

# The effect of pyramid method training on increasing the maximal strength: An experimental study in female judo athletes

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## ABSTRACT

This study is conducted to examine the preliminary effects of the Pyramid Method training on increasing the maximal strength of female judo athletes, as Judo demands an optimal combination of strength, speed, and endurance. The maximal strength is an important foundation in power ability and the execution of the technique, as in throwing (nage waza), especially in pulling, pushing, and in holding back enemies technique (osaekomi waza). In this quasi-experimental study, the purposive sampling technique is used. We involve 14 female Judo athletes from Persatuan Judo Seluruh Indonesia Kota Surabaya who have experience in training for around three years in a minimum. The experimental study receives Pyramid Training Program for a total of eight weeks, with the focus on the bench press test, power clean, squat, and deadlift. This program is designed for general preparation, according to the strength periodization steps. The experimental result of the Paired T-test and Mixed ANOVA Repeated Measures shows a significant increase and a large within-sample interaction effect between time and experimental group in every strength variable ( $p < .005$ ). Significant time  $\times$  group interaction effects with large within-sample effect sizes were observed across all strength variables in the experimental group, while no significant improvements were found in the control group ( $p < .005$ ). The conclusion from this study is that the Pyramid Training was associated with significant within-sample improvements in the maximal strength of female Judo athletes in the preparation phase by giving optimal stimulus in the neuromuscular systems and is highly relevant for adolescent female athletes who are sensitive to weight variation, which may support physical qualities underlying throwing and grappling techniques. It is suggested that the next study involve bigger samples and a longer duration to evaluate the long-term effect of specific Judo techniques performance.

**Keywords:** Performance analysis, Pyramid training, Maximal strength, Female athlete, Judo.

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## INTRODUCTION

Judo is a martial art that needs all physical components (Da Silva et al., 2021). It needs precise strength, speed, flexibility, balance, agility, and endurance (Kowalczyk et al., 2025). The one component of the main bio motor, which highly determines the ability of the early Judo players foundation, is strength (Krstulović et al., 2006). So that Judo players at least have already had the early model to become the greatest and unstoppable Judo athletes. Strength emerges as a crucial element that has to be followed up on in Judo sport gradually and planned, so that the result will go optimal and minimize the risk of injury (Fernandes Da Costa et al., 2024; Rodríguez et al., 2024), which in turn needs to follow the 7 principles of exercise (Khandelwal, 2019) under every strength exercise phase, which consist of anatomy adaptation phase, hypertrophy, maximal strength, and power (Bompa & Buzzichelli, 2022). This process starts with the anatomy adaptation phase, which functions to prepare muscles to receive heavier weight exercise. After that, the hypertrophy takes part, which enables the muscles to shape into bigger and stronger forms. Next, the maximal strength phase is used to train the nerve system to produce the most optimal force. Last, the power phase is used to change the strength into explosive powers, which is essential in Judo movement technique. However, I will discuss the importance of the maximal strength phase for Judo players. The maximal strength phase is highly important as it becomes the early foundation of power to be more effective and efficient in the throwing technique (*nage waza*), such as pulling and pushing, also for holding back enemies' techniques (*osaekomi waza*), so the enemies can't stand up and flee from the holding back position for a certain time.

Some document analysis, such as articles from the research, from Heshmati et al., (2020) discuss that the charge of Pyramid and Reserve Pyramid are effective in increasing the power and muscle mass. Moreover, the study from Cormie et al., (2011) about the importance of increasing and maintaining maximal strength for the athletes' performance success in every branch of sport. The previous study, through analysis, has identified the drawbacks of the study, such as the examined study does not receive special attention in the Strength Pyramid training. The study that examines the linear and non-linear (undulating) periodization of Judo athletes shows a 1RM increase in various exercises (including bench press and squat), but the focus is on the comparison of the periodization model, not on the comparison of the exercise design set, such as Pyramid vs. straight sets (Santos & Franchini, 2021). One study shows a significant increase in maximal strength of the four movements of squat, bench press, pull-up, and clean and jerk after 8 weeks of training. However, it does not show the Pyramid training structure set because it only focuses on the exercise design, which is adjusted with each athlete's goal performance, and does not use the same exercise method for everyone (Harris et al., 2019).

The pyramid method training will produce a different total volume of the set and repetition, compared to the straight sets, which have the same repetitions and sets. Remembering that exercise volume is the important variable in determining the strength adaptation and hypertrophy, the lack of studies that compare the Pyramid training method with other methods for Judo athletes directly, such as straight sets with equated volume, creates a research gap. The main gap is the lack of studies that tested the chronic effects (long-term effects) of Pyramid training towards the increase of the maximal strength (bench press, power clean, barbell squat, deadlift) in Judo athletes. However, due to the limited availability of homogeneous female judo athletes at the club level, the present ones are exploratory in nature, aiming to provide preliminary evidence rather than definitive causal inference. Therefore, small-scale experimental investigations remain relevant as pilot data to inform future randomized controlled trials in combat sports.

As a basis for rationalizing the problem through observation and interview, it turns out that the understanding of physical exercise cannot be stated as adequate for the Judo trainers, if they only taught based on their

experiences. How good it would be if the experiences were supported by sports science to receive an optimal result in minimizing injury risks, because, based on some case studies, which concern in high injury risk in teenagers, especially females, as they are experiencing early maturation in the growth process (Bowerman et al., 2014; Costa e Silva et al., 2017). However, according to PHV, teenagers will experience faster progress because they are more sensitive toward adaptation, which is caused by the given exercise, and also become their investment before becoming elite athletes. In this context, the existence of the gap based on evidences indicate that injury risks for teenage athletes are higher than those of the same age, especially on the elbow and shoulder, which is caused by the wrong throwing, or falling techniques, or even by a sprained knee (Frey et al., 2019), because doing such a spinning technique, changing direction fast, and getting hit repeatedly.

In the branch of Judo sport, it needs a training approach that not only focuses on weightlifting, but also on the neuromuscular stimulus quality, which is received by the muscle. One of the approaches that is commonly used in strength training is the Pyramid training, which involves the increase and decrease of weight in one training session gradually. So, the Pyramid training becomes the most relevant because according to Angleri et al., (2017), it shows that weight variation in the Pyramid training can increase the motor neuron by activating various motor units for increasing muscle contractility, because physiologically it stimulates muscle fibres IIa and IIb types by domain. The combination of high intensity and progressive variation in this method produces maximal strength, explosive power, and neuromuscular coordination. Thus, many kinds of set combinations and repetition can significantly increase the maximal strength. In every aspect, the available information on the effect of Pyramid method training on the maximal strength of female Judo athletes is quite limited. This study examine preliminary responses the strength training exercise using the Pyramid training approach in the 2-month general preparation phase, which consists of bench press, power clean, squat, and deadlift.

## **METHODS**

### ***Participants***

The research participants consisted of 14 female Judo athletes of Persatuan Judo Seluruh Indonesia Kota Surabaya, who participated in this study, as shown in the table 2. They should have a minimum of three years of training experience and have participated in various provincial and national championships. All athletes who participated must be in the early period of general preparation and not had any injuries. We received approval from every athlete to participate in this study, and they promised to train by following the instructions from the researcher and trainer. This study used a quasi-experimental design by purposive sampling technique. This design was selected due to practical constraints in elite female judo populations and is consistent with exploratory or pilot experimental studies commonly used in applied sport science to examine feasibility and direction of training effects. There are two groups in this study, which are the experimental group and the control group. The control group followed a conventional resistance training approach using fixed-load straight sets without systematic pyramidal load variation. The training program takes 8 weeks, with 3 sessions per week (Monday, Wednesday, and Friday) at 14.00 -16.00 WIB, as shown in the table 1. No a priori power analysis was conducted, as the study was designed as a feasibility-oriented exploratory investigation rather than a confirmatory trial.

### ***Training load and volume***

To minimize confounding effects related to training exposure, both experimental and control groups followed identical weekly training frequency (three sessions per week) and identical exercise selection. The primary difference between groups was the load progression structure (pyramid versus conventional loading), while rest intervals and session duration were kept constant. Although total volume load was not mathematically

equated, this approach reflects real-world judo training practices and supports ecological validity in applied settings.

Table 1. Training program.

Week	Meeting	Training item	Training dose
1-3	1-9	Warming up. Animal movement (bear crawl forward, bear crawl backward, inchworm forward, and backward) 20 meters with each movement. Bench press, power clean, squat, and deadlift (85% of each athlete's 1RM). Cooling down.	Frequency: 5 Intensity: High Set: 3 Interval: 2-5 Minutes Recovery: 3-5 Minutes
4-6	10-18	Warming up. Animal movement (bear crawl forward, bear crawl backward, inchworm forward, and backward) 20 meters with each movement. Bench press, power clean, squat, and deadlift (90% of each athlete's 1RM). Cooling down.	Frequency: 4 Intensity: High Set: 3 Interval: 2-5 Minutes Recovery: 3-5 Minutes
7-8	19-24	Warming up. Animal movement (bear crawl forward, bear crawl backward, inchworm forward, and backward) 20 meters with each movement. Bench press, power clean, squat, and deadlift (95% of each athlete's 1RM). Cooling down.	Frequency: 3 Intensity: High Set: 3 Interval: 2-5 Minutes Recovery: 3-5 Minutes

### Procedures

In this study, the instrument used to measure the height of participants is the Stature meter, and for the weight, the Tanita BC-545N is used. After that, all participants perform the Bench Press, Power Clean, Squat, and Deadlift tests. Before the intervention, every participant must fill out the written agreement letters to show their willingness to participate in this study. Here are the following procedures that were received by participants:

#### *The bench press test*

In this study, the baseline data collection groups were conducted one day before the intervention. Before testing, the researcher explained the purpose and the procedure of the correct bench press test. Then, participants warmed up by performing certain animal movements to prevent injury during the test (McGiguan, 2017).

1. Lie supine on a bench in a five-point body contact position: feet on the floor, head on the bench, buttocks on the bench, and shoulders and upper back in contact with the bench. Optimally, the feet should be as close to the centre of the body as possible to facilitate leg drive.
2. Grip the bar with the hands slightly wider than shoulder width.
3. A spotter should help untrack the bar and position it over the centre of the chest.
4. Hold the bar with the elbows fully extended above the centre of the chest.
5. Lower the weight straight down to the centre of the chest (between the nipple line and xiphoid process).
6. At the bottom of the movement, the elbows should be slightly tucked toward the body without being perpendicular to the shoulders or close to the body.
7. Without bouncing the bar off the chest, extend the elbows and press the weight straight up.
8. Maintain the five-point body contact position during the exercise.
9. The spotter should aid in racking the bar once the exercise is completed.

#### *The power clean test*

The early data collections were also conducted one day before the intervention. The researcher

explained the purpose and the correct procedure of the power clean test. Then, participants warmed up by performing certain animal movements to prevent injury during the test (McGiguan, 2017).

1. Using a slightly wider than shoulder-width pronated or hook grip, begin by taking hold of a loaded barbell in a lifting rack (or set of blocks) that is set at mid-thigh height.
2. Position the heels approximately shoulder-width apart, with the feet facing slightly outward.
3. Bend at the knees slightly and flex at the hips to lean the torso forward, allowing the barbell to move down the thighs to a starting position that is just above the knees. At this position, the shoulders should be over the barbell, the elbows pointing out, and the head facing forward and in line with the spine.
4. Begin the upward movement by rapidly extending the hips, knees, and ankles while maintaining the shoulder position over the barbell.
5. Allow the barbell to slide up the thighs to ensure it remains as close to the body as possible.
6. As the joints of the lower body reach full extension, rapidly shrug the shoulders.
7. When the shoulders reach their highest elevation, flex the elbows to enable the barbell to remain close to the body as it rises in the vertical plane. The explosive nature of this phase may cause the feet to lose contact with the floor.
8. Rapidly move the feet and legs into a quarter-squat position while forcefully pulling the body under the barbell.
9. As the body moves under the barbell, rapidly thrust the elbows forward to catch the barbell on the front of the shoulders.
10. In the catch position, the torso is nearly erect, the shoulders are slightly in front of the hips and the head remains in a neutral position.
11. Recover to a standing position with the barbell on the front of the shoulders.
12. In a controlled fashion, lower the elbows to untrack the barbell from the shoulders, and then slowly lower the barbell to the thighs.

#### *The squat test*

The early data collections were also conducted one day before the intervention. The researcher explained the purpose and the correct procedure of the squat test. Participants warmed up by performing certain animal movements to prevent injury during the test (McGiguan, 2017).

1. Begin by gripping the bar with a shoulder-width pronated grip and placing it on the upper back and shoulders (high-bar or low-bar position can be used). The toes point slightly outward, the chest is out, and the head is tilted slightly upward.
2. Descend by flexing the hips and knees while maintaining a neutral back position until the desired position is reached. This is usually when the thighs are parallel to the floor.
3. Return to the starting position by extending the hips and knees while maintaining a neutral back position.

#### *The deadlift test*

The early data collections were also conducted one day before the intervention. The researcher explained the purpose and the correct procedure of the deadlift test. Participants warmed up by performing certain animal movements to prevent injury during the test (McGiguan, 2017).

1. Using a slightly wider than shoulder-width pronated or hook grip, begin by taking hold of a loaded barbell in a lifting rack (or set of blocks) that is set at mid-thigh height.
2. Position the heels approximately shoulder-width apart, with the feet facing slightly outward.
3. Bend at the knees slightly and flex at the hips to lean the torso forward, allowing the barbell to move down the thighs to a starting position that is just above the knees. At this position, the shoulders

should be over the barbell, the elbows pointing out, and the head facing forward and in line with the spine.

4. Begin the upward movement by rapidly extending the hips, knees, and ankles while maintaining the shoulder position over the barbell.
5. Allow the barbell to slide up the thighs to ensure it remains as close to the body as possible.
6. As the joints of the lower body reach full extension, rapidly shrug the shoulders.
7. When the shoulders reach their highest elevation, flex the elbows to enable the barbell to remain close to the body as it rises in the vertical plane. The explosive nature of this phase may cause the feet to lose contact with the floor.
8. Rapidly move the feet and legs into a quarter-squat position while forcefully pulling the body under the barbell.
9. As the body moves under the barbell, rapidly thrust the elbows forward to catch the barbell on the front of the shoulders.
10. In the catch position, the torso is nearly erect, the shoulders are slightly in front of the hips and the head remains in a neutral position.
11. Recover to a standing position with the barbell on the front of the shoulders.
12. In a controlled fashion, lower the elbows to untrack the barbell from the shoulders, and then slowly lower the barbell to the thighs.

### **Materials**

The materials used in this study included standard resistance training equipment consisting of an Olympic barbell and calibrated weight plates for bench press, power clean, squat, and deadlift exercises. Anthropometric measurements were obtained using a stature meter for body height and a Tanita BC-545N bioelectrical impedance analyser for body mass assessment. All strength testing and training sessions were conducted in an indoor training facility under standardized environmental conditions, supervised by certified coaches to ensure correct technique execution and participant safety throughout the intervention period.

### **Statistical analyses**

Statistical analysis was conducted using IBM SPSS (Version 22.0). Shapiro-Wilk Test ( $p < .05$ ) applied, and pre-test and post-test data from every group were compared using the paired sample T-test. The data was shown as mean and standard deviation. The data was tested for its normality using the Shapiro-Wilk test. Moreover, the data was tested using a T-test to determine the significance of the difference in the same data after the different measurements. Then, it continued by determining which groups were different from the others to find out which specific groups are different using a paired sample T-test. Given the exploratory nature of the study and the small sample size, statistical outcomes should be interpreted with caution. Effect sizes were reported to describe the magnitude of observed changes rather than to support population-level inference. The mixed ANOVA results are therefore presented as indicators of within-sample interaction patterns, not as definitive evidence of causal superiority. Given the small group sizes, assumptions underlying parametric interaction models may be partially violated; therefore, inferential statistics are complemented by effect size interpretation.

## **RESULTS**

All participants in this study, whose characteristics are shown in Table 2, regularly follow the training and participate in the training program according to each group's training programs. These findings reflect substantial within-sample improvements following the intervention and should be interpreted as preliminary evidence within the studied cohort.

Table 2. Players data.

Groups	Jumlah	Age (year)	Weight (kg)	Height (cm)
Experimental group	7 participants	19.1 ± 4.3	48.5 ± 8.1	153.2 ± 6.1
Control group	7 participants	18.4 ± 4.0	57.6 ± 14.1	158.2 ± 8.5

Table 3. shows the test results of the paired sample T-test (pre-test and post-test). Those tables show a significant difference in the experimental groups statistically, because the sig. value is < .05 and the control groups do not show any difference because of sig. > .05.

Table 3. Test result of paired T-Test (pre-test – post-test)

Test	Groups	Mean ± SD	Sig.
Bench press	Experimental	12.1 ± 4.0	.000
	Control	0.3 ± 0.5	.172
Deadlift	Experimental	16.4 ± 4.8	.000
	Control	0.7 ± 1.0	.106
Power clean	Experimental	8.2 ± 2.4	.000
	Control	2.2 ± 4.0	.184
Squat	Experimental	41.4 ± 12.9	.000
	Control	1.9 ± 2.0	.052

Table 4. shows the result of the mixed ANOVA repeated measures analysis, which shows the presence of a very strong interaction between time and groups in the increase of the strength capability in all measurement variables. In the bench press test, the experimental groups receive a bigger increase than the control groups, as it is reflected in the value  $F(1,12) = 60.08$ ,  $p < .001$ ,  $\eta^2p = .834$ , which indicates very big interaction effects. In the deadlift test, where the experimental groups show a better increase than the control groups, as shown in the value  $F(1,12) = 72.20$ ,  $p < .001$ ,  $\eta^2p = .857$ . This interaction pattern suggests larger within-sample changes following the applied training program. In the power clean test, it also shows a significant difference in increase between groups, in the value of  $F(1,12) = 11.97$ ,  $p < .005$ ,  $\eta^2p = .499$ , which indicates a medium to large interaction effect. Meanwhile, the squat test gives a value of  $F(1,12) = 64.70$ ,  $p < .005$ ,  $\eta^2p = .844$ , which indicates a very big interaction effect. All of these findings show that the training program that was given to the experimental groups demonstrated larger improvements in increasing the strength performance in various lifting exercises, rather than the control groups, which showed minimal increase and were not significant.

Table 4. Test result of repeated measures.

Test	Df	F	Sig.	Partial Eta Squared.
Bench press	1.12	66.08	.000	.834
Deadlift	1.12	72.20	.000	.857
Power clean	1.12	11.97	.005	.499
Squat	1.12	64.70	.000	.844

## DISCUSSION AND CONCLUSIONS

The participants' data during the physical training program during the preparation period shows an increase in the maximal strength through the Pyramid training in the female Judo athletes, which is the main finding of this study. This method is also linear with the periodization principle and overload progressive training, which emphasize neuromuscular adaptation and muscle hypertrophy optimally (Bompa & Buzzichelli, 2022;

Cormie et al., 2011); moreover, the other studies also show that resistance training with Pyramid and traditional methods is likely the same for its effectiveness to increase the positive adaptation in muscle strength and hypertrophy for elderly women (Ribeiro et al., 2017).

While these strength improvements are theoretically relevant to judo performance, no direct inference regarding competitive or technical outcomes can be made from the present data. The previous study shows that the Pyramid training is effective in increasing 1RM maximal strength in bench press, squat, and deadlift, whether in general or even in trained athlete populations. It also increases specific neuromuscular ability, which supports muscle torque production constantly in the knee joint and shoulder, as well as strengthening core muscle stability, such as the rectus abdominis, obliquus externus and internus, erector spinae, and transversus abdominis to work co-ordinately, so that the body becomes more stable to lift maximal weight, which means that this method is relevant to a functional strength program and training periodization (Greco et al., 2019; Liu et al., 2024). In addition, specific Judo training manipulation, which focuses on the lower muscle strength and endurance, must be maximized to increase competitive performance, because the high heart rate has not been proven to be a training intensity level that is accurate in all modalities of Judo training (Franchini et al., 2014; Harris et al., 2020). However, unlike large-scale randomized studies, the present findings should be viewed as hypothesis-generating, providing direction for future controlled trials rather than confirmatory conclusions.

Across all tested exercises, the experimental group demonstrated consistently larger interaction patterns compared with the control group. These findings support the previous literature, which shows that various variations of progressive weight are able to increase the neuromuscular adaptation (Angleri et al., 2017; Ribeiro et al., 2017; Costa et al., 2021). The significant increase in the squat test shows that Pyramid training provides an optimal stimulus for neuromuscular systems (Campos et al., 2002) due to the increased muscle strength, which will closely link with athletes' performance in general. Numerous studies support the argument that stronger muscle strength can increase performance in general sports ability, such as jumping, sprinting, and changing direction in order to perform throwing techniques (nage waza) and defending techniques (osaekomi waza), those athletes will be able to perform well (Suchomel et al., 2016). This method enables a more specific adaptation for female athletes, which generally more sensitive to weight variation due to physiological development factors during adolescence.

This study did not include retention or transfer tests to assess whether the observed strength gains translated into sustained adaptations or improved judo-specific technical performance. Therefore, the observed improvements likely reflect short-term neuromuscular adaptations rather than stable training-induced performance transfer. The limitations of this study include the small sample size ( $n = 14$ ), the intervention length is only for 8 weeks, and the focus is only on female athletes in the early phase of general preparation. This limits the generalization result on a larger population, including male athletes or different age groups. Meanwhile, this study does not evaluate the long-term effect of Pyramid training on specific Judo technique performances or injury prevention. Further research should involve larger samples, longer intervention duration, biomechanical measurements, and specific technique performances to evaluate the effectiveness of Pyramid training more comprehensively. Additionally, the absence of randomization and assessor blinding increases the risk of systematic bias. These limitations restrict causal interpretation and reinforce the need to consider the present study as preliminary evidence.

During the preparation phase, the Pyramid training was associated with meaningful improvements in maximal strength within the studied cohort, significantly in female Judo athletes, especially in the bench press, squat, deadlift, and power clean. Where this method is more specific to the sensitive female athletes in weight

variation due to physiological factors during adolescence, as it can push the neuromuscular system and stronger muscle strength, which may contribute to the development of physical qualities underlying throwing (nage-waza) and defensive techniques (osaekomi-waza).

This finding is consistent with the previous literature, which shows that a strength training program using the Pyramid method is effective in increasing maximal strength. Further research should involve larger samples, longer duration, biomechanical measurements, and also specific Judo technique performances to be more effective.

## AUTHOR CONTRIBUTIONS

Muhamad Fauzi Antoni, S. Pd., M. Kes.: conceptualization, methodology, data collection, and writing original draft. Dr. Dewangga Yudhistira, S. Pd., M. Pd.: data analysis, visualization, and editing draft. Dr. Novadri Ayubi, S. Or., M. Kes.: investigation and data curation. Laily Mita Andriana, S. Pd. M. Fis.: methodology and supervision. Dr. Adi Pranoto, S. Or., M. Kes.: validation and formal analysis. Dr. Ari Wibowo Kurniawan, M. Pd.: resources and project administration. Dany Pramuno Putra, S. Ftr., M. Kes.: supervision and project administration. All authors have participated sufficiently in the work to take public responsibility for its content. All authors have reviewed and approved the final version of the manuscript and agree to its submission and publication in the Journal of Human Sport and Exercise (JHSE).

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## DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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