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Effects of Body Weight Training Program on Strength and Power of Primary School Students

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Abstract

Background and Aim: This study showed that some students failed to meet the standard criteria for long jump tests at Tongfu School, Tianhe District, Guangzhou City, China, over the past year. This study was to study of effects of body weight training programs on the strength and power of primary school students.

Materials and Methods: Methodology: The study was a quasi-experimental design that was conducted with 60 students by a simple random sampling method, with an experimental group and a control group. They were examined pretest, after week four, and a posttest on strength and power. The experimental group was trained according to a bodyweight training program for an eight-week duration, three days a week (Monday, Wednesday, and Friday), for one hour and a half per day, while the control group was trained according to a regular training program. The research instruments were a bodyweight training program, strength tests such as squat wall tests, sit-ups, and push-ups, and power tests, such as a standing long jump. The data analysis for mean and standard deviation, comparing the differences using one-way ANOVA, repeated measurement, and Bonferroni post hoc, was done pairwise. The significance level was set at.05.

Results: (1) There were significant differences in strength and power between the control and the experimental group, all pairwise, the experimental group was higher than the control group. (2) Mean comparison within the experimental group found that strength and power were significant differences all pairwise post hoc.

Conclusion: Comparing the experimental group to the control group, the former showed noticeably more strength and power. Furthermore, all pairwise comparisons made post hoc showed a significant increase in strength and power within the experimental group.

Keywords: Body weight Training Program; Strength; Power; Primary School Students

Introduction

The problem addressed in this study stems from the physical fitness test results of Tongfu School, Tianhe District, Guangzhou City, China. Over the past year, some students failed to meet the standard criteria for long jump tests in China. This aligns with previous research indicating that physical activity related to health among Chinese elementary school students has been an interesting topic of study recently. Health-related physical fitness among Chinese primary school students has been a topic of interest in recent studies. Research has shown that physical fitness levels have been impacted by various factors, including the COVID-19 pandemic (Xie et al, 2023). Additionally, studies have highlighted the importance of muscular strength training programs in improving muscular fitness and perceived physical competence in Chinese male adolescents (Hu, et al., 2022). Furthermore, trends in physical fitness among Chinese rural children and adolescents have been evaluated over the years, indicating both positive and negative trends in different components of physical fitness (Zhao, et al., 2022). These findings underscore the significance of promoting health-related physical fitness, including muscular strength and power training, among primary school students in China to enhance overall well-being and physical competence. Strength and power training methods for primary school students have shown positive effects on muscle development. Studies have highlighted the benefits of various training programs. Functional training (FT) programs and regular Physical Education (PE) classes have been found to significantly improve trunk muscle strength and mobility in primary school girls (Lasković, et al, 2022). Additionally, self-regulated strength training interventions have demonstrated improvements in motor performance and functional body-related knowledge in primary school students (Stanković, et al, 2022).

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Strength training methods vary in their effects on muscle strength and damage. Research indicates that different types of contractions, such as isometric, concentric, and eccentric, have distinct impacts on muscle damage and fatigue levels (Böge & Patlar, 2022; Almeida Barros, et al., 2020). Additionally, resistance training protocols like traditional, tension, and occlusion training can influence muscle damage indicators and neuromuscular performance (Xiaolin, et al, 2023). Core strength training has been shown to enhance stability and overall fitness in young soccer players, improving their competitive abilities (Dong, et al, 2023). Moreover, resistance exercise with intermittent blood flow restriction has been found effective in increasing muscle thickness and maximal strength, particularly in high school athletes (Tang, X., 2022). Incorporating vibration training into strength training routines can significantly enhance muscle strength, explosive power, and endurance in athletes.

Power training various training methods have been studied for enhancing muscle power in primary school students. Research suggests that functional training programs, such as circuit training involving body weight, resistance bands, and medicine balls, can effectively improve muscle power in children aged 6 to 15. Studies have shown that interventions like medicine ball training, self-regulated strength training, and circuit training can lead to significant enhancements in muscle strength, endurance, and power in primary school children (Lasković, et al, 2022; Stojanović, et al, 2023). These training methods, when implemented under monitored conditions and with qualified supervision, have demonstrated positive outcomes in improving physical fitness components like push-ups, sit-ups, jump tests, and local muscular endurance. Therefore, incorporating such structured and supervised training programs in school-based physical education can be beneficial for enhancing muscle power in primary school students.

Bodyweight training (BWT), a form of resistance training, has been identified as an appropriate and beneficial exercise modality for primary school students. Research indicates that resistance training, including BWT, can be safely implemented in youth populations, provided it is supervised by qualified professionals and involves age-appropriate instruction and training loads. This ensures the safety and efficacy of the training program, potentially reducing the risk of sports-related injuries in young athletes (Collins, et al, 2018). Furthermore, BWT has been shown to enhance cardiorespiratory fitness in inactive adults, suggesting its potential benefits for improving physical fitness in younger populations as well (Faigenbaum & Myer, 2010). The effectiveness of resistance training interventions, including BWT, on weight status in youth has been explored, with findings suggesting a positive impact on body fat percentage and skinfolds, although not significantly affecting body mass or BMI (Hollingsworth, J.C., et al., 2020). This indicates that while BWT may not directly influence weight, it can contribute to a healthier body composition in children. Additionally, resistance training has been associated with improvements in 'the self', including aspects such as self-efficacy and physical self-worth, which are crucial for the mental health and overall well-being of young people (Fairclough, et al, 2016). Moreover, the implementation of physical activity programs in schools, including resistance training, is effective in achieving healthier BMI levels in primary school children over the long term (Collins, et al, 2019). This underscores the potential of BWT as part of school-based physical activity interventions to combat childhood obesity and promote healthier lifestyles. In summary, BWT is an appropriate and beneficial form of resistance training for primary school students, offering advantages in terms of safety, physical fitness, mental health, and obesity prevention (Linda, et al, 2021; Benson et al, 2007; Nuno, et al, 2007; Saeterbakken et al, 2022; Mei, et al, 2016).

Implementing muscle power training through bodyweight exercises in primary school students, as emphasized by Huhtiniemi, et al (2023) could significantly enhance musculoskeletal fitness (MF) and motor performance. Strength training interventions with self-regulated intensity, as highlighted by Stojanović, N., et al. (2023) lead to notable improvements in motor skills and functional body-related knowledge. Wu, et al (2023) suggest that promoting physical activity and maintaining a healthy Body Mass Index (BMI) positively impacts self-concept, self-esteem, and academic performance in students. Kliziene, et al (2023) said that, further support this by indicating that combining health education with physical activity interventions in schools effectively improves motor abilities and helps combat physical inactivity and weight gain in children. Therefore, integrating structured exercise routines, self-regulated training, and

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health education within the school curriculum can holistically enhance power and overall physical fitness in primary school students.

To address this issue, the researchers would conduct a study involving bodyweight training to address the problem of students with lower-than-standard strength and power levels in the elementary school group. This would serve as a guideline for future physical fitness development.

Objectives

1. To develop a bodyweight training program to improve strength and power in primary school students.

2. To study the effects of a bodyweight training program on strength and power in primary school students

2. To compare the mean effect of the body weight training program on strength and power between groups.

3. To compare the mean effect of the body weight training program on strength and power within the experiment group, pretest, after weeks 4, and posttest.

Literature review

Strength and power for primary school students

The importance of strength and power for primary school students was multifaceted, impacting their physical development, psychological empowerment, and social interactions. Research indicates that engaging in movement games and relays can significantly increase motor skill manifestation indices, including strength, among primary school students, highlighting the role of physical education in developing these essential attributes (Zul, U., 2017). Furthermore, the concept of empowerment, both intrapersonal and interpersonal, is crucial for students, enabling them to pursue social and achievement goals effectively. This empowerment is facilitated by teachers sharing power with students, thus enhancing their motivation and achievement by meeting their needs for power and belonging. Strength trainability in children, including the effects of detraining, reveals that regular, supervised strength training can lead to significant improvements in muscular strength, which, even after a period of detraining, does not diminish significantly in absolute terms, especially for lower limbs (Peeri et al, 2012). This underscores the importance of consistent physical activity for maintaining strength levels. Additionally, self-regulated strength training has been shown to positively affect sports motor performance and functional body-related knowledge in children, further advocating for the inclusion of strength training in primary education (Nitzsche, et al, 2015). Gender differences in strength indices post-COVID-19 have been studied, with significant differences found in specific strength tests, suggesting the need for tailored physical education programs that address these disparities (Gherghel, T. Ș., 2023). The portrayal of gender roles in fairy tales and their perception by students also influences their understanding of power and strength, often reinforcing traditional gender stereotypes (Cocoradă, E., & Aldea, D., 2018). The dynamics of power and solidarity in classroom settings, including the English language classroom, reflect the complex interplay between social relations and educational practices, affecting students' empowerment and learning outcomes (Méndez, T., & García, A., 2012). The effectiveness of games in developing strength in boys of primary school age further supports the integration of playful activities in physical education to enhance strength development, with specific recommendations on the number of games, repetitions, and rest intervals for optimal results (Marchenko & Ishchenko, 2016). Lastly, the ideological aspects of school practices, including the selection of content and the exclusion of certain topics like sexual education, highlight the broader context within which notions of power and strength are constructed and conveyed in educational settings (Lucifora, et al, 2018). This comprehensive overview underscores the critical importance of strength and power for primary school students, not only in physical terms but also in their psychological and social development.

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The body weight training exercises for improving strength and power.

The effectiveness of bodyweight training exercises for improving strength and power can be discerned through various research findings that explore different training modalities. Velocity-based training (VBT) and traditional resistance training (TRT) have been compared, with low and high-velocity loss (lowVL and highVL) showing notable effects on strength, jump, and sprint performance, suggesting that exercises incorporating velocity elements could be beneficial (Held, et al, 2022). Whole-body vibration (WBV), as an adjunct or alternative to classical resistance training, particularly benefits elderly individuals with functional limitations, indicating its potential for enhancing isometric and dynamic strength as well as power (Rogan, et al, 2015). Free-weight exercises, such as the barbell squat, have been shown to significantly improve jump performance compared to machine-based exercises like the leg press, highlighting the importance of incorporating free-weight movements for power development (Wirth, et al, 2016). In law enforcement training, the hexagonal bar deadlift (HBD) demonstrated strong correlations with body drag performance, suggesting that exercises improving absolute and relative strength are crucial for tasks requiring power (Lockie, et al, 2019). Eccentric-overload training, through unilateral and bilateral movements, has been shown to significantly impact muscle hypertrophy and functional performance, with unilateral training offering more benefits in certain areas (Nuñez, et al, 2018). Nighttime protein consumption combined with exercise training has been explored for its effects on resting metabolic rate (RMR), appetite, and body composition, indicating the importance of nutrition in conjunction with physical training for strength and power improvements (Eddy, A., et al., 2012). Supplementation with phosphatidic acid (PA) in a strength training context significantly increased lean body mass (LBM) and strength, suggesting that nutritional supplementation can enhance the effects of strength training exercises (Escalante, et al, 2016). Training programs focusing on optimum power (OP) and traditional power training (TT) showed that OP with individualized loads and repetitions could lead to more efficient training outcomes with less neuromuscular fatigue (José, et al, 2017). Kinetic and kinematic analysis of free-weight exercises like the back squat and jump squat across multiple loads revealed that ballistic exercises produce greater outputs, emphasizing the effectiveness of these exercises for strength and power development (Thompson et al, 2023). Finally, the relationship between muscular strength, power qualities, and sports performance has been studied, with findings suggesting that while strength and power are associated with performance, the transfer effects to sport-specific skills require further research (Gabbett, T. J., 2013). In summary, the most effective bodyweight training exercises for improving strength and power appear to be those that incorporate velocity elements, free-weight movements, eccentric overload, and ballistic exercises.

Conceptual Framework

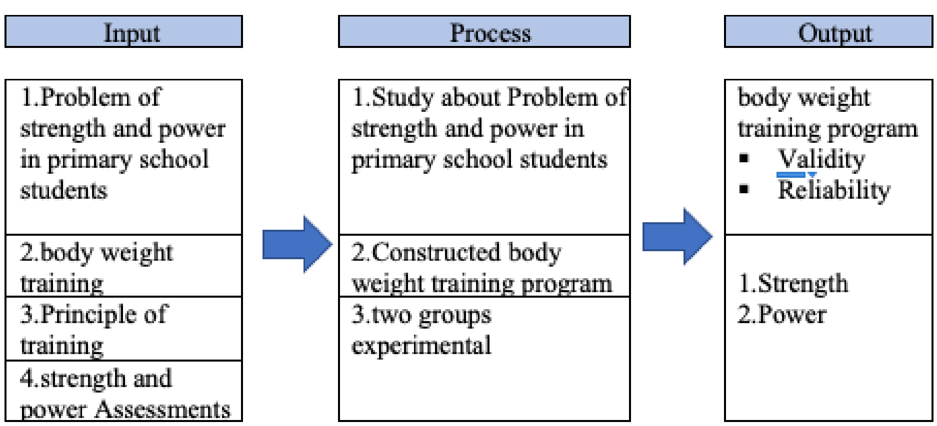

Figure 1 Conceptual Framework

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Methodology

Population and sample

The population was 250 students from six classes of fifth grade in the academic year 2023 of the primary section of Tongfu School, Tianhe District, Guangzhou City, China.

The subject was two classes from six classes with sample random sampling and systematic random sampling in two groups with strength and power ranging, then the slot training method for the control and experimental groups, each with 30 students.

The inclusion criteria were as follows:

1. Be a student from fifth grade in the academic year 2023, Tangfu School, Tianhe District, Guangzhou,
2. Be a person whose power and muscle strength are below standard.
3. Those who do not have any injuries that hinder training must get the approval of the doctor.
4. Those who have passed the training readiness assessment according to the PAR-Q+ 2022 assessment form, The physical activity readiness questionnaire for everyone.
5. Be a person who voluntarily agrees to participate in the program and signs the consent document.

The exclusion criteria were as follows:

1. Less time to participate in experiments 80% of the 8-week training period
2. Participants did not complete the test by the date and time specified by the researcher.
3. Have a medical condition or injury that prevents them from continuing the training.
4. Request to leave the research project

This research was approved for human research board from Certificate No.195/2566 /issue date 19 November 2023 /expiry date.18 November 2024.

Research Design

This study was a quasi-experimental research with control and experimental that repeated measurement, pre-test, after weeks 4 and post-test. The Independent variable was the body weight training program and the dependent variables were strength and power in primary school students.

Research Instrument

Instruments in this research were such as:

1. A bodyweight training program that combines strength and power from body weight as resistance training and plyometric training methods; the training duration was 8 weeks, 3 days/week (M/W/F), 90 minutes each day. Training program contents validity was 94, which IOC: Index of item objective congruence evaluated by 5 experts, and then to try out with 5 subjects, the intensity, load vellum, recovery times, and training exercise were appropriate for experimental training.
2. Strength tests such as squat wall tests, sit-ups, and push-ups. Power test, such as a standing long jump.

Data collection

The researchers conducted the data collection process as follows:

1. Request permission to conduct research in schools from Thonburi University and contact the Tongfu School, Tianhe District, Guangzhou City, China to submit permission documents.
2. Schedule sample groups and research assistants to clarify research procedures, testing, and experiments, and set dates and times for experiments to ensure mutual understanding.
3. Proceed to collect basic data of the sample group and test their strength and power before conducting experiments.
4. Conduct experiments according to the researcher's program and proceed to test strength and power after the 4th and post-test weeks of training.
5. Compile and analyze the test data statistically for further analysis.

Data Analysis

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1. Mean and standard deviation
2. Compare the mean between two groups with t-test independent
3. Compare the mean within the experimental group with one-way ANOVA repeated measurement and pairwise Bonferroni post hoc
4. Significant difference level at .05

Results

The research results support the hypothesis that the strength and power of the post-test in the experimental group were better than in the control group.

Table 1 Mean compare of pre-test between control and experimental group on strength and power with t-test independent

Variable	Group	Mean+ SD	D	t	P
Squat wall (min)	Cont.	3.10 + 2.13	.01	.03	.78
	Exp.	3.09+1.94			
Sit-up (Time/minute)	Cont.	20.10 + 4.36	-.33	-.25	.07
	Exp.	20.43+5.98			
Push-up (Time/minute)	Cont.	16.23+ 5.55	-3.00	-1.56	.11
	Exp.	19.23+ 8.97			
Standing long jump (cm)	Cont.	152.80+ 20.99	-2.37	-.44	.81
	Exp.	155.17+ 20.95			

*P<.05

From Table 1, there was no significant difference between the control group and the experimental sets.

Table 2 Mean comparison of post-test between control and experimental group on strength and power with t-test independent.

Variable	Group	Mean+ SD	D	t	P
Squat wall (min)	Cont.	4.73 + 2.09	-1.12	-2.16	.04*
	Exp.	5.85 +1.93			
Sit-up (time/minute)	Cont.	29.23+ 3.95	-5.67	-5.11	.01*
	Exp.	34.90+4.61			
Push-up (Time/minute)	Cont.	24.67+ 5.04	-9.70	-6.31	.01*
	Exp.	34.37+ 6.74			
Standing long jump (cm)	Cont.	177.10+ 17.59	-13.63	-3.29	.01*
	Exp.	190.70+ 14.32			

*P<.05

From Table 2, there were significant differences between the control group and the experimental group, that all pairwise, the experimental group was higher than the control group.

Table 3 Mean and standard deviation of Muscle strength, power

Variables	Cont. Group			Exp. Group		
	Pre-test	After week 4	Post-test	Pre-test	After week 4	Post-test
	M+SD.	M+ SD.	M+ SD.	M+SD.	M+ SD.	M+ SD.
Wall squat test (min)	3.10+2.13	3.88+ 2.14	4.73+ 2.09	3.09+1.94	4.57+1.89	5.85+1.93
Sit up 60 sec (time/minute)	20.01+4.36	23.47+4.10	29.23+ 3.95	20.43+5.98	26.23+5.62	34.9+4.61
Push up 60 sec	16.23+5.55	19.07+5.28	24.67+ 5.04	19.23+8.97	25.03+7.97	34.37+ 6.74

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Variables	Cont. Group			Exp. Group		
	Pre-test	After week 4	Post-test	Pre-test	After week 4	Post-test
	M+SD.	M+ SD.	M+ SD.	M+SD.	M+ SD.	M+ SD.
(time/minute)						
Standing Long jump (cm)	152.80+20.99	168.23+19.40	177.10+ 17.59	155.16+20.95	179.9 + 17.15	190.70+ 14.32

Form Table 3 found that,

1. Wall squat test of the control group with pretest, after week 4 and posttest was 3.10+2.13, 3.88+ 2.14 and 4.73+ 2.09 sec; and experimental group was3.09+1.94, 4.57 +1.89 and 5.85+1.93 sec respectively.

2.Sit up a 60-sec test of the control group with a pretest, after week 4 and the posttest was 20.01+4.36, 23.47 + 4.10, and 29.23+ 3.95 times; and the experimental group was 20.43+5.98, 26.23 + 5.62 and 34.9+4.61 times respectively.

3. Push up a 60-sec test of the control group with a pretest, after week 4 and the posttest was 16.23+5.55, 19.07 + 5.28, and 24.67+ 5.04 times; and the experimental group was 19.23+8.97, 25.03 +7.97 and34.37+ 6.74 times respectively.

4. The Standing Long jump of the control group with pretest, after week 4 and posttest was 152.80+20.99,168.23 +19.40 and 177.10+ 17.59 cm; and the experimental group was 155.16+20.95, 179.9 + 17.15 and 190.70 + 14.32 cm respectively.

Table 4 Mean comparison within the experimental group on muscle strength and power by one-way ANOVA repeated measurement

Variables	Source of variant	Type III Sum of Squares	df	MS	F	p
Wall squat	Week	115.12	2	57.56	1287.25	.01*
	Error	2.59	58	.05		
	total	117.71	60	57.61		
Sit up	Week	3180.36	2	1590.18	1263.81	.01*
	Error	72.98	58	1.26		
	total	3253.34	60	1591.44		
Push up	Week	3497.69	2	1748.84	877.11	.01*
	Error	115.64	58	1.99		
	total	3613.33	60	1750.83		
Standing long Jump	Week	19940.87	2	9970.43	557.22	.01*
	Error	1037.80	58	17.89		
	total	20978.67	60	9988.32		

*P< .05

Form Table 4 found that for all of the variables, there was one pairwise significant difference. Significant differences were found in the mean comparison table of all strengths and power within the experimental group.

Table 5 Pairwise post hoc by Bonferroni on strength and power between pre-test, after weeks 4 and post-test.

Variable	Test	Pre-test	After weeks 4	Post-test
Wall squat	Pre-test	XXX	-1.48*	-2.77*
	After weeks 4		XXX	-1.29*
	Post-test			XXX
Sit up	Pre-test	XXX	-5.80*	-14.47*

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Variable	Test	Pre-test	After weeks 4	Post-test
	After weeks 4		XXX	-8.67*
	Post-test			XXX
Push up	Pre-test	XXX	-5.80	-15.13*
	After weeks 4		XXX	-9.33*
	Post-test			XXX
Standing long Jump	Pre-test	XXX	-24.73*	-35.57*
	After weeks 4		XXX	-10.83*
	Post-test			XXX

*P<.05

Form Table 5 found that, all pairwise pre-test after week 4, pre-tests with post-test, and after week 4 with post-test had significant differences.

Discussion

The results indicate that there were significant differences in all pairwise comparisons: pre-test with after week 4, pre-test with post-test, and after week 4 with post-test. Additionally, the muscle strength and power of the experimental group were better than those of the control group. This is because the weight training program implemented was able to stimulate the experimental group to respond adaptively according to the principles of training. This includes considerations such as training intensity, frequency, duration, and rest intervals, which were appropriately tailored to elicit the desired physiological adaptations. The training program's effectiveness in stimulating physiological responses is influenced by various factors such as training weight, frequency, duration, and rest time (Teixeira, C. V. L. S., et al, 2018). Research suggests that shorter rest intervals between sets, like 1 to 2 minutes, can be sufficient for maintaining maximal power output during power-based exercises, aiding in power development. Additionally, studies show that the combination of creatine supplementation with resistance training can enhance strength gains regardless of rest interval length between sets, emphasizing the importance of proper supplementation. Moreover, the length of rest intervals between sets significantly impacts training volume, with longer rest periods leading to higher volumes completed, potentially enhancing strength and hypertrophy adaptations. Advanced training techniques can also influence muscle responses, with different techniques producing slight variations in volume load and muscle excitation. Overall, optimizing training variables like weight, frequency, duration, and rest time is crucial for eliciting appropriate physiological responses to training programs.

Additionally, there are studies concerning the relationship between muscle strength and power. Research has highlighted the intricate relationship between muscle power and muscle strength, indicating that enhancements in muscle strength can result in increased muscle power (Ličen & Kozinc, 2023; Hadouchi, M., et al., 2022). Specifically, resistance training has been identified as a valuable method for improving both upper and lower body muscle power in overweight and obese men (Yapici, H., et al., 2022). Moreover, studies have shown that power training, as opposed to strength training, offers greater potential for enhancing muscle power and performance on activity tests in older adults (Burbank, C. M., et al., 2023). This suggests that interventions focusing on enhancing muscle strength through resistance training can potentially lead to improvements in muscle power, emphasizing the importance of tailored exercise programs to target both aspects of muscle function.

Conclusion

A bodyweight training program that combines strength and power from body weight as resistance training and plyometric training methods was suitable for primary school students due to its safety for

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adolescents who were still growing. In this study, it was found that the bodyweight training program could improve strength and power in primary school students.

Recommendation

1. Practice should be designed to have fun while practicing as an incentive for the next training.
2. Maybe using wearables or AI for real-time feedback on form and speed during bodyweight exercises.
3. In the next research, training should be designed with body weight and musical rhythm.

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