and 11 is critical for physical development and should be a focus for intervention. Programs must account for individual differences in maturation, especially during adolescence, and consider factors like nutrition, activity levels, and gender-specific growth patterns to optimize outcomes.

5. Conclusions

Age is a significant determinant of physical performance in children, with older age groups demonstrating superior explosive power and core muscular endurance compared to younger peers. These findings reinforce the importance of tailoring physical activity and fitness programs to developmental stages in childhood. Future research should aim to

include additional variables such as biological maturation, sex differences, and environmental influences to better understand the dynamics of physical performance during growth.

Abbreviations

BMI	Body Mass Index
SBJ	Standing Broad Jump
LSD	Least Significant Difference

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Author Contributions

Suvo Roy: Conceptualization, Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing

Md. Azadul Islam: Formal Analysis, Project administration, Supervision, Visualization, Writing – review & editing

Md. Arman Gazi: Funding acquisition, Methodology, Resources, Validation, Writing – review & editing

Sayed Raihanul Islam: Project administration, Resources, Supervision, Visualization, Writing – review & editing

Md. Rayhan Rakib: Conceptualization, Data curation, Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing

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Conflicts of Interest

The authors declare no conflicts of interest.

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