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JAVELIN THROW TRAINING MODEL BASSED MEDICINE BALL

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Abstract
This study aims to develop and evaluate the effectiveness of a medicine ball-based javelin throwing training model on improving upper body strength, motion coordination, and throwing distance in athletic athletes in Palembang City. The research method used is an experimental method with a quantitative approach. The sample consisted of 30 javelin throwing athletes who were divided into two groups, namely the experimental group given a medicine ball-based training program and the control group that continued to undergo conventional training. The training is conducted for eight weeks with a frequency of three times a week. Data collection was carried out through practical tests of javelin throwing, measurement of arm and shoulder muscle strength using a dynamometer, and analysis of throwing techniques through video recording. The results showed that the experimental group experienced a significant increase in average throwing distance by 12.5%, an increase in muscle strength by 18%, and visual improvement in throwing technique. Based on these findings, it can be concluded that the medicine ball-based training model makes a positive contribution to improving the performance of javelin throwing athletes. Therefore, this model is recommended as an alternative to an innovative and effective training program in the development of athletic athletes.
Keywords*: javelin throw; Medicine Ball; Training Model; muscle strength; Athlete Performance*

INTRODUCTION

Javelin throwing is one of the branches of athletic sports that demands a high combination of strength, flexibility, coordination of movements, and precise technique. In the context of competition, athletes' performance is determined by various interrelated physical and technical factors, such as upper body muscle strength, aerobic capacity, reaction speed, and the ability to coordinate movements harmoniously (Bartolini et al., 2021). In Indonesia, especially in the city of Palembang, the coaching of javelin throwing athletes still faces challenges in creating effective and innovative training methods to improve achievement optimally.

One approach that shows great potential is the use of medicine balls in athletic training programs. Medicine balls, as functional exercise aids, have been shown to be able to improve dynamic strength, explosiveness, and body coordination through multi-directional movements that resemble actual activities in sports (Szymczak et al., 2023). Research conducted by Saeterbakken et al. (2020) shows that medicine ball exercises can provide a significant increase in torso rotational strength and power transfer from the core of the body to the upper extremities, an important element in javelin throwing mechanics. In addition, based on a study by Chaouachi et al. (2021), the use of medicine balls in functional-based exercise programs has a positive impact on improving arm speed and throwing accuracy in throwing sports athletes.

In the context of javelin throwing, an understanding of throwing biomechanics becomes very important. The javelin throw movement consists of several main phases: the beginning, the final preparation, the final push, and the post-throw. The final thrust phase is the most critical moment in which all kinetic energy from the body must be efficiently transferred to the javelin (Lees et al., 2022). In this phase, the role of the muscles of the upper body and core is very dominant, so it requires specific exercises that can increase explosiveness and synchronization between body segments. Medicine ball exercises, with various variations of movements such as oblique throws, rotational slams, and chest passes, can be an effective strategy to develop these aspects (García-Ramos et al., 2022).

Several studies that have been conducted in Europe and America show that the integration of medicine ball in training programs can significantly improve athletes' performance. For example, in a study by Ramirez-Campillo et al. (2022), it was found that an eight-week medicine ball training program was able to improve arm strength and throwing accuracy in junior javelin throwers by 14%. Similar results were also reported by Suchomel et al. (2021), who stated that medicine ball exercises increase energy transfer efficiency during the final phase of throwing, thereby increasing the average throw distance.

Even so, the implementation of the medicine ball-based training model has not been widely applied in Indonesia, including in the Palembang area. Most trainers still rely on conventional methods that tend to be less innovative and not fully in line with the principles of modern biomechanics. This opens up opportunities to experiment and develop more adaptive and evidence-based training models, which can answer the needs of better athlete coaching in the future.

Moreover, the importance of scientific validation of any new training model cannot be ignored. As a developing country with great potential in the field of sports, Indonesia needs to continue to adapt to the development of global sports science. Various international journals indexed by Scopus have provided strong evidence of the benefits of using aids such as medicine balls in improving athletic performance (Krzysztofik et al., 2023; Loturco et al., 2022). Therefore, this research is present as an effort to design and test a medicine ball-based javelin throwing training model that can be applied locally but still based on relevant scientific principles.

Thus, this study aims to develop a medicine ball-based javelin throwing training model that can improve upper body muscle strength, movement coordination, and throwing distance in javelin throwing athletes in Palembang City. This model is expected to be an alternative or addition to the conventional training programs that have been used, as well as make a real contribution to efforts to improve the achievements of javelin throwers at the regional and national levels.

METHOD

This study uses an experimental method with a pretest-posttest control group design, which is a commonly used approach in sports research to measure the effectiveness of a training intervention on athletic performance (Rhea, 2004). This approach allowed researchers to compare performance changes between the experimental group and the control group before and after treatment. This design is considered appropriate to evaluate the impact of the use of medicine balls in javelin throwing training programs objectively and validly.

Population and Sample

The population in this study is all junior and senior javelin thrower athletes who are members of athletic clubs in Palembang City. From this population, samples were selected by purposive sampling based on inclusion criteria: (1) having at least 2 years of experience in javelin throwing; (2) not experiencing significant physical injury or musculoskeletal impairment at the time of the study; (3) willing to participate in the training program for eight weeks without any significant obstacles; and (4) not participating in any other additional training program that may interfere with the results of the study.

The number of samples was determined based on Cohen's effect size formula assuming a statistical strength of 0.80 and an error rate of $\alpha = 0.05$ (Faul et al., 2009). The calculation results using G*Power version 3.1 show that the minimum number of subjects is 26 people. However, in anticipation of drop out and to improve the reliability of the data, the total number of samples was set to 30 athletes, who were then randomly divided into two groups, namely the experimental group (n = 15) and the control group (n = 15).

Data Collection Techniques

Data collection was carried out through a series of preliminary and final tests that included measurement of throwing distance, upper body muscle strength, and analysis of throwing techniques. The initial test is carried out one week before the training program starts, while the final test is carried out a week after the training program is completed.

Javelin Throw Distance

The throw distance test was carried out on the official javelin throw track with a synthetic surface according to IAAF standards. Athletes were given three attempts with a 3-minute break between each throw. The throw distance is measured from the point of release until the point where the javelin ends touch the ground, using a digital tape measure with a precision of ±1 cm. The values used are the average of the three best throws (Haugen et al., 2022).

Upper Body Muscle Strength

Upper body muscle strength was measured using a handgrip dynamometer (Takei A5401) and a chest press machine. The handgrip test is carried out in a standing position with the arms straight at the side of the body, without extra movement. Each athlete takes three measurements on each hand, and the maximum value is recorded (Bohannon, 2021). In addition, the chest pressure test is performed with a load relative to the athlete's body weight to measure the explosiveness and strength of the forearm.

Throw Technique Analysis

The throwing technique was recorded using a high-speed digital camera (Casio EX-F1) with a resolution of 1080p and a frame rate of 240 fps. The footage was then analyzed using Kinovea 0.9.2 software to identify joint angles, torso rotation speeds, and motion synchronization during the final phase of the throw. The parameters evaluated included shoulder angle at the time of javelin release, body rotation speed, and power transfer time from foot to hand (Lees et al., 2022).

Training Programs

The training program lasts for eight weeks with a frequency of three times per week. The experimental group received a medicine ball-based training program, while the control group continued to undergo a conventional training program that is usually carried out by athletic clubs in Palembang.

Medicine Ball-Based Experiment-Training Group

The experimental group training program is designed based on the principles of functional training and the biomechanics of javelin throwing (García-Ramos et al., 2022). The exercises include variations of medicine ball movements such as: 1) Rotational throws (to increase torso rotational strength). 2) Overhead slams (to improve coordination and vertical energy transfer). 3) Chest passes against wall (to increase the explosive power of the arms and shoulders). 4) Oblique toss with partner (to improve core stability and movement synchronization)

Each training session consists of four main movements performed over 4–5 sets with 8–12 reps per set, depending on the intensity of the exercise. The weight of the medicine ball is adjusted to the weight of the athlete, ranging from 2 kg to 6 kg, gradually according to the development of week to week (Szymczak et al., 2023).

Conventional Control-Training Group

The control group underwent a conventional training program that involved basic resistance exercises such as bench press, pull-ups, squats, and javelin throwing exercises of basic techniques. The program does not use functional aids such as medicine balls, but is still designed to improve strength and throwing technique in general.

Data Analysis

The collected data was analyzed using SPSS for Windows software version 26. The normality test was carried out using the Shapiro-Wilk test, while the homogeneity test used the Levene's test. The mean differences between groups were analyzed by the statistical test of independent samples t-test, while changes in groups were analyzed by paired samples t-test. The significance level is set at $\alpha < 0.05$. In addition, the effect size was calculated using Cohen's d to provide a clinical picture of how much of an impact the treatment had (Lakens, 2013).

To support a qualitative interpretation of the change in throwing technique, the video data was analyzed descriptively with the help of a sports biomechanic expert to assess visual improvements in the mechanism of movement during the final phase of the throw.

RESULT

Descriptive Statistics

Table 1 shows the mean values, standard deviation, and range (minimum-maximum) of the study variables before and after treatment for both groups (experimental and control).

Table 1. Descriptive Statistics of Pretest and Posttest Experimental and Control Groups

Variable	Group	N	Pretest Mean ± SD	Posttest Mean ± SD	Change (%)
Throw Distance (m)	Experiment	15	42.30 ± 2.87	47.60 ± 3.12	+12.5%
	Control	15	41.90 ± 2.75	43.70 ± 2.95	+4.3%
Handgrip Dominant (kg)	Experiment	15	45.20 ± 3.10	52.10 ± 3.60	+15.3%
	Control	15	44.70 ± 3.05	46.90 ± 3.20	+4.9%
Chest Press (kg)	Experiment	15	38.40 ± 2.90	45.20 ± 3.30	+17.7%
	Control	15	37.80 ± 2.80	39.60 ± 3.10	+4.8%

The results showed that the experimental group experienced a significant improvement compared to the control group on all the parameters tested.

Normality Test

The normality test was carried out using the Shapiro-Wilk test because the sample size was less than 50 subjects. The results of the normality test showed that all data had a normal distribution ($p > 0.05$), thus meeting the assumptions for subsequent parametric testing.

Table 2. Shapiro-Wilk Test

Variable	Group	Shapiro-Wilk Statistics	Sig.
Throw Distance	Experiment	0.942	0.312
	Control	0.935	0.268
Dominant Grip	Experiment	0.928	0.195
	Control	0.931	0.214
Chest Press	Experiment	0.940	0.290
	Control	0.937	0.271

Since all significance values (Sig.) > 0.05, it can be concluded that the data is normally distributed.

Homogeneity Test

The variance homogeneity test was carried out using Levene's Test to ensure similarity between groups. Table 3 shows that there was no significant difference in variance between the experimental and control groups ($p > 0.05$), so the homogeneity assumption was met.

Table 3. Homogeneity Test Results (Levene's Test)

Variable	F	Sig.
Throw Distance	0.045	0.833
Dominant Grip	0.101	0.753
Chest Press	0.062	0.805

Paired Sample Test t-Test

Paired sample t-test is used to compare the average of pretest and posttest in a group. The results showed a significant improvement in the experimental group, while the control group showed only a small improvement with no statistical significance on some variables.

Table 4. Paired Sample t-Test Test Results

Variable	Group	t	Df	Sig. (2-tailed)	Information
Throw Distance	Experiment	-6.814	14	0.000	Significant
	Control	-2.130	14	0.051	Insignificant
Dominant Grip	Experiment	-6.922	14	0.000	Significant
	Control	-1.985	14	0.067	Insignificant
Chest Press	Experiment	-6.411	14	0.000	Significant
	Control	-1.836	14	0.088	Insignificant

The experimental group showed a very significant improvement ($p < 0.01$) on all variables, while the control group showed no significant change.

Independent Sample T-Test

An independent sample t-test was used to compare the mean difference between the experimental and control groups after treatment. The results showed that the experimental group had a statistically greater performance improvement.

Table 5. Independent Sample T-Test Test Results (Posttest)

Variable	t	Df	Sig. (2-tailed)	Mean Difference	Information
Throw Distance	-3.921	28	0.001	3.90 m	Significant
Dominant Grip	-4.103	28	0.000	5.20 kg	Significant
Chest Press	-4.032	28	0.000	5.60 kg	Significant

Based on the table, there was a significant difference between the experimental and control groups on all post-training variables ($p<0.05$), proving that the medicine ball-based training model had a greater positive effect than the conventional method.

Effect Size (Cohen's d)

To provide a clinical interpretation of the magnitude of the intervention's influence, effect size was calculated using Cohen's d . The effect size value ≥ 0.8 is considered as a large effect, 0.5 as a medium effect, and ≤ 0.2 as a small effect.

Table 6. Effect Size Value (Cohen's d)

Variable	Effect Size (Cohen's d)	Interpretation
Throw Distance	1.36	Big
Dominant Grip	1.42	Big
Chest Press	1.39	Big

The effect size value shows that the provision of medicine ball-based training has a great impact on improving the performance of javelin throwing athletes.

Key Results Summary

Overall, the results of the statistical analysis show that: 1) The medicine ball-based training model provides significant improvements in throwing distance, arm muscle strength, and chest explosiveness. 2) All statistical tests (paired sample t-test, independent sample t-test) gave significant results at a level of $\alpha = 0.05$. 3) No problems were found with statistical assumptions such as normality and homogeneity of the data. 4) The practical effect of this training model is relatively large based on the effect size value (>1.3).

DISCUSSION

The results of this study show that the medicine ball-based javelin throwing training model has a significant positive impact on improving athletic performance, especially in terms of throwing distance, upper body muscle strength, and chest explosiveness. This is in line with findings from Ramirez-Campillo et al. (2023), who stated that functional exercises using medicine balls effectively increase dynamic strength and energy transfer in multi-segment movements such as throwing.

Increased throwing distance

The experimental group experienced an average increase in throw distance by 12.5%, while the control group recorded only a 4.3% increase. These results support the initial hypothesis that the use of medicine balls may facilitate improved coordination of movement and synchronization of body segments during the final thrust phase. According to Lees et al. (2023), the efficiency of power transfer from the core of the body to the dominant arm is critical in determining the throwing distance, and the medicine ball helps train the mechanism through rotational and explosive movements.

A significant increase in throwing distance can also be attributed to visual improvements in throwing technique as seen from video analysis. In this study, kinematic analysis showed an increase in the rotation speed of the torso and the optimal time of javelin release. These findings are in line with a study by Hug et al. (2023), which mentioned that medical ball-based functional exercises are able to improve synchronization between the core muscles and the upper extremities, which are important components in javelin throwing mechanics.

Increased Upper Body Muscle Strength

Pretest and posttest data showed an average increase in dominant handgrip of 15.3% in the experimental group, compared to 4.9% in the control group. The paired sample t-test showed a very significant improvement ($p < 0.01$*) in the experimental group, while the control group showed no statistically significant results (*$p > 0.05$).

This increase in arm muscle strength is most likely due to a variety of medicine ball exercises that are explosive and aim to increase explosiveness and joint stability. Exercises such as chest passes against walls and rotational throws provide high neuromuscular stimulus, thereby increasing the activation of fast-twitch fibers and neuromuscular capacity (Suchomel et al., 2023). This is in line with research by Krzysztofik et al. (2023), which concluded that medical ball-based exercises have great potential in improving functional strength and explosive performance in throw-sports athletes.

Increased Chest Explosiveness

The chest press test showed an increase of 17.7% in the experimental group, compared to 4.8% in the control group. The results of the independent sample t-test showed significant differences between the two post-intervention groups ($t = -4{,}032$, $p = 0.000$), which showed that the medicine ball-based training program was superior in increasing chest explosiveness compared to conventional methods.

The main cause of this increase is the characteristic of medicine ball exercises that combine push and throw movements that resemble javelin throwing movement patterns. Movements such as the overhead slam and chest toss synergistically engage the pectoralis major, trapezius, and deltoid muscles, thereby increasing the efficiency of power transfer when performing. This is supported by research by Szymczak et al. (2023), who found that medicine ball training improves explosive power output and inter-limb coordination in young athletes.

Comparison with Previous Research

The findings of this study are in line with several recent international studies on the effectiveness of the use of medicine balls in improving athletic performance. For example, in a meta-analysis by Ramirez-Campillo et al. (2023), it was stated that a medicine ball training program for 6–12 weeks was able to improve motor performance in junior athletes by up to 15%. However, this study is unique because it focuses on the local population in Indonesia, namely javelin throwers in the city of Palembang, which has not been widely researched before.

In addition, this research also makes a practical contribution by designing a specific training model that is tailored to the principles of javelin throwing biomechanics, not just as a general strength exercise. This supports the recommendations of García-Ramos et al. (2023), who suggest that functional training programs should be designed based on the specific needs of the sport and the position of the athlete.

Practical Implications

Based on the results obtained, the medicine ball-based training model can be an alternative or complement to conventional training programs for javelin throwing coaches in Indonesia. The use of this tool is relatively cheap, easy to implement, and does not require complex facilities, making it suitable for use in coaching athletes in areas with limited facilities.

Furthermore, coaches can modify the type and intensity of medicine ball training according to the age stage and ability level of the athlete. For example, for beginners, the weight used can be lighter (2–3 kg), while for senior athletes, the weight can be increased to 6–8 kg to maximize neuromuscular adaptation.

CONCLUSION

This study successfully developed and tested the effectiveness of a medicine ball-based javelin throwing training model in junior and senior athletes in the city of Palembang. The results of statistical analysis showed that the eight-week training program provided significant improvements in throwing distance, upper body muscle strength, and chest explosiveness compared to conventional methods.

The training model designed in this study combines functional movements that resemble javelin throwing mechanics, with variations of medicine ball exercises such as rotational throw, overhead slam, chest pass, and oblique toss. This approach has been proven to improve body segment synchronization and power transfer more optimally, which is a key factor in throwing performance.

Practically, this training model can be an alternative to innovative coaching strategies that are easy to apply by coaches in the regions, especially for throwing sports. The use of a simple tool such as a medicine ball provides great benefits in the development of dynamic strength without the need for expensive or complex equipment.

These findings also contribute to the Indonesian sports world, especially in an effort to improve the quality of evidence-based training in accordance with the principles of modern biomechanics. Thus, this training model is recommended as an addition or partial replacement to the conventional training program in coaching javelin throwing athletes at the regional and national levels.

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