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Jump Power Meter-Based Leg Muscle Power Analysis in Sepak Takraw Athletes

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Abstract: Sepak takraw involves explosive jumping movements, so leg muscle power plays a very important role. Analyzing leg muscle performance with the jump power meter (JPM) application will make it easier to analyze data, but analysis with JPM has not yet been carried out. This study aimed to analyze the leg muscle power profile of sepak takraw athletes using the Jump Power Meter (JPM) test instrument, as well as to determine the correlation mechanism between body weight, jump height, gender, and power performance variables. This study is a quantitative descriptive cross-sectional study involving 88 sepak takraw athletes (46 males and 42 females). Purposive sampling was used to select participants. The research instrument was a Jump Power Meter (JPM), which can measure jump height, body weight, power (in watts), and power (in kg.m/s). SPSS version 23 was used to aid with data analysis procedures such as category mapping, the Mann-Whitney difference test, and the Spearman-Rho correlation test. The data suggest that the majority of male athletes (39.13) and female athletes (35.71) fall into the fair and poor category. The female group had a lower average power (watts) than the male group, which was 12.74 watts. Jump height and power (watt) have a positive correlation (r=0.821) with a significance level of 0.000 < 0.05. Body weight and power (watts) have a positive correlation (r=0.735), with a significance level of 0.000 < 0.05. There is a strong correlation between power (in watts) and power (in kg.m/sec) (r=0.984) with sig 0.000<0.05. These findings have practical implications for coaches to implement digital-based physical monitoring and improve the foundation of strength training, as well as specifically monitored power training.

Keywords: Jump power meter (JPM), explosive power, sepak takraw, physical performance analysis

1. Introduction

Sepak takraw is a sport that involves a lot of jumping [1]. Technically, the player positions consist of tekong (serving), feeder (feeding), and killer (smashing) [2]. Despite their varied roles, all three positions have one thing in common: adequate leg muscle function. Rapid muscular contractions are required for smashing, somersaulting, and attempting to block while jumping [2,3]. Thus, high-intensity techniques cannot be maximized without good leg muscular power.

Power is defined as the endeavor to exert force as swiftly and strongly as feasible in a short period of time [4]. In line with the prior research, power is the product of speed and strength [5]. Although leg muscle power is recognized as a crucial component of sepak takraw, a fundamental gap exists.

Leg muscle power measures in sepak takraw clubs continue to be conducted using conventional instruments, specifically the Sargent jump or vertical jump [6]. Rationally, this instrument lacks accuracy in test findings. Manual measures rely mainly on the athlete's reach and are quite subjective when determining the highest point of

contact. Conventional methods provide jump height data in centimeters, eliminating kinetic measurements [7]. Reaching upwards necessitates arm flexibility; when an athlete lacks sufficient flexibility, this constitutes a flaw in vertical jump measurement [7]. Therefore, there is an urgent need to adopt digital-based tests to reduce subjectivity and human error while also providing scientific data for evaluating training programs.

There are limitations in analyzing leg muscle power in watts in sepak takraw. Many studies continue to presume that jump height is a measure of power measured in centimeters [6], which leads to a misconception in data analysis and knowledge. Thus, continued research will result in collective error. For example, Broto and Maulana's study emphasized power, but the results were measured in centimeters, implying that the findings were vertical jumps [8,9]. Furthermore, leg muscle measuring studies have largely equated athletes' physical characteristics, without any evaluation between genders. This necessitates additional data analysis to determine the differences and similarities in leg muscle power. Assumptions about power differences are based primarily on visual observations of smash strength, rather than the quantification of actual muscular work.

Understanding the power differentials between men and women is critical as a parameter for building training programs. Without good empirical data, coaches frequently use the same programs. In this approach, sports science can use technology to get exact outcomes. Precision analysis is required for the best performance. The Jump Power Meter (JPM) is a novel method for evaluating leg muscle power [7,10]. The JPM is a digitalized tool that measures leg muscle power. Haryono et al. created it as a means of advancing precision technologies [7]. Although the JPM has been extensively evaluated, it has only been applied to volleyball players. The JPM is ideal for assessing leg muscle power in sports involving upward hops, such as volleyball, basketball, and sepak takraw. However, the JPM test has never been employed in sepak takraw, making this a pressing research question.

The JPM moves the evaluation focus from "how high" to "how strong." JPM will output statistics such as height, weight, jump height, power conversion to watts, and power conversion to kilograms. JPM allows athletes to digitally map their profiles. The generated data is objective and reproducible, allowing real-time feedback.

Analyzing leg muscle strength with the Jump Power Meter (JPM) to identify power gaps and how these differences affect jumps is critical for effective gender-based physical test standardization. The goal of this study was to conduct a thorough analysis of leg muscle strength in sepak takraw athletes utilizing the Jump Power Meter (JPM) test approach. The research questions were the following:

1. What is the leg muscle power profile (watts) in male athletes?
2. What is the leg muscle power profile (watts) in female athletes?
3. How do leg muscles (watts) compare in male and female athletes?
4. How is jump height related to leg muscle power (watts)?
5. How is body weight related to leg muscle power (watts)?
6. How is power (kg.m/s) related to leg muscle power (watts)?

2. Materials and Methods

Study participant

The research method employed was descriptive quantitative with a cross-sectional type. This study involved 88 male and female sepak takraw athletes aged 18 to 20 years, with 46 males and 42 females. The sampling technique used was a complete sampling. The Jump Power Meter (JPM) was used to measure leg muscle power [7,10,11].

Study organization

All athletes were given instructions to practice stretching exercises to loosen their muscles for 6-8 minutes. The study team then gave them instructions on how to do the test. The test procedure for the JPM (Jumping Machine) consisted of the following:

a. *Stage 1: Participants were asked to climb onto the JPM (plate). Once they were facing the plate, the system automatically measured their weight.*
b. *Stage 2: After the weight was recorded, the system provided instructions to the participant with an audible signal.*
c. *Stage 3: Participants immediately jumped upward.*
d. *Stage 4: Upon takeoff, the system reads the data, displaying power in watts, power in kg.m/s, jump height, and jump time. These values are presented in the table 1 and figure 1 below as guidelines and illustrations:*

Table 1. Categorization norms for sepak takraw leg muscle power

Group	Power Range (Watts)	Categorization
Female	>14.05	Very good
	13.33 – 14.05	Good
	12.59 – 13.32	Fair
	11.86 – 12.58	Poor
	≤9.42	Very poor
Male	>14.05	Very good
	13.33 – 14.05	Good
	12.59 – 13.32	Fair
	11.86 – 12.58	Poor
	≤ 11.85	Very poor

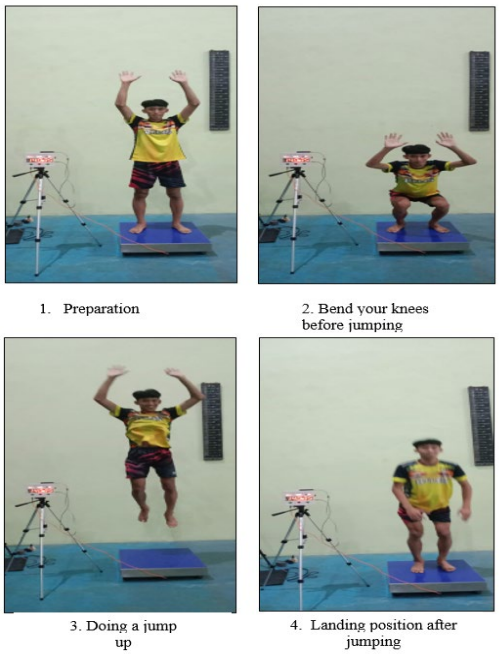

Figure 1. The Procedures for using JPM

Data Analysis

The data was analyzed using descriptive percentage analysis, the Man-Whitney comparison test, and the Spearman rho correlation, all with a significance level of $p<0.05$. SPSS version 23 was used to aid with the data analysis technique [4,12].

3. Results

Table 2. Results of descriptive analysis of men and women

The Male's Group	N	min	max	mean	Standard deviation
Jump height (cm)	46	45	68	55.17	4.739
Weight (kg)	46	48.34	82.77	63.32	7.91
Power (watts)	46	11.25	14.51	12.74	.751
Power (kg.m/s)	46	114.71	148.00	130.00	7.594
Female's group	N	min	max	mean	Standard deviation
Jump height (cm)	42	30	57	41.83	6.000
Weight	42	48.34	82.77	63.32	7.91
Power (watts)	42	9.00	11.77	10.21	.671
Power (kg.m/s)	42	91.75	120.00	104.01	7.081

Table 2 shows that the male group has a better physical profile of the legs (watts) than the female group; the male group's jump height is 55.17 cm with a power of 12.74 watts, while the female group's jump height is 41.83 cm with a power of 10.21. This indicates a difference in physical capacity based on gender analysis.

Table 3. Power frequency results (watts) based on categorization

Category	Male (N46)	Percentage (%)	Female (N42)	Percentage (%)
Very good	2	4,35%	2	4.76%
Good	13	28,26%	8	19.05%
Fair	18	39,13%	15	35.71%
Poor	12	26,09%	14	33.33%
Very poor	1	2,17%	3	7.14
Total	46	100%	42	100%

According to Table 3, the distribution of leg muscle power (watts) is better in the "fair" category, with 39.13% for males and 35.71% for females. Although a small number of athletes fall into the good and very good categories, there are still shortcomings because there are still around 26%-33% of athletes in the "poor" category."

Table 4. Results of the Mann-Whitney comparison of males and females

Group	**N**	**Mean rank**	**Sum of ranks**	**Sig**
Male	46	65.33	3005.00	0.000
Female	42	21.69	911.00	

The Mann-Whitney test results presented in Table 4 indicate a significant difference of 0.000 <0.05 in power (watts) between male and female groups. The results indicate that the male group performs better than the female group.

Table 5. Spearman's Rho correlation results for jump height and power (watts)

Group	N	Correlation	Sig.(2-tailed)
Jump height males and famales	88	.821	.000
Power (watts) of males and females	88	.821	.000

Table 5 shows a strong correlation (r=0.821) with a significance level of 0.000<0.05, demonstrating a significant correlation between leap height and power (watts). As a result, the higher the jump, the greater the power detected by the device.

Table 6. Correlation results between body weight and power (watts)

Group	N	Correlation	Sig.(2-tailed)
Weight of boys and girls	88	.735	.000
Power (watts) of boys and girls	88	.735	.000

Table 6 demonstrates a significant correlation between body weight and power (r=0.735). As a result, body mass adds to the calculation of kinetic energy created during an upward jump.

Table 7. Correlation results of power (kg.m/s) and power (watts)

Group	N	Correlation	Sig.(2-tailed)
Power (kg.m/sec) of men and women	88	.984	.000
Power (watt) men and women	88	.984	.000

Table 7 demonstrates a significant correlation (r=0.984) between power (watts) and power (kg.m/s). This clearly shows that increased power (watts) leads to an increase in power (kg.m/s). This also suggests that the JPM device is highly accurate in converting measurement results.

4. Discussion

The purpose of this study was to analyze leg muscle power using the Jump Power Meter (JMP) test parameters. The results showed that the majority of male (39.13%) and female (35.71%) takraw athletes were in the "fair" category, with a relatively high percentage of "poor" athletes. Physical aspects, particularly leg muscle power, are critical parameters for executing motions in matches [13,14]. According to prior research, leg muscular strength in sepak takraw is an important physical factor because every movement, including jumping, requires leg muscle power [15]. Low power (watt) attainment implies that the ability to recruit motor units has not yet reached an optimal level for producing maximum explosive power in a short period of time. This could potentially be related to the Stretch Shortening Cycle (SSC), which necessitates a rapid transition from eccentric to concentric phase [16]. Athletes with "fair" and "poor" results may have a long contraction period, preventing them from optimizing their upward jump, but this is influenced more than just partially. Other impacting factors include a suboptimal strength foundation, which has an impact on power optimization, and a lack of integration of power training methods, such as combining weight training and plyometrics.

Several studies have found that weight training combined with plyometrics has a considerable impact on power [17,18]. Previous research has demonstrated that complex training can improve basketball strength and power [19]. Similarly, soccer requires power when jumping and running; training with weights and a combination of plyometrics improves leg muscle power [20]. More recently, weight training and plyometrics have been shown to improve leg muscular power in takraw [21]. This is used to evaluate training systems aimed at developing muscle power.

The findings revealed a significant difference in power (watts) between the male and female groups, with males outperforming females. This distinction may be impacted, among other things, by physiological variables such as higher testosterone levels in men, which promote muscle hypertrophy (rapid twist), a key component of explosive motions. Furthermore, women's pelvises are structurally wider, which could have an impact on vertical jump efficiency. Female athletes' improvement plans should include not only weight training but also the optimization of biomechanical jumping skills.

The findings indicate a significant correlation between body weight and power (watts). Similar to Newton's Second Law [22], the force required to accelerate an object is proportional to its mass. Athletes with a larger body mass will create more

power against gravity. However, it should be noted that body weight does not always contribute positively because it contains fat, water, muscle, and bone. It can also be related to the athlete's training duration and intensity, both of which affect power. As a result, further study, including body composition measurement, cannot be used to establish a definitive correlation between body weight and power (kg · m · s).

The results reveal a correlation between power (watts) and power (kg · m · s), indicating that when power (watts) increases, so does power (kg · m · s). This suggests that the JPM has good consistency. However, the use of watts is more common under the International System of Units (SI), which allows for data comparisons between sports around the world. Furthermore, JPM can record the kinetic parameters underlying the jump, resulting in more accurate data for assessing the athlete's preparedness in detecting leg muscle power, which has previously been done manually using a vertical jump measuring instrument that only displays in centimeters.

5. Limitations

Although this research can detect the leg muscle power capabilities digitally, there are still constraints to the research, including (1) The limitations of kinematic analysis have not examined the knee joint angle during the run-up, and body posture coordination throughout the flight has not been visually detected, (2) The parameters for measuring body weight are limited to total body mass, and have not studied muscle mass and fat percentage, making it difficult to identify whether there is a true positive correlation to pure power generated by functional strength, (3) The research sample is limited to takraw athletes in the Central Java region, therefore these findings cannot be generalized widely, and further research is required.

6. Conclusions

Based on the results and discussion, it was concluded that the implementation of the jump power meter (JPM) provided objective measurement results in evaluating the leg muscle power of sepak takraw athletes. The main result was that the majority of leg muscle power was in the “sufficient” and “insufficient” categories. Comparative analysis showed that there was a significant difference in leg muscle power, with the male group performing better than the female group. There is a positive correlation between body weight and power (watts), and there is a positive correlation between power (watts) and power (kg.m/sec). This study provides practical contributions for coaches to switch to technology-based measurement tests with more objective results. This highlights the importance of digitalization-based training analysis, as well as strength and plyometric training approaches to optimize power.

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Conflicts of Interest:

All authors declare no conflict of interest.

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