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The Effect of Plyometric Training on the Power and Reactive Agility of Karate Athletes

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Abstract **Background:** Training is a means to improve physical condition. Many kinds of training can improve physical conditions, including plyometric training. This study aims to test the effectiveness of the plyometric training model to increase the power and reactive agility of karate athletes in the kumite category. **Methods:** This study utilized an experimental method using a one-group Pretest-Posttest Design. The research sampling used was purposive sampling. The data collection technique in this study consisted of power and reactive agility, which was a standing broad jump test and a standardized reactive agility test. The instrument was given twice to the sample as a pre-test and post-test. The treatment given in this study is in the form of plyometrics modification exercises arranged in an exercise program. Treatment is given for four consecutive weeks with a frequency of 3 sessions/per week. Data analysis in this study used Two Way Anova, which was processed using SPSS version 26. **Conclusions:** The results of the study were diverse, for the increase in limb power showed no significant differences, and the plot diagram concluded that an interaction effect occurred. As for the increase in reactive agility, there were four items of significant differences, and the plot diagram concluded that there was an interaction effect that occurs.

Keywords Karate, Plyometric, Power, Reactive Agility

1. Introduction

Training is a developing program for athletes to prepare for competition according to the chosen sport. Good training is systematically designed by following the sport's characteristics, the availability of time, and the athletes themselves. Training will achieve maximum results when following the training systematics [1]. Suharno [2] states that training is a process of perfecting athletes to achieve maximum quality through giving physical, technical, tactical, and mental burdens that are regularly directed, increasing, gradual, and repeated in time. Physical, technical, tactical, and mental are important aspects in achieving maximum achievement [3]. According to Syafruddin [4], the principles of training are fundamental provisions in the process of coaching and training and must be obeyed by coaches, training participants, and athletes. In sports activities, muscle strength is an important element for moving the organs of the body. Without great muscle strength, maximum achievements will not be achieved [5].

Karate is categorized into *kata* and *kumite*. The *kata* category arranges the form in a predetermined sequence of techniques and *offensive* and *defensive* movements. *Karateka* (karate practitioners) have a time of 60-80 seconds to complete a *kata*, and every violation above or below the duration will be punished [6]. *Kumite* is a real match/fight between two competitors under strict rules; they are free to move, kick and hit in a defensive and attacking manner. Attack movements in the *Kumite* category contain sudden accelerations, changes of

direction, and sudden, fast, and explosive [7]. Karate athletes of the *Kumite* category move quickly with short and narrow steps [8,9].

For a *karateka* to have fast, directional, sudden movements, and explosive defence and attack techniques against opponents, he/she requires the physical components of *strength*, *speed*, *agility*, quickness [10], power, reaction [11], and equilibrium [12]. Furthermore, he/she also requires an anaerobic energy system [13] which is used for short and high-intensity attacks. An aerobic stem is also necessary for karate *Kumite* [8] for recovery in the rest period.

Improving the aforementioned physical components requires efficient and effective physical training [10,14,15,16,17]. Efficient and effective physical training for karate athletes of the *Kumite* category can improve physical components synchronously, safely, and efficiently training time and cost [18,19,20].

Training is a means to improve physical condition. Many kinds of training can improve physical conditions, including plyometric training [21]. This plyometric training aims to help athletes improve their achievements by considering various aspects of the training, including the ability in karate. *Plyometric training* is defined as fast and explosive exercises that use energy stores and increase muscle activity during the muscle contraction phase at the time of exercise. Plyometrics training can power the upper and lower limbs [24].

Plyometric training uses one's weight or several tools to stimulate exercise and consists of various forms of exercise loading [23]. Plyometric training involves movements to strengthen muscle tissue and train nerve cells to carry out a stimulus in the form of muscle contractions with a certain pattern so that the muscles can quickly produce the strongest possible contraction [24]. Plyometrics has several forms of exercise often used to train endurance, strength, speed, and agility in motion in sports [25]. This plyometric exercise will be effective if the coach can compile an appropriate training program or training period so that the training does affect the ability. The principle of the plyometric training method is that the muscles always contract when lengthening and shortening. Plyometric training is useful for increasing muscle nerve reactions, explosiveness, speed, and the ability to generate force (energy) in a certain direction. Plyometric training is one of the methods to develop explosive power, an important component of most performance in sports [26]. Plyometric training aims to local fatigue of the muscles and central nervous system. The exercise must be properly planned and programmed to give the expected result. The forms of plyometric exercises that can improve physical abilities while improving the movements of the fulcrum technique and when hovering in the air are quite varied [23].

The forms of *plyometric* training in this program are (1) Pyo-forward with Foreward shuttle run 1st version; (2) Pyo-forward with Foreward shuttle run 2nd version; (3) Pyo-side with Side shuttle run 1st version; (4) Pyo-side with Side shuttle run 2nd version; and (5) Pyo Fore-side with Fore-backward shuttle

The preliminary research results with the survey method using questionnaires in *google form* given to 100 Karate coaches in Indonesia showed that 25% of the sample did not pay close attention to the special physical preparation for Karate athletes. As many as 75% had paid attention but had difficulty compiling the training program, especially determining the training mode or type, training intensity, and training volume. Moreover, Karate coaches, in general, also had difficulty choosing tools to measure the results of physical training that are appropriate or according to the characteristics of karate and the difficulty of compiling training programs in unison to improve the special physical components of karate (*power* and *reactive agility*).

2. Materials and Methods

This study utilized an experimental method using *a one-group Pretest-Posttest Design* [27], so this study only used one group as an experimental group.

The research sampling used was *purposive sampling*, which is the determination of a sample with a certain purpose or considerations [28]. The sampling criteria for this study were: 1) a karate trainer and athlete, and 2) willing to do treatment to improve their physical component. The sample used in this study was 21 INKAI DIY karate athletes, which consisted of cadet, junior, U-21, and Senior classes.

The data collection technique in this study consisted of power and reactive agility, was a standing broad jump test and a *standardized reactive agility* test. The Standing Broad Jump test aimed to determine the speed and strength of leg muscles in carrying out various special activities so that they were suitable for taking measurements of biomotor power. Meanwhile, the Reactive Agility Test used developments from Sekulic et al. [29], a tool called test stop-n-go reactive agility (SNG-RAT), which had been standardized before. The instrument was given twice to the sample as a pre-test and post-test. The treatment given in this study is in the form of plyometrics modification exercises arranged in an exercise program. Treatment is given for four consecutive weeks with a frequency of 3 sessions/per week [30].

Data analysis in this study used Two Way Anova, which was processed using SPSS version 26. Two-Way ANOVA was performed to determine the size of the effect of increasing the results of *reactive agility* and *power* after being given the developed weight training modification treatment. Two Way ANOVA or two-path variance analysis is an analysis to determine the relationship between two-factor variables (category data) and dependent variables [31].

Table 1. Average Yield Power

Descriptive Statistics

Dependent Variable: Standing Board Jump

Gender		Mean	Std. Deviation	N
Laki-Laki	Kadet	241,67	12,583	3
	Junior	218,33	15,275	3
	U-21	247,50	13,229	4
	Senior	236,67	25,166	3
	Total	236,92	18,545	13
Perempuan	Kadet	195,00	10,000	3
	Junior	205,00	27,839	3
	U-21	185,00	7,071	2
	Total	196,25	18,077	8
Total	Kadet	218,33	27,508	6
	Junior	211,67	21,370	6
	U-21	226,67	34,010	6
	Senior	236,67	25,166	3
	Total	221,43	27,025	21

Table 2. Homogeneity Assumption Power

Levene's Test of Equality of Error Variances[a]

Dependent Variable: Standing Board Jump

F	df1	df2	Sig.
1,169	6	14	,376

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Gender + KelasUsia + Gender * KelasUsia

Table 3. Two Way Anova Power

Tests of Between-Subjects Effects

Dependent Variable: Standing Board Jump

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	10232,143[a]	6	1705,357	5,457	,004
Intercept	888037,247	1	888037,247	2841,719	,000
Gender	7203,000	1	7203,000	23,050	,000
KelasUsia	140,464	3	46,821	,150	,928
Gender * KelasUsia	1808,333	2	904,167	2,893	,089
Error	4375,000	14	312,500		
Total	1044250,000	21			
Corrected Total	14607,143	20			

a. R Squared = ,700 (Adjusted R Squared = ,572)

3. Results

Power (Standing Broad Jump)

From table 1, we can assess the average power value based on gender and category class. The results show the average value of male cadet class power was 241.67; junior caliphate was 218.33; class U-21 was 247.50, and senior class was 236.67. Meanwhile, the results showed that for females, the average value of the cadet class power was 195; the junior class was 205, and the U-21 was 185.

Table 2 shows the value of Sig. 0.376 where the > 0.05, so it can be said that the variants between groups differ significantly.

After obtaining the average results and the assumption of homogeneity, the results were also the Two-Way Anova test. The result is listed in table 3.

From table 3, we get important values that can be summed up as follows:

Corrected Model:

The influence of all independent variables (gender, category class and gender interaction with category class) on dependent variables (power value). If the significance value is (Sig.) < 0.05 (Alpha) = Significant. The significance stated above, 0.004, means that the model was valid for men

Intercept:

The value of changes in dependent variables without the need to be influenced by the existence of independent variables means that the dependent variables can change their value without the influence of the independent variables. If the significance (Sig.) < 0.05 (Alpha) = Significant. The significance stated above, 0.000, means *significant intercepts*.

Gender:

The influence of gender on power in the model. If the significance (Sig.) < 0.05 (Alpha) = Significant. The significance stated above, 0.000, means that gender has a significant effect.

Age Class:

The influence of age class on power in the model. If the significance (Sig.) < 0.05 (Alpha) = Significant. The significance stated above, 0.928, means that the age class has no significant effect.

Gender*Age class:

The influence of Gender*age class on power in the model. If the significance (Sig.) <0.05 (Alpha)= Significant. The significance stated above, 0.089, means that the age class has no significant effect.

Error:

The Error value of the model, the smaller better the model.

R Squared:

Multiple determination values of all independent variables with dependents. The significance stated above, 0.700, which is close to 1, means a strong correlation.

After obtaining the calculation results, a conclusion of the Two-Way ANOVA hypothesis can be drawn. The results of the F test show that there is a significant difference or receiving H1. Therefore, it was appropriate for this ANOVA Test to be continued to the next stage, namely the Post Hoc Test. The table below is a Tukey Post Hoc Table used to assess which categories of power variables have significant differences:

Table 4. Post Hoc Test Power

Post

Dependent Variable: Standing Board Jump

Tukey HSD

(I) Kelas Usia		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Kadet	Junior	6,67	10,206	,913	-23,00	36,33
	U-21	-8,33	10,206	,846	-38,00	21,33
	Senior	-18,33	12,500	,482	-54,67	18,00
Junior	Kadet	-6,67	10,206	,913	-36,33	23,00
	U-21	-15,00	10,206	,480	-44,67	14,67
	Senior	-25,00	12,500	,234	-61,33	11,33
U-21	Kadet	8,33	10,206	,846	-21,33	38,00
	Junior	15,00	10,206	,480	-14,67	44,67
	Senior	-10,00	12,500	,853	-46,33	26,33
Senior	Kadet	18,33	12,500	,482	-18,00	54,67
	Junior	25,00	12,500	,234	-11,33	61,33
	U-21	10,00	12,500	,853	-26,33	46,33

Based on observed means, the error term is Mean Square(Error) = 312,500.

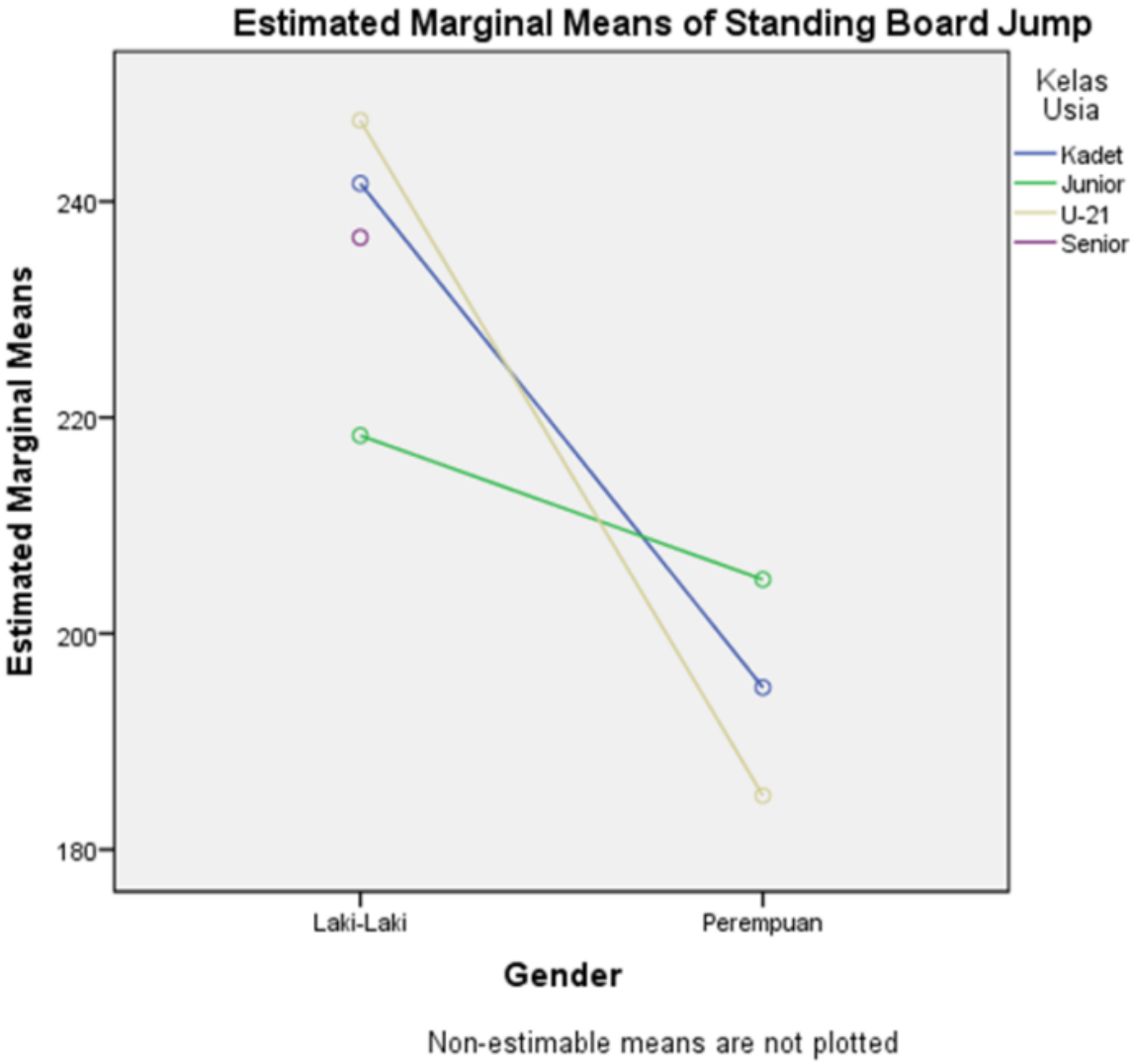

Figure 1. Plot Chart Power

For which there is a significant difference marked with an asterisk (*). From table 4, they are not marked with stars, meaning they have no significant differences. In addition to post hoc, it was also necessary to add a plot diagram that was useful to show whether there was an interaction of effects between variables. However, this diagram cannot be used as valid reference material and just for giving a depiction. If the lines do not show alignment, then an interaction effect is suspected.

The diagram above shows that there is a line alignment, and then it is concluded that an interaction effect occurs.

Table 5. Average Yield Reactive Agility

Descriptive Statistics

Dependent Variable: Reactive Agility

Gender		Mean	Std. Deviation	N
Laki-Laki	Kadet	7,1967	,32532	3
	Junior	7,7000	,31193	3
	U-21	6,7925	,23243	4
	Senior	6,6133	,66161	3
	Total	7,0538	,54870	13
Perempuan	Kadet	7,2000	,18682	3
	Junior	7,8833	,52291	3
	U-21	7,6050	,43134	2
	Total	7,5575	,46432	8
Total	Kadet	7,1983	,23727	6
	Junior	7,7917	,39797	6
	U-21	7,0633	,49565	6
	Senior	6,6133	,66161	3
	Total	7,2457	,56473	21

Table 6. Homogeneity Assumption Reactive Agility

Levene's Test of Equality of Error Variances[a]

Dependent Variable: Reactive Agility

F	df1	df2	Sig.
1,938	6	14	,144

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Gender + KelasUsia + Gender * KelasUsia

Table 7. Two Way Anova Reactive Agility

Tests of Between-Subjects Effects

Dependent Variable: Reactive Agility

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4,132[a]	6	,689	4,291	,012
Intercept	1001,157	1	1001,157	6239,058	,000
Gender	,479	1	,479	2,986	,106
KelasUsia	2,212	3	,737	4,595	,019
Gender * KelasUsia	,502	2	,251	1,563	,244
Error	2,247	14	,160		
Total	1108,886	21			
Corrected Total	6,378	20			

a. R Squared = ,648 (Adjusted R Squared = ,497)

Reactive Agility

From table 5, we can assess the average *reactive agility* score based on gender and category class. The results show the average reactive agility male cadet class score was 7.1967; the junior class was 7.7000; U-21 class was 6.7925, and the senior class was 6.6133. Meanwhile, the results showed that the average score of *reactive agility* in the female cadet class was 7.2000; the junior class was 7.8833, and the U-21 class was 7.6050.

Table 6 shows the value (Significance) of Sig. 0.144, where the > 0.05. Therefore, it can be said that the variants between groups differ significantly.

After obtaining the average results and the assumption of homogeneity, the results were also the Two Way Anova test. The result is as follows:

From table 7, we get important values that can be summed up as follows:

Corrected Model:

The influence of all independent variables (gender, category class, and gender interaction with category class) on dependent variables (power value). If the significance (Sig.) < 0.05 (Alpha) = Significant. The significance stated above is 0.012, meaning the model is invalid.

Intercept:

The value of changes in dependent variables without the need to be influenced by the existence of independent variables means that the dependent variables can change their value without the influence of the independent variables. If the significance (Sig.) < 0.05 (Alpha) = Significant. The significance stated above is 0.000, which means significant intercepts.

Gender:

The influence of gender on power in the model. If Significance (Sig.) < 0.05 (Alpha)= Significant. The significance stated above, 0.106, means that gender has no significant effect.

Age Class:

The influence of age class on power in the model. If the significance (Sig.) <0.05 (Alpha)= Significant. The significance stated above, 0.019, means that the age class has no significant effect.

Gender*Age class:

The influence of Gender*age class on power in the model. If the significance (Sig.) <0.05 (Alpha)= Significant. The significance stated above, 0.244, means that gender*age class has no significant effect.

Error:

The Error value of the model, the smaller, the better the model.

R Squared:

Multiple determination values of all independent variables with dependents. The significance stated above, 0.648, which is close to 1, means a strong correlation.

After obtaining the results, a conclusion of the Two-Way ANOVA hypothesis can be drawn. The F test results show a significant difference or receiving H1, so it was appropriate for this ANOVA Test to be continued to the next stage, namely the Post Hoc Test. The table below is a Tukey Post Hoc Table used to assess which categories of power variables have significant differences:

For which there is a significant difference marked with an asterisk (*). Table 8 shows four marked with stars, meaning four items of significant difference.

In addition to the post hoc, it is also necessary to add a plot diagram that is useful to show whether there was an interaction of effects between variables. However, this diagram could not be used as valid reference material and just for giving an idea. An interaction effect was suspected when the lines did not show alignment.

Table 8. Post Hoc Test Reactive Agility

Multiple Comparisons

Dependent Variable: Reactive Agility

Tukey HSD

(I) Kelas Usia		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Kadet	Junior	-,5933	,23128	,092	-1,2656	,0789
	U-21	,1350	,23128	,935	-,5372	,8072
	Senior	,5850	,28325	,212	-,2383	1,4083
Junior	Kadet	,5933	,23128	,092	-,0789	1,2656
	U-21	,7283*	,23128	,032	,0561	1,4006
	Senior	1,1783*	,28325	,005	,3550	2,0016
U-21	Kadet	-,1350	,23128	,935	-,8072	,5372
	Junior	-,7283*	,23128	,032	-1,4006	-,0561
	Senior	,4500	,28325	,416	-,3733	1,2733
Senior	Kadet	-,5850	,28325	,212	-1,4083	,2383
	Junior	-1,1783*	,28325	,005	-2,0016	-,3550
	U-21	-,4500	,28325	,416	-1,2733	,3733

Based on the observed means, the error term is Mean Square (Error) = ,160.

*.The mean difference is significant at the .05 level

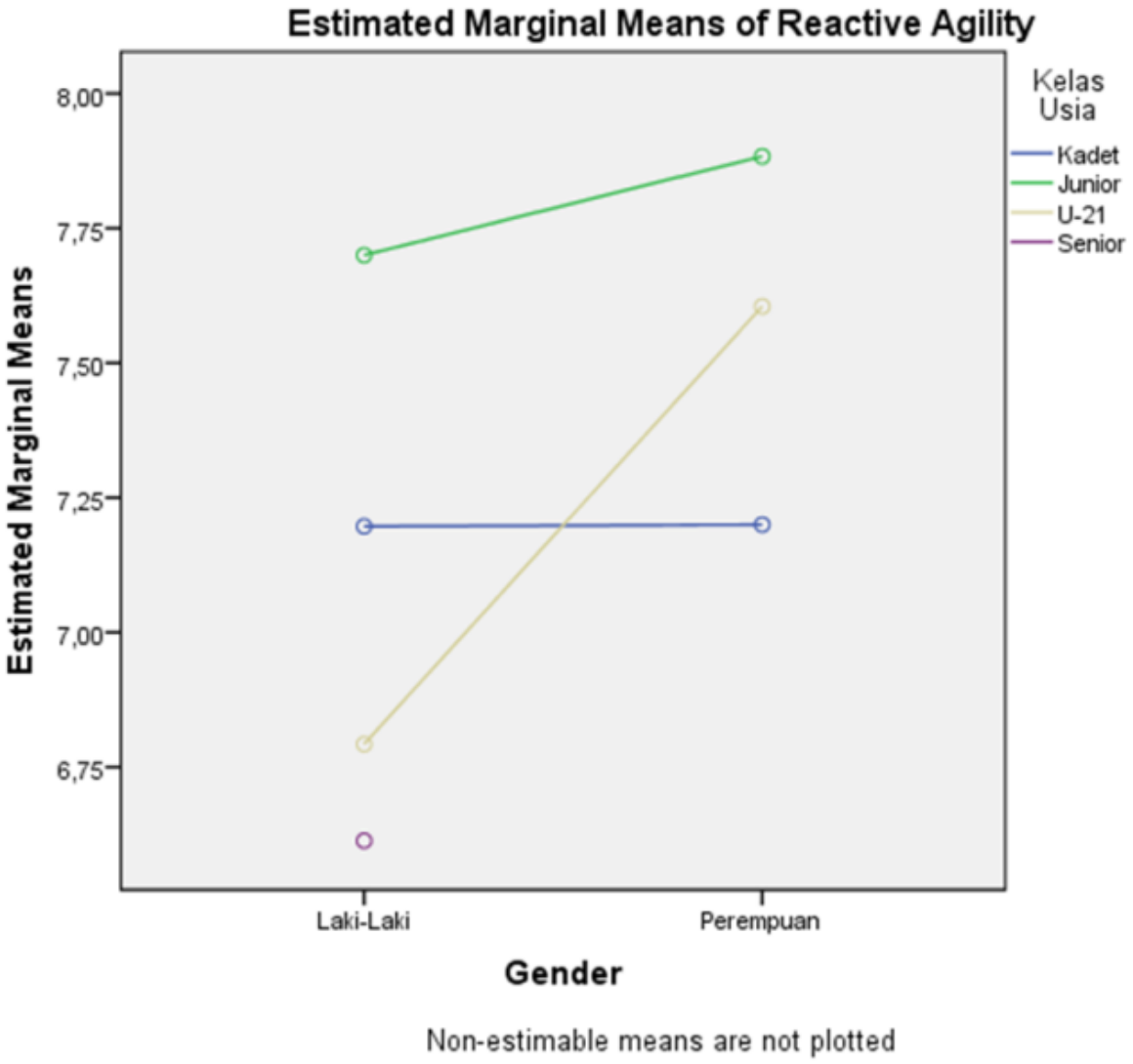

Figure 2. Plot Chart Reactive Agility

The diagram above shows that there is a line alignment, and then it is concluded that an interaction effect occurs.

4. Discussion

In the sport of karate, there are two categories, namely, moves (*kata*) and battles (*Kumite*), which have different characteristics. In the physical element of athletes, the word is more about the physical elements of power and strength. In contrast to the Kumite category [32], the physical aspect of reactive agility is needed because reactive agility is a combination of several biomotor components. For a karateka to have fast, directional, and sudden movements, as well as explosive defence and attack techniques against opponents, requires or requires a physical component of strength, *speed*, *agility*, *quickness* [10], power, reaction [11], and equilibrium [12]. In addition, it also requires an anaerobic energy system [13] which is used for short and high-intensity attacks, so that aerobic stem is also necessary for karate *Kumite* [8] for recovery in the rest period.

Physique is one of the important components to support karate athletes to reach the pinnacle of achievement [33]. An athlete must train with the right and continuous program to excel in the game [34]. Therefore, karate receives a long-term stimulus and is accompanied by making fast and strong movements. Athletes prioritize the ability to reactive agility and power. If karate athletes have good *reactive agility* and power, athletes can defend and attack optimally when competing.

Reactive agility is very important in karate because all movements performed while playing require speed to make decisions and perform movements as quickly as possible [35]. Athletes with good *reactive agility* will easily accept stimulus, anticipate opponents' attacks, and execute attacks quickly without losing balance. Therefore, it is necessary to measure the *reactive agility ability of* karate.

However, to date, no instrument has had the characteristics of the sport of karate. Therefore, a karate athlete test instrument must be conducted to determine the increase in achievements.

Power is speed, and power is the main biomotor component in sports [36] and *power* is the result of maximum strength and speed in performing a movement in a very short time [37]. After knowing the meaning of power, in this study, power is focused on the muscles of the limbs. At the same time, limb muscle power is one of the most important parts of sports activities because, with strong limbs, a person is biased towards running, jumping, and doing all activities well. Sports that are dominant with speed, such as karate, need strength training, especially power, by paying attention to the appropriate parameters and periodization flow to produce maximum results. Strength *training and conditioning (S&C) training* programs are very important to be given to athletes or sportspeople to reach the peak of achievement. Elite athletes have better strength, *power*, speed, and jumping ability than ordinary athletes.

The novelty of this study is that in addition to increasing strength, power, the speed of the body after getting a stimulus (combined speed, *agility* and reaction time is called *reactive agility*) and the training mode uses a combination of *plyometric* training mode *c* and *reactive agility* training. The data analysis process used a Two-Way ANOVA.

5. Conclusion

The results of the research varied, for an increase in leg power it did not show a significant difference. This can be seen from the results of the F test showing that there is a significant difference, which means that it can be a post hoc test. From the post hoc test results, all variables are not marked with stars, meaning that nothing exists a significant difference. The plot diagram concludes that there is an interaction effect.

Whereas for an increase in reactive agility, there are four items of significant difference. This can be seen from the results of the F test indicating that there is a significant difference, which means that it can be a post hoc test, from the post hoc test results, Sada 4 is marked with an asterisk, meaning there are 4 items, there is a significant difference, and the plot diagram concludes that there is an interaction effect that occurs.

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