Analysis of Influence of Core Strength Training on Medicine Ball Performance of Junior High School Students based on SPSS

Feng Wu[a], Jun Yuan[b*], Yanhong Liu[c]

School of Physical Education, Shenzhen University, Shenzhen, Guangdong Province, China

[a]13531070289@139.com, [b*]yuanjun@szu.edu.cn
[c]lucyliu@szu.edu.cn

Abstract. Objective: Through the use of SPSS mathematical statistics software, the influence of core strength training on the medicine ball performance of junior high school students was analyzed, to provide theoretical basis for scientific and efficient physical training of junior high school students. Methods: 60 healthy junior high school students (30 males and 30 females each) were randomly selected in Shenzhen and divided into Group A and Group B. In Group A, 15 males and 15 females were randomly selected as experimental group to undergo core strength training, while in Group B, 15 males and 15 females were randomly chosen as the control group to receive traditional strength training. And then, the differences in medicine ball performance between the two groups were detected after eight weeks of training. Results and analysis: Group A showed a statistically significant improvement in medicine ball performance ($P<0.01$), with a difference of 1.08±0.15m. Males improved by 1.13±0.16m, females by 1.04±0.14m. Group B also exhibited a significant improvement ($P<0.01$) with a difference of 0.41±0.09m. Conclusion: After core strength training, the medicine ball performance of both the experimental group and the control group improved, and the core strength training group improved more significantly, in addition, the performance of males improved slightly higher than that of females. On this basis, a series of suggestions were put forward from the aspects of scientific training and dialectical application of strength training to help junior high school students effectively improve their medicine ball performance.

Keywords: SPSS; core strength training; medicine ball performance; junior high school students.

1 Introduction

With the continuous progress of educational reforms and the deepening of quality education, physical education in schools is increasingly emphasizing the cultivation of students' physical fitness and athletic skills. Medicine ball, as a pivotal physical test in middle school entrance examinations, holds a significant position. However, effec

M. Yu et al. (eds.), *Proceedings of the 2024 5th International Conference on Big Data and Informatization Education (ICBDIE 2024)*, Advances in Intelligent Systems Research 182,
https://doi.org/10.2991/978-94-6463-417-4_25

tively enhancing the medicine ball performance of junior high school students has consistently been the focus of physical education practitioners. In recent years, core strength training has demonstrated remarkable achievements in competitive sports. Core strength refers to the force generated by all muscles and ligaments attached to the core area under neural contraction. The strength and coordination of core muscles influence the control of body balance, variations in movement posture, transmission of force between limbs, body movement speed, and movement direction[1]. Currently, core strength training, as one of the effective methods to improve students' physical education performance in middle school entrance examinations, can meet the requirements of most sports for students' abilities. Employing a reasonable core strength training method can help junior high school students enhance physical fitness, maintain movement balance, and reduce the risk of sports injuries[2]. Moreover, core strength training differs from traditional strength training in terms of purpose, methods, and effects. Core training focuses on improving body stability and coordination[3], using static exercises to reduce muscle and joint injuries, while traditional training emphasizes enhancing limb strength, utilizing high-intensity dynamic exercises that may increase the risk of injury. In terms of training methods, core training predominantly enhances strength through non-steady-state training, whereas traditional training enhances strength in a stable state.

Based on the extensive literature review on core strength training and theoretical support, this study utilizes SPSS software to analyze experimental data. The aim is to provide a scientific reference for schools and teachers in developing more effective physical fitness improvement plans. Simultaneously, the study seeks to offer a theoretical basis for the promotion and application of core strength training among junior high school students. The innovation of this study lies in its focus on junior high school students, specifically investigating the impact of core strength training on medicine ball performance. Additionally, the study explores the variation in medicine ball performance based on gender, providing new research perspectives and practical experiences for the development of physical education theories.

2 RESEARCH METHODS

2.1 Literature Data Method

Utilizing academic platforms such as the China National Knowledge Infrastructure (CNKI) and the Science Citation Index Expanded (SCI), relevant literature was systematically retrieved. The collected literature was then summarized and analyzed to serve as the theoretical foundation for this study.

2.2 Experimental Method

A total of 60 healthy students were randomly selected from junior junior high school students in Shenzhen, including 30 male students and 30 female students. The 60 participants were divided into two experimental groups, labeled as Group A and Group B. Group A consisted of 15 randomly selected males and 15 females designat-

ed for core area strength training experiments. Meanwhile, Group B comprised 15 randomly chosen males and 15 females undergoing traditional strength training as the control group.

Before the experiment, baseline tests were conducted on the participating students in medicine ball exercises to understand the fundamental conditions of the experimental subjects. During the experiment, targeted core strength training was undergone by the experimental group, while traditional strength training was administered to the control group. No additional training beyond the designed physical exercises was conducted. The experiment spanned 8 weeks, with three sessions per week, each lasting 40 minutes, totaling 24 training sessions. Upon conclusion of the experiment, post-training medicine ball tests were once again conducted for both the experimental and control groups, with data from various indicators being collected for analysis.

2.3 Statistical Analysis

This research employed SPSS 25.0 statistical analysis software to process and analyze data. Comparative analyses were conducted between the experimental and control groups, examining the basic physical data before experimentation, the scores of the experimental group before and after the experiment, the performance changes between male and female students within the experimental group before and after the experiment, as well as the pre- and post-experiment scores in the control group. The results were presented in the form of mean±standard deviation, where $P<0.05$ indicated significant differences. These comparisons aimed to explore the teaching effectiveness of the experiment.

2.4 Core Strength Training Method

After reviewing pertinent literature on core strength training, an experimental plan for core strength training was formulated[4]. The training program for the experimental group comprised four cycles, each lasting 2 weeks. Additionally, the exercises within each cycle followed a progression from easy to challenging, gradually advancing from stable to unstable states. Training sessions were scheduled for Monday, Wednesday, and Friday afternoons, with each session lasting 40 minutes (Table I).

Table 1. SCHEDULE FOR CORE TRAINING

Cycle	Periodic Time	Name	Training Schedule
First Cycle	Weeks 1-2	Plank	3 sets, 60s each
		Plank Jacks	3 sets, 25 reps
		Push-ups	3 sets, 12 reps
		Leg Raises	3 sets, 20 reps
Second Cycle	Weeks 3-4	Alternating Plank on Yoga Ball	3 sets, 60s each
		Alternating Plank	3 sets, 60s each
		Bosu Ball Squats	5 sets, 12 reps

		Bosu Ball Russian Twists	3 sets, 20 reps
Third Cycle	Weeks 5-6	Leg Raises with a Ball Squeeze	3 sets, 20 reps
		Weighted Plank	3 sets, 60s each
		Barbell Weighted Hip Bridge	5 sets, 8 reps
		Weighted Push-ups	3 sets, 12 reps
Fourth Cycle	Weeks 7-8	Bosu Ball Weighted Plank	3 sets, 60s each
		Barbell Weighted Alternating Plank	3 sets, 60s each
		Weighted Bosu Ball Push-ups	3 sets, 12 reps
		Barbell Weighted Bosu Ball Squats	5 sets, 12 reps

The first cycle spans Weeks 1-2, serving as foundational training primarily centered around stable-state core exercises performed without equipment. It consists of plank support, Plank Jacks (open and close one's feet quickly while in a plank position), push-ups, and leg raises, aiming to initiate initial stimulation in the core muscle groups, establishing a solid groundwork for the subsequent training phase.

The second cycle, Weeks 3-4, focuses on reinforcing training through non-stable-state core exercises. It includes alternating planks on a yoga ball, regular alternating planks, Bosu ball squats, and Bosu ball Russian twists. This phase primarily aims to enhance core muscle strength, elevate body balance control, stimulate deeper, smaller muscle groups, and increase explosive power in the core muscles.

The third cycle, Weeks 5-6, signifies the mid-term training phase, emphasizing stable-state weighted core strength exercises. It involves exercises like ball squeeze leg raises, weighted planks, barbell weighted hip bridges, and weighted push-ups. This phase builds upon the foundational work from the prior cycles, further strengthening core muscle strength and endurance.

The fourth cycle, encompassing Weeks 7-8, marks the final phase, emphasizing non-stable-state weighted core strength training. This phase includes exercises like Bosu ball weighted planks, barbell weighted alternating planks, weighted Bosu ball push-ups, and barbell weighted Bosu ball squats for non-stable-state weighted training.

3 RESULTS AND ANALYSIS

3.1 Comparison of Basic Data between Experimental and Control Groups

Based on the data presented in Table II, no significant differences were observed between the experimental and control groups concerning height, weight, age, or medicine ball scores. All p-values were greater than 0.05, meeting the prerequisites for subsequent experimentation.

Table 2. COMPARISION OF BASIC DATA BETWEEN EXPERIMENT AND CONTROL GROUP

Group	Height (cm)	Weight (kg)	Age (years)	Medicine Ball Performance (m)
Experimental	165.27±0.73	54.62±3.74	12.7±0.32	7.93±1.45
Control	166.11±0.41	55.29±3.19	12.9±0.26	7.90±1.41
P-value	0.26	0.17	0.07	0.29

Note: P-value>0.05 indicates no significant difference.

3.2 Impact of Core Strength Training on Medicine Ball Performance

1) Comparison of Medicine Ball Performance before and after Experiment in the Experimental Group.

As shown in Table III, through the comparative analysis of pre- and post-experiment data, the average medicine ball distance before training was 7.93±1.45 meters. Following targeted core area strength training, the post-experiment distance increased to 9.01±1.41 meters, marking an improvement of 1.08±0.15 meters compared to pre-training distances. The contrast between post-training and pre-training data in the experimental group exhibited highly significant differences ($P < 0.01$). This indicates a notable enhancement in both core strength and medicine ball proficiency among the participants due to the implemented training program.

Table 3. COMPARISON OF TEST RESULTS BEFORE AND AFTER CORE STRENGTH TRAINING IN THE EXPERIMENTAL GROUP

Group	Medicine Ball Score (m)	Difference (m)	Improvement Ratio
Before	7.93±1.45		
After	9.01±1.41**	1.08±0.15**	13.6%

Note: *P<0.05, **P<0.01.

2) Comparison of Medicine Ball Performance before and after Core Strength Training within Gender Groups in the Experimental Group.

The medicine ball performance before and after core strength training within gender groups in the experimental group is shown in Table IV and Figure 1, data analysis shows that the male and female students in the experimental group have significantly improved after training. Before training, the average medicine ball distance for male students was 8.97±1.12 meters. After targeted core area strength training, the post-training score rose to 10.10±0.98 meters, marking an increase of 1.13±0.16 meters, showing a highly significant difference in medicine ball performance ($P<0.01$). For female students, the average medicine ball distance before training was 6.89±0.89 meters. After a combined core strength training, the post-training score increased to

7.93±0.82 meters, indicating a 1.04±0.14 meters improvement, also presenting a highly significant difference in medicine ball performance (P<0.01).

Upon comprehensive analysis of pre and post-training data for male and female students, it's evident that both genders experienced substantial improvements in medicine ball performance after targeted core area strength training. However, the extent of improvement between genders showed no significant difference, with only a marginal 0.09-meter difference. This suggests that the impact of core strength training on medicine ball performance does not significantly vary between genders, indicating minimal gender-related disparities.

Table 4. COMPARISON OF MEDICINE BALL PERFORMANCE BEFORE AND AFTER CORE STRENGTH TRAINING WITHIN GENDER GROUPS IN THE EXPERIMENTAL GROUP

Gender	Group	Medicine Ball Score (m)	Difference (m)
Male	Before	8.97±1.12	1.13±0.16**
	After	10.10±0.98**	
Female	Before	6.89±0.89	1.04±0.14**
	After	7.93±0.82**	

Note: *P<0.05, **P<0.01.

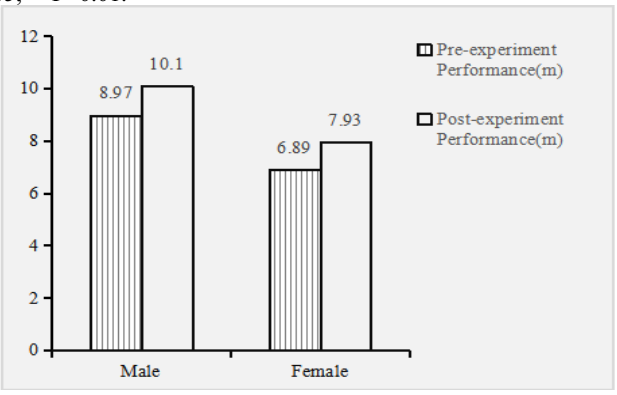

Fig. 1. Comparison Of Medicine Ball Performance Before and After Experiment Within Gender Groups In The Experimental Group

3) Comparison of Medicine Ball Performance before and after Training in the Control Group.

The comparative analysis of pre and post-training data in the control group is shown in Table V, the average medicine ball distance before training was 7.90±1.41 meters. After traditional training, the post-training score increased to 8.31±1.42 meters, marking an improvement of 0.41±0.09 meters compared to pre-training distances. The comparison between post-training and pre-training data in the control group

exhibited highly significant differences (P<0.01), indicating a relatively slower improvement in medicine ball performance within the control group.

Table 5. COMPARISON OF MEDICINE BALL PERFORMANCE BEFORE AND AFTER TRAINING IN THE CONTROL GROUP

Group	Medicine Ball Score (m)	Difference (m)	Improvement Ratio
Before	7.90±1.41		
		0.41±0.09**	5.2%
After	8.31±1.42**		

Note: *P<0.05, **P<0.01.

4) Comparison of Medicine Ball Performance before and after Experiment within Gender Groups in the Control Group.

Table 6. COMPARISON OF MEDICINE BALL PERFORMANCE BEFORE AND AFTER TRADITIONAL TRAINING WITHIN GENDER GROUPS IN THE CONTROL GROUP

Gender	Group	Medicine Ball Score (m)	Difference (m)
Male	Before	8.98±0.83	0.43±0.12**
	After	9.41±0.84**	
Female	Before	6.83±0.97	0.38±0.05**
	After	7.21±0.96**	

Note: *P<0.05, **P<0.01.

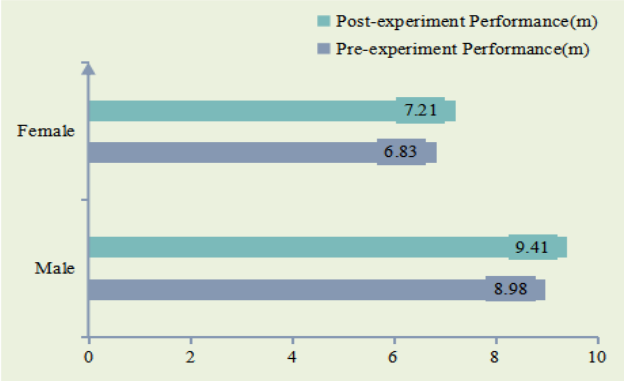

Fig. 2. Comparison of Medicine Ball Performance before and after Experiment within Gender Groups in the Control Group

The comparative analysis of pre and post-experimental data for male and female control groups is shown in Table VI and Figure 2, the average distance of Medicine Ball throws by male participants before the experiment was 8.98±0.83m. Following traditional training, the experimental performance increased to 9.41±0.84m, showcas-

ing an improvement of 0.43±0.12m compared to pre-experiment results. The Medicine Ball test exhibited a highly significant difference post-experiment compared to pre-experiment ($P<0.01$).

For female participants, the average distance of Medicine Ball throws before the experiment was 6.83±0.97m. After engaging in combined core strength training, the experimental performance increased to 7.21±0.96m, reflecting an improvement of 0.38±0.05m compared to pre-experiment results. Similar to the male group, the Medicine Ball test showed a highly significant difference post-experiment compared to pre-experiment ($P<0.01$).

Upon comprehensive analysis of pre and post-experimental data for both genders, it is evident that after undergoing traditional training, both male and female participants experienced an enhancement in their Medicine Ball throwing performance. However, the degree of improvement between the two genders did not exhibit a significant difference, with a marginal difference of only 0.05m. This suggests that traditional training has a relatively minor impact on the Medicine Ball throwing performance of students of different genders, showing no pronounced disparity based on gender.

5) Analysis of Medicine Ball Performance for Both Groups After the Experiment.

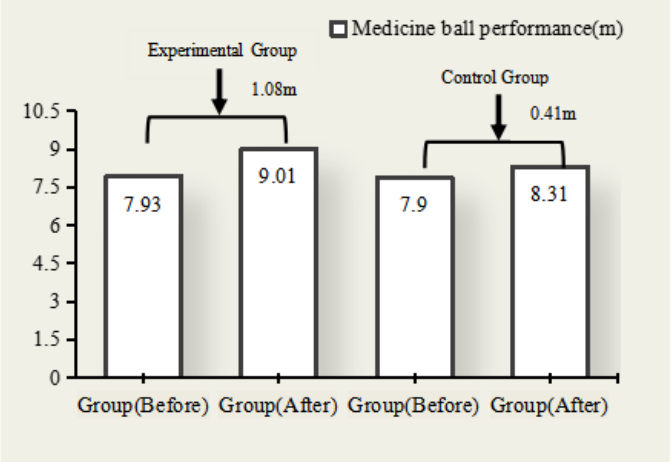

Fig. 3. Comparison of Medicine Ball Performance for Both Groups Before and After the Experiment

After the combined 8-week core strength training experiment, combined with the overall situation presented in Figure 3 and the above charts, it's evident that both groups exhibited significant improvements in medicine ball performance. However, the effects induced by the two different training methodologies varied noticeably. Specifically, the targeted core area strength training significantly enhanced medicine ball performance in the physical education assessment.

The students in the experimental group showed a higher increase in medicine ball distances and improvement ratios compared to those in the control group. Medicine ball performance primarily evaluates students' upper body strength, core strength, and coordination between upper and lower limbs. Assessing the improvement ratios pre and post-training, the experimental group showed a considerably larger increase compared to the control group. Although the initial scores between the two groups were relatively similar before the experiment, the experimental group demonstrated only a slight advantage over the control group. However, after the training, the improvement in medicine ball performance for the experimental group significantly surpassed that of the control group.

3.3 Analysis of Influential Factors and Mechanisms

1) Enhancement of Core Muscle Strength.

Targeted core area training effectively amplifies the strength of core muscles, including the abdominals, obliques, and back muscles. These muscles play a pivotal role in medicine ball execution, significantly boosting both speed and power in the throw.

2) Body Posture and Balance Control.

Targeted core area training enhances body posture and balance capabilities, enabling secondary school students to maintain steadiness and precision in their medicine ball actions[5]. This refinement leads to increased accuracy and consistency in medicine ball performance, consequently elevating overall scores.

3) Improved Body Flexibility and Coordination.

Targeted core area training elevates body flexibility and coordination, allowing secondary school students to seamlessly control various body parts during the medicine ball maneuver. This enhanced control results in improved medicine ball techniques and overall effectiveness.

4) Enhanced Muscular Synergy.

Targeted core area strength training enhances the coordination among different muscle groups, enabling athletes to harmoniously engage various muscle sets while executing the medicine ball. This synergy significantly augments the medicine ball's force and velocity, leading to a notable enhancement in medicine ball performance.

4 CONCLUSIONS AND SUGGESTIONS

4.1 Conclusion

Through the comparative analysis of the experimental data, it's evident that there is a notable improvement in medicine ball performance after core strength training. This

enhancement can be attributed to the need for coordinated action between the upper and lower limbs, as well as the coordinated activation of the deep core muscle groups and the ability for rapid muscular force production. The core region, located at the body's center, acts as a bridge between the upper and lower body, showcasing a substantial development in muscle coordination and the deeper muscle groups. It plays a pivotal role in coordinating the combined efforts of the upper and lower limbs, while traditional strength training effectively develops larger muscle groups and superficial muscular strength. Hence, a balanced and judicious allocation of core muscle and traditional strength training at appropriate intervals during the training process stands as the optimal choice for strength enhancement. Core strength training emerges as the key factor in significantly improving medicine ball performance. However, the study of medicine ball involves various intricate aspects, demanding comprehensive exploration. Hence, in future teaching and training sessions, it's essential to explore multidimensional and diverse methods and measures conducive to enhancing the level of performance in this discipline.

4.2 Suggestions

1) Adhering to Physiological Foundations in Training Load

It is crucial to adhere to the physiological development and exercise training principles of students, ensuring a rational arrangement of training loads and the utilization of scientifically sound advanced training methods. Furthermore, during the training process, attention should be dedicated to the precision of movements to prevent sports injuries. Providing ample rest time for muscle strength recovery is essential, facilitating a further enhancement of training effects and enabling students to improve their performance more effectively and swiftly.

2) Exploiting the Advantages of Strength Training Methods

Core strength training and traditional strength training are two crucial means of enhancing students' physical fitness, each possessing unique advantages and limitations. In the teaching process, it is imperative to dialectically and judiciously apply both training methods[6], managing the relationship between the two to optimize training effectiveness. Additionally, based on the muscular force characteristics of the medicine ball exercise, precise adjustments to training strategies are necessary to ensure the specificity and efficacy of the training.

3) Scientifically Integrating Strength Training Methods

During physical fitness training, it is essential to integrate both core strength training and traditional strength training. According to the diverse requirements of different phases in the training process of the medicine ball exercise, a rational and scientific allocation of training content should be provided. This comprehensive training strategy can fully leverage the advantages of both training methods, leading to a comprehensive improvement in training effectiveness. For instance, in medicine ball training, combining stability training from core strength and heavy-load training from traditional strength effectively can enhance students' throwing proficiency.

Acknowledgment

This research was funded by 2020 Guangdong Provincial Discipline Co-construction Project(GD20XTQ03) and Shenzhen University Gathering Plan(2023SZU53).

References

1. Stephen, A., Ian, B., Darrell, B., Mark, B., Howard, H., Jonathan, S. Electromyographic Response of Global Abdominal Stabilizers in Response to Stable- and Unstable-Base Isometric Exercise. Journal of Strength and Conditioning Research, 2015, 29(6): 1609-1615.
2. Hill, J., Leiszler, M. Review and Role of Plyometrics and Core Rehabilitation in Competitive Sport. Current Sports Medicine Reports, 2011,10(6): 345-351.
3. Chen, F. Z. Experimental Study on the Improvement of Medicine Ball Performance of Junior High School Students with Core Strength Training. The Test and Study, 2018,34:146-147.
4. Gao, J.C., He, X.S. Research on the Influence of Core Strength Training on Medicine Ball Performance of College Entrance Examination Students Majoring in Physical Education. Science & Technology of Stationery & Sporting Goods, 2018,2:191-192.
5. Zhou, W., Mou, K., Jin, X.D., Huang, R.H. Teaching Medicine Ball in Junior High School and Improving Students' Core Physical Fitness-A Discussion on the Influence of Students' Strength and Flexibility on Medicine Ball Performance. New West, 2018,14:61-62.
6. Shuai, Y.Q. Experimental Study on the Improvement of Medicine Ball Performance of Junior High School Students with Core Strength Training. Hunan University of Science and Technology, 2015.