

Explosive Power Analysis of Leg Muscles of Volleyball Players

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ABSTRACT

Background: Volleyball in Madiun City is increasingly competitive, so it is necessary to improve physical condition. The UNIPMA Volleyball Team won 2nd place in the PPMI Volleyball Cup in the framework of the 10th PPI Anniversary. Of course, this must be maintained and must always be improved. Therefore, an explosive analysis of the leg muscle power of male and female volleyball players at PGRI Madiun University in 2026 must be carried out as a basis for determining the training program.

Method: This study uses a survey method using test and measurement techniques. This type of research is descriptive quantitative. The population is 30 athletes, a sample of 30 athletes as well, consisting of 15 male athletes and 15 female athletes. Using a total sampling technique. The test instrument uses a vertical jump test.

Results: The results of male athletes with an average power of 439.2 joules / second (439 watts). The results of the female athletes' with an average power of 274.413 joules/second (274 watts).

Conclusion: The power of male athletes with a percentage of 20% for the classification of "Very Good" and 80% for the classification of "Good". While the power of female athletes with a percentage of 40% for the classification of "Good" and 60% for the classification of "Medium".

Keywords: Analysis, power, leg muscles, volleyball.

1. Background

The world of volleyball has developed greatly today, both among adults and young people. Sport itself is any activity that involves the mind, body, and soul in an integrated and systematic manner to encourage, foster, and develop physical, spiritual, social, and cultural potential (Kemenpora, 2022). Various types of sports are commonly competed in by the community, such as basketball, soccer, volleyball, futsal, and so on. Volleyball is very popular in East Java, especially in the city of Madiun. Therefore, many volleyball competitions are held in Madiun City. Some basic volleyball techniques include serving, passing, smashing, and blocking (Mulyadi & Pratiwi, 2020). Volleyball is increasingly competitive, so improving physical condition is necessary. Sports development in all remote areas of the country must be prioritized (Soliven & D, 2025). Explosive power is a biomotor component that significantly influences an athlete's performance (Ferreira et al., 2019). In general physical condition, male athletes are superior to female athletes (Tsakiri et al., 2025).

The components of physical condition consist of strength, endurance, speed, flexibility, agility, coordination, balancing, power, accuracy, reaction (Candra et al., 2024). Of the ten components of physical

condition, the most important physical component for volleyball players is explosive leg muscle power. Power is the ability of a muscle or group of muscles to exert maximum force in the shortest possible time (Candra et al., 2024). To support maximum results, several training principles must be considered, such as the overload principle, multilateral development, specialization principle, individualization principle, training intensity principle, training quality principle, variation principle, reversibility principle, specification principle, and recovery principle (Setyawan, 2022). In addition, training must also be programmed by considering several aspects and provisions (Zelenovic & Singh, 2023).

Four weeks of plyometric training significantly increased explosive power (Kryeziu et al., 2019). However, plyometric training also depends on the athlete's level, gender, sporting activity, duration, and type of plyometric training (Aksovic et al., 2021). Furthermore, explosive power can be enhanced through well-planned, rational, and organized training (Aksović, Kocić, et al., 2020). To determine the extent of leg muscle power produced, the test instrument must be valid and reliable. One study proposed a unique test that measures explosive power in the right and left leg muscles separately (Shalom et al., 2023). Many researchers have suggested that optimizing the physical components of power can be improved using plyometric training (Gherghel et al., 2021).

A 12-week plyometric training program can also significantly increase explosive leg muscle power (Begu et al., 2017). Age also significantly influences a player's explosive leg muscle power (Aksovic & Beric, 2016). From several literature sources mentioned above, it is necessary to seriously improve the capacity and abilities of physical components. Strong leg muscle power will result in high jumps in volleyball players, in this case especially volleyball players in the PGRI Madiun University environment. This is done to achieve brilliant achievements for volleyball athletes at PGRI Madiun University. On the PGRI Madiun University website, the UNIPMA Volleyball Team won 2nd place in the PPMI Volleyball Cup in the framework of the 10th PPI Anniversary (Sasmito, 2024). Of course, this must be maintained and must always be improved. Therefore, an analysis of the explosive leg muscle power of male and female volleyball players at PGRI Madiun University in 2026 must be conducted.

The research gap in this study is that no research has been conducted in volleyball on explosive power by converting the vertical jump, measured in centimeters, to joules/watts, the units of power. This is because all research on leg muscle power focuses solely on jump height, not specifically on leg muscle power measurements using the correct units. For example, research written by (Qesha Arief et al., 2024).

2. Methods

The method used in this research is a survey using testing and measurement techniques. This study uses a descriptive research type with a quantitative approach. Descriptive research is a research design that aims to describe or explain systematically, factually, and objectively accurately about an observed object and what is happening in the present (Budiwanto, 2017). In quantitative research, the analysis process leads to the statistical presentation of data, generally represented in a set of tables or charts along with a discussion (Gazali et al., 2022). Data will be presented in the form of numbers, tables, graphs or charts, and similar forms. The population in this study is all male and female volleyball athletes or players at Universitas PGRI Madiun in 2026, with a breakdown of 15 male athletes and 15 female athletes. This study used total sampling as the sampling technique because it uses the entire population as its sample. The total sample size was 30 people. The research location was at the Cendekia Sports Hall of PGRI Madiun University, Street Margatama, Madiun City.

The test instrument used to measure this power component is a vertical jump test measured in centimeters, which will then be converted to joules/watts, as stipulated in Article 66 of the Minister of Youth and Sports Regulation (Permenpora, 2026). The required materials and tools include a recording form, a tape measure, a vertical jump board, chalk, a broom, and a tester. The results of the vertical jump measurement will be converted to joules or watts, the units of power.

The following formula is used to convert vertical jump results measured in centimeters to joules or watts:

$$P = \frac{U}{\Delta t}$$

$$P = \frac{F (d)}{\Delta t}$$

$$P = \frac{m \cdot g \cdot d}{t} = \text{Joule/second}$$

Description:

- P = Power
- m = Body Mass (Kg)
- g = Gravity (9.8(m)/s²)
- d = Distance Traveled (meters)
- t = Time Required to Travel the Distance (seconds) (Setyawan, 2017).

The Standard Operating Procedure (SOP) for conducting a vertical jump test is as follows:

- a. Hang or attach the vertical jump board to the wall.
- b. Then, the athlete stands sideways to the wall (not facing it), with the right and left feet together close to the wall.
- c. Then, the fingers of the right or left hand (either one may be used) are coated with powdered chalk.
- d. Then, the hand is extended upward as high as possible and touched to the vertical jump board.
- e. The highest point of contact (when standing) is the first achieved height, or Mark 1, and the height is recorded in centimeters.
- f. Then, the athlete jumps as high as possible with both feet. While jumping, the athlete must touch the chalk-covered fingers to the vertical jump board, achieving the second achieved height, or Mark 2, and the height is recorded in centimeters.
- g. The difference between Mark 2 and Mark 1 is then referred to as the final jump result.
- h. This data collection was carried out 3 times and the best results were taken (Wiriawan, 2017).

The vertical jump norms will be displayed in the following table:

Table 1. Vertical Jump Norms (In Centimeters)

Gender	Very Good	Good	Medium	Poor	Very Poor
Male	> 65	50 – 65	40 – 49	30 – 39	< 30
Female	> 58	47 – 58	36 – 46	26 – 35	< 26

(Mackenzie, 2015)

3. Results

Explosive Power Measurement Data for Male Volleyball Athletes

Below, we present measurement data on the explosive power components of leg muscles in male volleyball athletes from PGRI Madiun University, along with jump heights and classifications. The data is as follows:

Table 2. Jump Height and Explosive Power Data of Male Volleyball Athletes' Leg Muscles

No	Name	Body Mass (Kg)	Jump Height (Cm)	Power (Joule)	Classification
1	AA	65	53	383,6	GOOD
2	TR	71	57	455,8	GOOD
3	UY	73	69	567,3	VERY GOOD

4	RW	70	58	414,4	GOOD
5	WQ	63	55	390,3	GOOD
6	DF	73	67	504,5	VERY GOOD
7	JK	74	59	436,6	GOOD
8	LK	77	51	432,4	GOOD
9	HG	69	57	393,3	GOOD
10	DF	72	54	384,8	GOOD
11	VB	70	55	428,7	GOOD
12	SDA	73	58	419,1	GOOD
13	AAR	72	68	489,6	VERY GOOD
14	TI	75	58	435	GOOD
15	NNM	76	59	453	GOOD

Based on the data outlined in the table above, out of a sample of 15 athletes, three had a vertical jump classification of "Very Good." Meanwhile, the other 12 athletes had a vertical jump classification of "Good." For clarity, the data will be presented as percentages in the following chart:

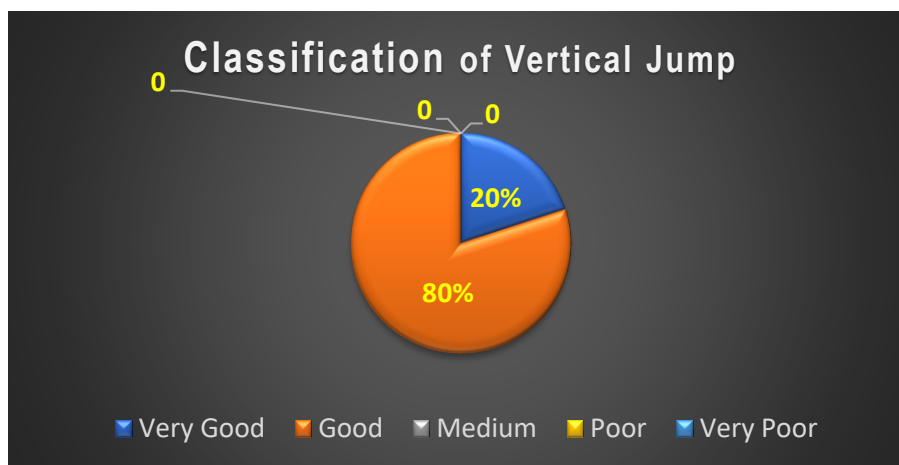


Fig 1. Percentage of Leg Muscle Power Classification of Male Volleyball Athletes.

The pie chart above shows that 20% of the men's volleyball athletes at PGRI Madiun University were in "Very Good" condition, while 80% were in "Good" condition. The data above will be further described using the statistical analysis below.

Descriptive Vertical Jump Data for Men's Volleyball Athletes

The following table displays descriptive statistics for vertical jump data in centimeters for men's volleyball athletes from Universitas PGRI Madiun.

Table 3. Descriptive Data on Vertical Jump of Male Volleyball Athletes in Centimeters

	N	<i>Descriptive Statistics</i>				
		<i>Minimum</i>	<i>Maximum</i>	<i>Mean</i>	<i>Std. Deviation</i>	<i>Variance</i>
VJ_Male_Cm	15	51	69	58.53	5.410	29.267
<i>Valid N (listwise)</i>	15					

Based on the table data above, we can see that the minimum value of the athlete's vertical jump is 51 cm and the maximum value of the athlete's vertical jump is 69 cm, with an average jump of 58.53 cm. Meanwhile,

the standard deviation is 5.410 and the variance is 29.267. From this data, it will then be processed and converted into a power quantity with units of joules/watts which will be presented in the table below:

Table 4. Descriptive Conversion Data in Joules

<i>Descriptive Statistics</i>						
	N	Minimum	Maximum	Mean	Std. Deviation	Variance
Power_Male_Joule	15	383.6	567.3	439.227	50.3052	2530.609
<i>Valid N (listwise)</i>	15					

Based on the conversion table data above, the minimum power value for athletes is 383.6 joules and the maximum power value for athletes is 567.3 joules, with an average power of 439,227 joules. Meanwhile, the standard deviation is 50.3052 and the variance is 2530.609. For ease of reading, the data will be presented in graphical form as follows:

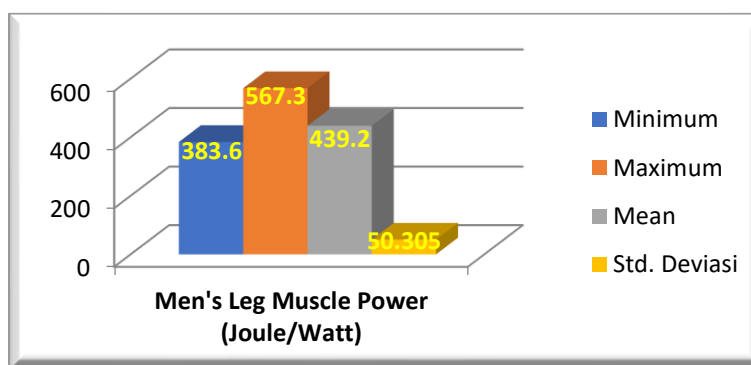


Fig 2. Male Volleyball Athletes' Leg Muscle Power Graph (Joules/Watt)

Explosive Power Measurement Data for Female Volleyball Athletes

Below, we present measurement data for the explosive power component of leg muscles in female volleyball athletes from PGRI Madiun University. We also present jump heights, complete with classifications. The data is as follows:

Table 5. Jump Height and Explosive Power Data of Leg Muscles of Female Volleyball Athletes

No	Name	Body Mass (Kg)	Jump Height (Cm)	Power (Joule)	Classification
1	FA	55	40	245	MEDIUM
2	IPW	57	42	269,6	MEDIUM
3	WU	56	47	303,4	GOOD
4	RY	58	46	272,3	MEDIUM
5	QS	53	42	224,8	MEDIUM
6	AST	57	40	235,2	MEDIUM
7	HGY	60	41	246	MEDIUM
8	GP	61	48	322,4	GOOD
9	JI	61	45	274,5	MEDIUM
10	BA	59	42	245,2	MEDIUM
11	MK	60	47	314,0	GOOD
12	OV	62	50	306,8	GOOD

13	FK	58	49	284,2	GOOD
14	DCT	63	43	270,9	MEDIUM
15	HI	61	49	301,9	GOOD

Based on the data outlined in the table above, out of a sample of 15 athletes, 6 had a vertical jump classification of "Good." Meanwhile, 9 other athletes had a vertical jump classification of "Moderate." For clarity, the data will be presented as percentages in the following chart:

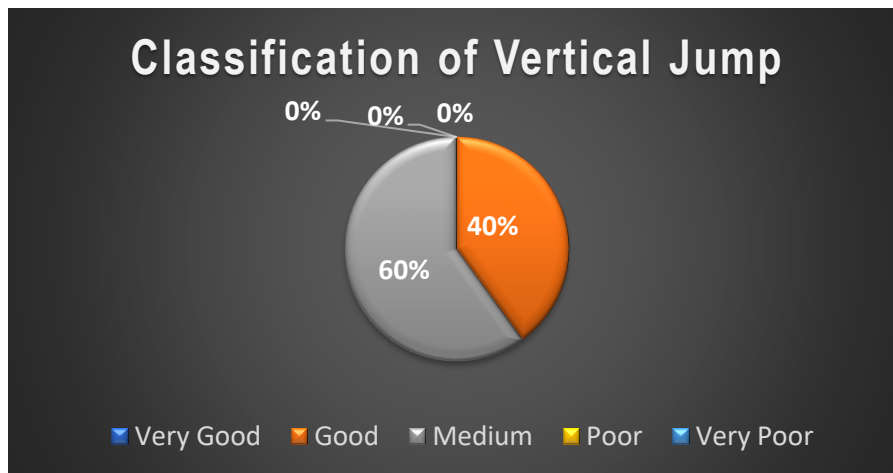


Fig 3. Percentage of Leg Muscle Power Classification of Female Volleyball Athletes.

The pie chart above shows that 40% of female volleyball athletes at PGRI Madiun University have "Good" leg muscle power, while 60% are in "Fair" condition. The data above will be further described using the statistical analysis below.

Descriptive Vertical Jump Data for Female Volleyball Athletes

The following table displays descriptive statistics for vertical jump data in centimeters for female volleyball athletes at PGRI Madiun University.

Table 6. Descriptive Vertical Jump Data for Female Volleyball Athletes in Centimeters

<i>Descriptive Statistics</i>						
	<i>N</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Mean</i>	<i>Std. Deviation</i>	<i>Variance</i>
VJ_Female_Cm	15	40	50	44.73	3.494	12.210
<i>Valid N (listwise)</i>	15					

Based on the table data above, we can see that the minimum value of the athlete's vertical jump is 40 cm and the maximum value of the athlete's vertical jump is 50 cm, with an average jump of 44.73 cm. Meanwhile, the standard deviation is 3.494 and the variance is 12.210. From this data, it will then be processed and converted into a power quantity with units of joules/watts which will be presented in the table below:

Table 7. Descriptive Conversion Data in Joules

<i>Descriptive Statistics</i>						
	<i>N</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Mean</i>	<i>Std. Deviation</i>	<i>Variance</i>
Power_Female_Joule	15	224.8	322.4	274.413	30.6772	941.091
<i>Valid N (listwise)</i>	15					

Based on the conversion table data above, the minimum power value for athletes is 224.8 joules and the maximum power value for athletes is 322.4 joules, with an average power of 274.413 joules. Meanwhile, the standard deviation is 30.6772 and the variance is 941.091. For ease of reading, the data will be presented in graphical form as follows:

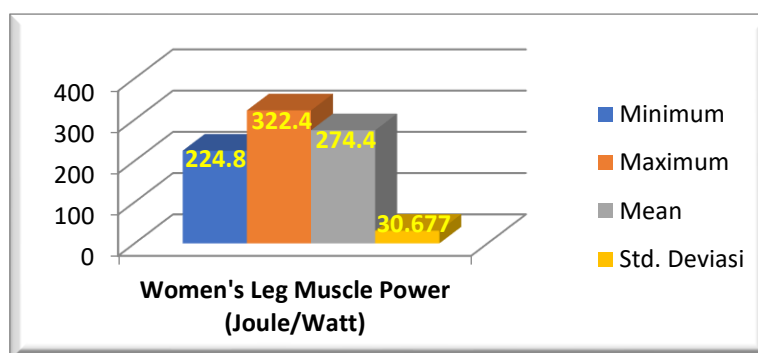


Fig 4. Graph of Leg Muscle Power of Female Volleyball Athletes (Joules)

4. Discussion

Based on the data analysis above, 20% of athletes had a "Very Good" physical power condition, and 80% of male athletes had a "Good" physical power condition. Meanwhile, 40% of female athletes had a "Good" physical power condition, and 60% of female athletes had a "Good" physical power condition. This indicates that the explosive power physical condition of the Universitas PGRI Madiun volleyball athletes is classified as quite good. This is certainly due to the training carried out by the athletes, whose training programs have been systematically and measurably planned by the Universitas PGRI Madiun volleyball coaches. As discussed, explosive leg muscle power can be improved using CT (Complex Training) and PLT (Plyometric Training) methods (Wang et al., 2023). In a study written by (Mocanu et al., 2023) it was stated that the analysis of the significance of the differences between non-athletes (NA), team sports game (TSG), individual sports (IS) had an average vertical jump score according to the sports activity category in the lower body strength test for men as follows:

Table 8. Analysis Of The Significance of Differences Between Average Scores by Categories of Sports Activities in Strength Test the Lower Body/Men (NA=48, TSG=52, IS=47)

Test Group	Mean	Std. deviation	Std. error	a-b	Sig. ^b	a-c	Sig. ^b	b-c	Sig. ^b
Vertical Jump Test/VJT									
a. NA	40.072	5.666	0.834						
b. TSG	44.976	5.748	0.801	-4.904*	0.000	-4.363*	0.001	0.541	1.000
c. IS	44.436	5.918	0.843						

The table shows 48 non-athletes with an average vertical jump score of 40.072 cm, 52 team sports participants with an average vertical jump score of 44.976 cm, and 47 individual sports participants with an average vertical jump score of 44.436 cm. Compared to the results of the men's volleyball athletes from Universitas PGRI Madiun, the vertical jump scores of the former were significantly superior, with an average jump score of 58.63 cm. However, when viewed based on the same sport classification, namely volleyball, the study by (Mocanu et al., 2023), was superior, with a score of 59.50 cm. The data is presented as follows:

Table 9. The Values of The Best 3 Individual Results for Each Strength Test at The Lower Body Level (According to The Practiced Sport)

Test	Performance 1 (sport)	Performance 2 (sport)	Performance 3 (sport)
Vertical Jump Test/VJT	59.50 (volleyball)	58 (Track and field)	57 (soccer)
Standing Long Jump Test/SLJ	274 (Track and field)	265 (volleyball)	264 (Track and field)
3-Hop Test	849 (Track and field)	822 (Track and field)	814 (volleyball)
The multiple 5 bounds test/MB5	1413 (volleyball)	1400 (Track and field)	1362 (Track and field)
30 s lateral double leg hop test	48 (fitness)	48 (soccer)	47 (soccer)
Speed Test 10 m	1.66 (Track and field)	1.68 (soccer)	1.69 (volleyball)
30 s Continuous vertical jumps	31 (sports dance)	28 (soccer)	28 (rowing)

Meanwhile, training methods used to increase explosive leg muscle power also need to be complemented by a good training program. Research from (Aksović, Berić, et al., 2020) suggests the following training program format for plyometric training:

Table 10. The Program of The First Plyometric Training During The Week

		Squat jump	Single leg jump	Counter movement jump	Ankle jumps	Tuck jumps	Lunge jump
1-3 weeks	NS	2	2	2	2	2	2
	NR	8	8	8	8	8	8
	PS	60s	60s	60s	60s	60s	60s
	PE	10s	10s	10s	10s	10s	10s
4-5 weeks	NS	2	2	2	2	2	2
	NR	10	10	10	10	10	10
	PS	60s	60s	60s	60s	60s	60s
	PE	10s	10s	10s	10s	10s	10s
6-7 weeks	NS	3	3	3	3	3	3
	NR	8	8	8	8	8	8
	PS	60s	60s	60s	60s	60s	60s
	PE	10s	10s	10s	10s	10s	10s
8-10 weeks	NS	3	3	3	3	3	3
	NR	10	10	10	10	10	10
	PS	60s	60s	60s	60s	60s	60s
	PE	10s	10s	10s	10s	10s	10s

Legend: NS-number of series; NR-number of exercises; PS-pause between series; PE-pause between exercises

All physical activities require flexible or flexible muscles, so stretching is essential before engaging in them. Unbeknownst to many, stretching with traditional resistance and compound training can increase explosive leg muscle power (Chen, 2023). Meanwhile, when compared to the jump height of 19-year-old basketball players, with an average jump height of 36.4 cm, volleyball players from PGRI Madiun University still excel. This data is presented by (Williams et al., 2021).

A common exercise performed by volleyball players is the squat jump, but the knee tuck jump can also increase explosive leg muscle power (Sudamara et al., 2026). Power training should also be accompanied by training leg muscle strength, which will support the jump when smashing a volleyball (Kurniawan et al., 2025). To determine leg muscle power levels, you can also jump upward with both hands on your waist and hold this for 15 or 30 seconds (Graur & Cristian, 2024).

In fact, a study by (Irwansyah & Ladipin, 2025) found that explosive leg muscle power can significantly influence hand-eye coordination during a player's smash. This isn't just one study; several other similar studies have found that explosive leg muscle power influences smashing skills (Ariston & Hanifa, 2025).

Plyometric training was chosen to increase explosive leg muscle power because the movements involve the Stretch Shortening Cycle (SSC), a rapid cycle of stretching and shortening in the muscle tendons (A. Samson et al., 2020). Plyometric training is also a highly effective, practical, and rapid conditioning training strategy for increasing power (Nagindrappa & Jange, 2026). This research has proven and confirmed in other studies that power gains can be achieved in a relatively short period of time, namely 6 weeks (Jastrzebski et al., 2014).

Meanwhile, research by (A. D. Samson et al., 2025), comparing plyometric training with weight training on explosive leg muscle power, yielded surprising results: the vertical jump results obtained with plyometric training were superior, with an average value of 44.27 cm, compared with weight training with an average value of 42.07 cm. The comparison table will be presented as follows:

Table 11. Study by (A. D. Samson et al., 2025)

Test	Plyometric Training Group		Weight Training	
	Mean	SD	Mean	SD
Pre-Test	38.13	1.55	39.00	0.85
Post-Test	44.27	1.83	42.07	0.96
T-Test	28.49*		16.88*	

Age and gender have also been reported to be determining factors in leg muscle power success (Zemkova & Stefanikova, 2025). Furthermore, several experts have developed theories regarding stimulus, fatigue, recovery, and adaptation, developed by (McGuigan, 2024). The following theory is presented in table form:

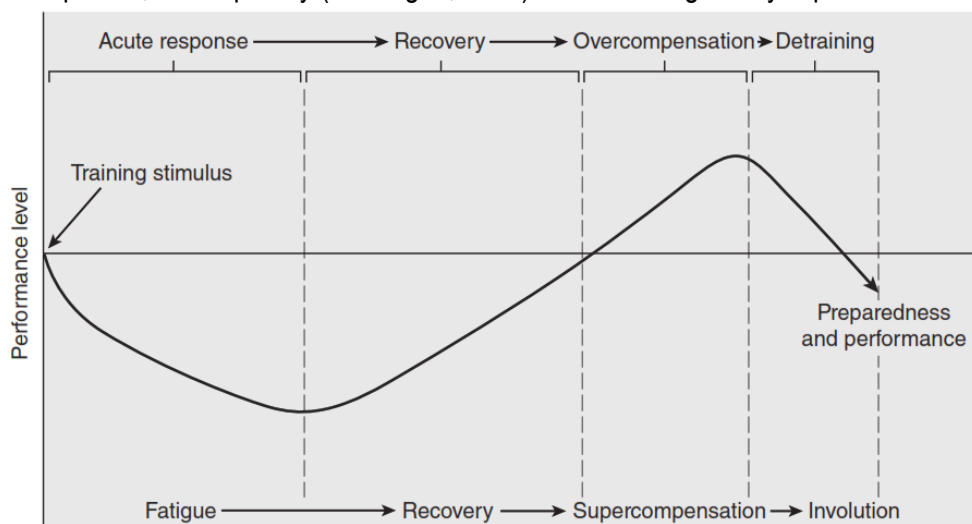


Fig 5: Stimulus, Recovery, Fatigue, and Adaptation Theory

5. Conclusions

Conclusions, 20% of athletes had a "Very Good" physical power condition, and 80% of male athletes had a "Good" physical power condition. Meanwhile, 40% of female athletes had a "Good" physical power condition, and 60% of female athletes had a "Good" physical power condition. This indicates that the explosive power physical condition of the Universitas PGRI Madiun volleyball athletes is classified as quite good.

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