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Effects of Jump Rope and High Jump Training with 1:1 Intervals on Increasing Vo2 Max and Anaerobic Threshold

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VO2 max is the "engine" of an athlete. The better VO2 max, the better physical abilities of an athlete to play games for a long time without significant exhaustion. Badminton players, for example, must have excellent physical condition. The physical condition of Indonesian players, especially their VO2 max, however, tends to be relatively low. This study aims to examine: (1) the effects of jump rope and high jump training with 1:1 intervals on increasing VO2 max and anaerobic threshold; (2) the difference between the effects of jump rope training with intervals of 1:1 and high jump with intervals of 1:1 on VO2 max and anaerobic threshold. This research uses a quantitative approach with a quasi-experimental method. The research design used in in this study is factorial design and data analysis using t-test and MANOVA. The results show that: (1) There is an effect of jump rope and high jump training with 1:1 intervals on increasing VO2 max and anaerobic threshold; (2) there is a difference in effects between jump rope training with 1:1 intervals and high jump with 1:1 intervals on VO2 max and anaerobic threshold. This study concludes that jump rope and high jump training with 1:1 intervals can increase VO2 max and anaerobic threshold, and that jump rope training with 1:1 intervals works more effectively.

Key words: *Training, Jump Rope, High Jump, Interval, VO2 Max, Anaerobic Threshold.*

Introduction

The root of the problem in the current game of badminton is the state of the player's heartbeat. In the third or final set most athletes are no longer able to move swiftly over the court. Under these circumstances, the opponent will find out that they are fatigued. Thus, they can easily continue to attack and win the match.

This problem is very common in badminton and has become a challenge for sports scientists to find out why this problem occurs. There is research that answers or provides a description and explanation of the problem. The research shows that if the athlete's pulse is above 180 beats per minute for 2 minutes or more there will be a drastic reduction in physical and psychological performance.

This can be seen at the end of the second or third set of a badminton game. The physical quality of the athlete decreases, the steps get heavier, the accuracy of the smash declines so much that the shuttlecock flies out of the court, and the athlete's spirit is clearly less visible. There are several possible solutions to the problems of how to delay the athlete's heart rate from reaching 180 and how the body can quickly recover once the heart rate reaches 180.

A badminton player must have excellent physical condition, however the physical condition of Indonesian players, especially their VO_2 max, is still relatively low. This happens to male players Ricky Karandasuardi (45.10 ml/kg/minute), M. Ahsan (46.4 ml/kg/minute), and Hendra S (48.4 ml/kg/minute) (Wiriawan, 2016). From this data, it is found that the average VO_2 max of Indonesian national player is around 46.63 ml/kg/minute. When calculated with VO_2 max norm, the male players are only in the "sufficient" category.

From the data on the physical condition of female players, the following VO_2 max data was found: Greysia Poly at 44.0 ml/kg/min, Maria Febe at 54.9 ml/kg/min, and Nitya K. Maheswari at 36.8 ml/kg/min (Wiriawan, 2016). On average, the VO_2 max of female Indonesian national players is 45.23. When calculated with the VO_2 max norm, the female players are in the "poor" category. This is very alarming. This is one of the physical factors behind why we often lose in badminton, especially when forced to play up to 3 sets.

As comparison, the VO_2 max of foreign badminton players are as follows: male players are at 56.9 ml/kg/minute (Ooi, 2019, p. 1) and female players are at 57.4 ml/kg/min, (Ghosh, 2008, p. 1). The previous data also shows a clear difference between the VO_2 max of Indonesian players and foreign players, which indicates that the training methods conducted by Indonesia to improve the players' physical condition are less effective because the VO_2 max of our players are still far below foreign players. Based on this gap, new training methods that can effectively improve the athletes' physical condition are needed. This is why two training models are

compared in this study to find out which one is the most effective to increase the VO_2 max and anaerobic threshold.

This study is also related to previous studies, which found that the most effective interval training to improve physical condition is the 1:1 interval, (Trecroci, 2015, p. 794), (Chen, 2012, p. 58), (Jahromi, 2016, p. 406), (Orhan, 2013, p. 268), (Ozer, 2011, p. 212). The advantage of this research is the measurement of VO_2 max and anaerobic threshold, and the treatment performed is controlled by polar in order to monitor the athlete's heart rate so that their physical progress can be monitored continually.

Research Methods

This is a quantitative research with a quasi-experiment method. This method was chosen because the researchers could not control factors other than the treatment given, for example other activities carried out by athletes in other places, the nutrients that enter their bodies, as well as the quality of their rest.

The research design used is factorial design. As the subject criteria have different abilities, ordinal pairing is used for group division. This technique enabled all groups to have equal abilities. Kerlinger in Maksum, (2012, p. 50) stated that, "factorial design is used to conduct experiments with two or more independent variables."

Figure 1. Diagram of research design, (Maksum, 2012, 50)

	X_1 (*jump rope*)	X_2 (*high jump*)
A (1:1)	AX_1	AX_2
B (1:2)	BX_1	BX_2

Notes:AX_1: jump rope training using 1:1 interval
AX_2: high jump training using 1:1 interval
BX_1: jump rope training using 1:2 interval
BX_2: high jump training using 1:2 interval

The four groups were given treatment for 8 weeks and 3 face-to-face sessions per week, so that the total treatment comprised 24 meetings. This was done so that the research subjects did not overtrain, because the drastic decrease in ability and state of pain was highest between 24 to 48 hours after training (Sarabon, 2013, p. 431). In addition, an 8-week period was chosen as the duration of treatment because a minimum time of 6 weeks is an ideal time for muscle and nerve adaptation (Mirzaei, 2014, p. 100). This study lasted 10 weeks as it referred to research

on jump ropes (Orhan, 2010 and Ozer 2011). The first week was used as a preliminary step, the second week was used as pre-test, the third week was used for data collection on the initial training load, the following 8 weeks were used for treatment, and the last week was used as post-test.

The population and sample in this study were all 22 male athletes of PB Nikko Steel Malang in East Java. This research is classified as population research because it uses all members of the population as research subjects.

The population in this study falls within the following criteria:

1. Of male gender
2. Aged 15-17 years old, an age range chosen based on the grouping of entry ages in the adolescent group
3. Practicing intensively for 3 times per week at PB. Nikko Steel Malang on Monday, Wednesday, and Friday

In this study, the collection of information on dependent variables of VO_2 max and anaerobic threshold uses tests and measurements. To measure the VO_2 max and anaerobic threshold, a multistage fitness test using polar was performed. The process of measuring the pre-test and post-test data of VO_2 max and anaerobic threshold was carried out at GOR Baranaga sport centre, one of the PB Nikko Steel Malang training sites where measurement tools are supported by SSFC (Suzuki Satria F150 Club) of the State University of Surabaya.

Research Results

Data Description of Jump Rope Interval 1:1 Group

This section describes the pre-test, post-test, average data and the percentage increase of each dependent variable, namely VO_2 max and anaerobic threshold. The calculation of the average and the percentage was performed using Microsoft Excel 2007. Better information on the collection of data in study group I can be seen in the following table.

Table 1: Results of Pre-test and Post-test Data for Jump Rope Interval 1:1 Group

No	**Name**	*Pre VO_2 max* **(ml/kg/min)**	*Post VO_2 max* **(ml/kg/min)**	*Pre AT* ***(bpm)***	*Post AT* ***(bpm)***
1	NOH	49.9	55.4	600	750
2	EVA	41.5	48.3	370	480
3	AJT	41.5	49.7	300	540
4	MAZ	43.9	52.6	480	570
5	MAL	44.2	51.3	300	420
6	DNI	43.6	51.1	450	600
7	ASN	47.4	53.4	350	570
8	HJ	41.5	50.6	180	450
9	ROB	44.2	51.8	220	430
10	MBN	39.2	48.4	310	490
11	AKB	36	46.2	150	480
	Mean	39.8	41.7	232.7	322.7
	% Increase	**18.16**		**55.79**	

An increase can also be seen in the other dependent variable, the VO_2 max. Based on the table, there was a significant increase after a treatment of jump rope training at a 1:1 interval was given for 8 weeks with a frequency of 3 times per week. This result is shown by the average VO_2 max in pre-test, which is 43 ml/kg/min, and the average VO_2 max in post-test, which is 50.8 ml/kg/min. In percentage, the increase in VO_2 max is 18.16%.

The increase also occurred in the anaerobic threshold variable. Based on the table, there was a significant increase in anaerobic threshold after a treatment of jump rope training at a 1:1 interval was given for 8 weeks with a frequency of 3 times per week. This is shown by the average AT in pre-test, which is 337.3, and the average AT in post-test, which is 525.5. In percentage, there was an increase in AT of 55.79%.

Data Description of High Jump Interval 1:1 Group

This section describes the pre-test, post-test, average and percentage of increase in the dependent variables, VO_2 max and anaerobic threshold. Calculation of the average and the percentage was performed using Microsoft Excel 2007. Better information on the collection of data in the study group II can be seen in the following table.

Table 2: Results of Pre-test and Post-test Data for High Jump Interval 1:1 Group

No	**Name**	*Pre VO_2 max* **(ml/kg/ min)**	*Post VO_2 max* **(ml/kg/ min)**	*Pre AT* ***(bpm)***	*Post AT* ***(bpm)***
1	MFS	50.8	52.2	310	370
2	APB	43.9	44.6	480	510
3	VBA	38.2	40.4	120	240
4	ACI	41.5	42.8	300	390
5	MFI	41.5	43.2	210	330
6	FAR	33.2	36.8	150	240
7	NIK	36	38.4	210	300
8	WIL	33.2	34.8	300	360
9	RAD	40.2	42.6	120	240
10	ELY	38.2	40.8	120	270
11	MW	40.8	42.2	240	300
	Mean	39.8	41.7	232.7	322.7
	% Increase	**4.86**		**38.67**	

The increase can be seen in the dependent variable VO_2 max. Based on the table, there was a significant increase after a high jump treatment was given at a 1:1 interval for 8 weeks with a frequency of 3 times per week. This result is shown by the average VO_2 max in pre-test, which is 39.8 ml/kg/min, and the average VO_2 max in post-test, which is 41.7 ml/kg/min. In percentage, the increase in VO_2 max is 4.86%.

The increase also occurred in the anaerobic threshold variable. Based on the table, there was a significant increase in the quality of anaerobic threshold after a high jump treatment was given at a 1:1 interval for 8 weeks with a frequency of 3 times per week. This result is shown by the average AT in pre-test, which is 232.7, and the average AT in post-test, which is 322.7. In percentage, the increase in AT is 38.67%.

Prerequisite Test

Before research hypothesis was analysed, prerequisite tests, namely the normality test and the homogeneity test, needed to be carried out first. These tests serve as a determination before entering the paired t-test analysis and multivariate analysis of variance or MANOVA. The prerequisite tests display the following data of the normality test and homogeneity test.

a. Data Normality Test

Data normality test is performed to investigate whether the data can be in the normal field or not. This data normality test is an initial step in the process of research analysis. The data normality test in this study used the Kolmogorov-Smirnov test. The normality test is briefly described in the following data normality test results.

Table 3: Results of Data Normality Test

Variable	Test	Group I (JR 1:1)	Group II (HJ 1:1)	Notes	Status
		Sig	Sig		
VO_2 Max	*Pre*	0.812	0.853	P > 0.05	**Normal**
	Post	1.000	0.821	P > 0.05	**Normal**
Anaerobic Threshold	*Pre*	0.992	0.957	P > 0.05	**Normal**
	Post	0.822	0.949	P > 0.05	**Normal**

Based on the table above, the five dependent variables of VO_2 max and anaerobic threshold have a normal data distribution. This is due to the significance value or probability value of each group showing (p) or sig> 0.05 so that H0 is accepted. This means that the data obtained from the population are normally distributed.

b. Data Homogeneity Test

A homogeneity test needs to be done to explain how two or more groups of sample data come from populations that have the same variance (homogeneous). In this study, a homogeneity test must be carried out to investigate the subject equation of the two study groups and the dependent variables, which are the objects to be analysed. In this way, whether the data comes from a homogeneous or inhomogeneous population can be identified. In this study, Levene's test with SPSS Version 18.0 was used to analyse the homogeneity of the data. The results can be seen in the following table.

Table 4: Results of Homogeneity Variance Test

Variable	Test	Sig (P)	Notes	Status
VO_2 Max	*Pre-test*	0.870	P > 0.05	homogeneous
	Post-test	0.860	P > 0.05	homogeneous
Anaerobic Threshold	*Pre-test*	0.676	P > 0.05	homogeneous
	Post-test	0.805	P > 0.05	homogeneous

c. Hypothesis testing

Hypothesis testing is consistent with the research design after it was found that the data obtained from pre-test and post-test dependent variables are normally distributed. In addition, it was found that the variance in each group was homogeneous. The next process is to analyse hypothesis one to four using paired sample t-test with PSS Version 18.0.

1) The effect of jump rope and high jump training at 1:1 intervals on increasing VO_2 Max and anaerobic threshold

To find out the effect of jump rope training at 1:1 intervals, the authors analysed the data of the difference test using the t-test with the help of SPSS version 18.0. The results of the difference test analysis are presented in the following table.

Table 5: Difference Test Results in Dependent Variables in Study group I (JR 1:1)

Variable	***Pair***	**t_{count}**	**Sig. (*2-tailed*)**	**Status**
VO_2 max	*Pre-Post*	-18.076	0.000	Different
AT	*Pre-Post*	-8.465	0.000	Different

Based on the above table, there are differences between dependent variables, namely VO_2 max and anaerobic threshold, before and after treatment. The probability value or significance level of each variable is 0.000, which means that P <0.05. Therefore, it can be stated that there is a difference after a jump rope 1:1 training is given. That means jump rope 1:1 training affects the increase in VO_2 max and anaerobic threshold.

Table 6: Results of Difference Test on Dependent Variables in Study group II (HJ 1:1)

Variable	***Pair***	**t_{count}**	**Sig. (*2-tailed*)**	**Status**
VO_2 max	*Pre-test - Post-test*	-8.037	0.000	Different
AT	*Pre-test - Post-test*	-8.409	0.000	Different

Based on the table above, there are differences between dependent variables, VO_2 max and anaerobic threshold, before and after treatment. Probability or significance level of each variable is 0.000. This means that P <0.05. Therefore, it can be stated that there are differences after high jump training at a 1:1 interval is given. This means that high jump training with a 1:1 interval affects the increase in VO_2 max and anaerobic threshold.

2) Results of difference test between groups

At this stage, the analysis is done with multivariate test. The results obtained after the analysis can be seen in the following table.

Table 7: Multivariate Test Multivariate Tests

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	.969	226.469[a]	5.000	36.000	.000
	Wilks' Lambda	.031	226.469[a]	5.000	36.000	.000
	Hotelling's Trace	31.454	226.469[a]	5.000	36.000	.000
	Roy's Largest Root	31.454	226.469[a]	5.000	36.000	.000
Treatment	Pillai's Trace	2.370	28.563	15.000	114.000	.000
	Wilks' Lambda	.004	41.948	15.000	99.782	.000
	Hotelling's Trace	20.249	46.798	15.000	104.000	.000
	Roy's Largest Root	11.788	89.585[b]	5.000	38.000	.000

Based on the table, the Wilks' Lambda test explains the difference in the increase in the dependent variables VO_2 max and the anaerobic threshold. This result is obtained because the probability value or sig value of Wilks' Lambda is 0.000 below the significance level. Thus, the value of sig <0.05, so it can be stated that there are differences in the increase of VO_2 max and anaerobic threshold in the two study groups.

Furthermore, if there are differences in influence between the study groups, a post hoc multiple comparation test is performed. The type of analysis used is the least significant difference (LSD) with SPSS version 18.0. The purpose of this test is to find out which research group has the most significant effect on the increase in VO_2 max and anaerobic threshold.

Table 8: Results of Post-Hoc Test with LSD on VO_2 Max Variable

Group		**Mean difference**	**Significance (p)**
Jump rope 1:1	*High jump* 1:1	5.8727	0.000
	Jump rope 1:2	4.2909	0.000
	High jump 1:2	5.7909	0.000
High jump 1:1	*Jump rope* 1:1	-5.8727	0.000
	Jump rope 1:2	-1.5818	0.0002
	High jump 1:2	-0.0818	0.0866

Based on the table above, significant differences were found between the two study groups. The value of this difference can be seen in the mean difference column. The difference in the

mean difference column means there is a difference in effect on the increase in VO_2 max. Based on the results of different tests on the dependent variable VO_2 max, jump rope 1:1 training produces a positive mean difference. Thus, it can be said that jump rope 1:1 training produces a greater effect on increasing VO_2 max than the other method of training.

Table 9: Results of Post-Hoc Test with LSD on Anaerobic Threshold Variable

Group		**Mean difference**	**Significance (p)**
Jump rope 1:1	*High jump* 1:1	98.1818	0.000
	Jump rope 1:2	68.1818	0.002
	High jump 1:2	128.1818	0.000
High jump 1:1	*Jump rope* 1:1	-98.1818*	0.000
	Jump rope 1:2	-30.0000	0.151
	High jump 1:2	30.0000	0.151

Based on the table above, significant differences were found in the four study groups. This result can be seen in the mean difference column. This column shows the difference in influence on the increase in anaerobic threshold. This means that jump rope 1:1 training provides the biggest change in increasing anaerobic threshold when compared to the other method of training.

Discussion

This section describes the results obtained after the collection and analysis of field data. An examination will subsequently be conducted regarding why jump rope training with 1:1 intervals and high jump training with 1:1 intervals have an effect on VO_2 max and anaerobic threshold, as well as why jump rope and high jump training with 1:1 intervals have different effects on VO_2 max and the anaerobic threshold.
First, jump rope training 1:1 has a significant effect in increasing VO_2 max and anaerobic threshold because the whole body is always given stressors through physical activity, namely jump rope 1:1 with high intensity and proper training load, so that the adaptation of muscles and organs, be it the heart and lungs, can occur. In this training, the muscles of the whole body, especially the muscles in the lower extremities, are forced to contract continuously because there is little rest between the exercises.

In turn, jump rope training 1:1 uses the same ratio of work and rest, which is 1:1. At this interval the cardiovascular system works hard when doing work, therefore the body must be ready to metabolize quickly and, shortly after work, is also required to recover quickly. This is what explains the significant effect of jump rope 1:1 training on VO_2 max and anaerobic threshold.

Second, high jump 1:1 training has a significant effect on increasing VO_2 max and anaerobic threshold. This is because in this exercise the body carries out intensive training with weights that are in accordance with the performance of each athlete. This exercise also has predominant anaerobic characteristics. Every bodily exercise is designed to reach the point of depletion, which is the boundary point between aerobics and anaerobics. Thus, after training for a relatively long time, the body will be trained to make the athlete's anaerobic threshold better.

The interval in this training is balanced with the working time, which is 1:1, so that the body will get high stress. This is because they have to do training activities of a moderate to high intensity with a short recovery. If done repeatedly, this can have a positive impact on the muscles, nervous system and organs of the body within a period of 8 weeks, resulting in a positive influence on the research variables. Therefore, it can be stated that the high jump 1:1 training can increase VO_2 max and anaerobic threshold.

Third, there is a difference in the effect of jump rope and high jump trainings with a 1:1 interval on the increase in VO_2 max and anaerobic threshold. The basic difference in jump rope and high jump trainings lies in the movements performed. Jump rope movement is more complex compared to high jump movement. In the jump rope training, all motors perform contractions, including both the upper and lower motors. The feet always perform the jumps so that the rope doesn't get caught. The hands also always make a circular motion so that the rope can keep moving around the body quickly. This is in contrast to high jump training, where the dominant movement is in the lower motion, namely the legs. This is what causes the respiratory and cardiovascular burden on the body to be greater when doing jump rope training.

The results in this study are in line with previous studies. According to Orhan (2013), "jump rope training has a positive effect on muscle strength, endurance, agility, flexibility, coordination, balance, upright jumping, rhythm, strength, speed, bone density, and increased ability."

In training with intervals of 1:1, the rest period is shorter, therefore the exercise is a high stressor for the body, because the body must recover in a short time. Components of the body, including the respiratory system, nervous system and skeletal system, are forced to work hard. Over time, these systems always get stressed so that they will gradually adapt to these conditions and their abilities will increase.

What needs to be stressed here is that the exercise must be carried out maximally so that it produces maximum impact. What is meant by maximum training here is a training that is controlled by the heart rate monitor so that the body does not over-train and get sick because it is unable to accept the provided portion of exercise. In the training in this study the athletes did

not overtrain or get injured because the training program provided was adjusted to the maximum abilities of the research subjects.

In addition, in training with a 1:1 interval, the energy is always forced to be available quickly so that over time the body can get used to providing energy quickly. The body will respond to staples of energy providers and over time will increase energy supply. The organs are also always forced to work optimally. For example, the heart is forced to quickly circulate the blood carrying O2 and nutrients through blood vessels whose sockets are enlarged (dilated). In addition, the lungs also work extra hard to capture and send O2 to the blood. Meanwhile, the muscles are also accustomed to working extra-fast with short breaks.

In predominantly anaerobic training, which is training with a 1:1 interval, what is used as the main source of energy is creatine phosphate. Creatine phosphate has the property of producing ATP in a very short time, which is approximately 8-10 seconds, (Bompa, 2015, p. 38). But the weakness of this energy source is that it is not available in large quantities, so it does not last long. When creatine phosphate is depleted, energy is provided through fast glycolysis. It can be said that at 1:1 training, the body will get used to storing more creatine phosphate and metabolize glycolysis faster too, so that energy supply for training is more optimal.

Conclusions

The conclusion of this study is that jump rope and high jump trainings with a 1:1 interval can increase VO_2 max and anaerobic threshold. Jump rope training with 1:1 intervals provides a more effective increase.

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