

Circuit Training with Interval Ratio at a Different Altitude Enhanced the Maximum Oxygen Volume Basket Ball Athletes

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Abstract: *The purposes of this study was analyzed: 1) Effect of circuit training with interval ratio to increase in VO2 Max 2) Effect of elevation of exercise site to increase VO2 Max. 3) The effect of interaction between the circuit training with the interval ratio and the height of the training site on the increase in VO2 Max. The research method used is experimental method. Population in this research was atlet Regency of Bangli and Buleleng Regency. The sample in this study was a Basketball athlete. Data collection techniques using MFT. Technique of data analysis using Analysis of Two Path Variant. Results of data analysis at significance level $\alpha = 0.05$ as follows: (1) VO2 Max athletes trained with circuit training with 1: 1 interval ratio (mean = 42.34) better than athletes trained by circuit training with ratio interval 1: 3 (mean = 39,13) obtained statistical value 10,395 with significance 0,002. (2) VO2 High-trained maxs (mean = 42.12) better than low-trained athletes (mean = 39,30) obtained statistical value of 7,784 with significance 0.007. (3) There is interaction influence between circuit training with interval ratio with altitude of exercise place obtained statistical value 49,785 with significance 0,000. The conclusion of the results of this study is that the hypothesis has been proved to be true, that circuit training with a 1: 1 interval ratio is better than circuit training with a 1: 3 interval ratio, and upland exercise is better than lowland exercise and interaction effects between the circuit training with the interval ratio and the height of the training ground. Circuit training with 1:1 interval ratio in the highlands is more appropriate.*

Keywords: circuit training, interval ratio, altitude, VO2 Max

1. Introduction

Physical fitness training is necessary to achieve physical fitness and achievement, tailored to the demands of each sport, with planned, systematic, tiered, progressive (progressive overload) and continuous training, to achieve predetermined standards [1]. To develop a proper physical exercise program and achieve goals in a particular sport, the whole should pay attention to the basic principles of the overall exercise that is; (1) overload principle, (2) principle of progressive resistance, (3) principle of arrangement of exercise, (4) principle of specificity (the principle of specificity), (5) principles of individuality, (6) principles of reversible principle, and (7) variety principles. One principle that needs special attention is the principle of progressive resistance, [1] says the attainment of an athlete's increase is a direct result of the amount and quality of practice.

Basketball is a form of exercise that requires the coordination of all organs of the body, and excellent physical fitness. Excellent physical fitness will have implications for speed, elegance, accuracy, agility, power, and excellent endurance. The technique of playing basketball is the basis for every player, including passing ball, dribbling, shooting ball [2]. The physical condition of the player is always demanded prime. The basketball also requires the stability of the locomotor condition to obtain muscle endurance. Even very necessary consolidation of heart and respiratory conditions, dynamic formation and relaxation. Physical exercise done regularly can improve

optimal physical fitness. The most important ingredient in physical fitness is cardiorespiratory endurance [3]. Maximum oxygen consumption (O₂ max) is used as a parameter of physical fitness degrees that can be trained with various model exercises to sustain the creation of other necessary motion coordination at specifications in the sport of basketball.

Circuit training forms that are combined with interval training have three characteristics: 1). Improve cardiorespiratory fitness and muscle fitness. 2). Applying the principle of progressive resistance. 3). Allows many individuals to practice in the same time, based on the ability of each individual, and obtain maximum practice in a short time. The implementation of circuit training program consists of several posts. In this research will use continuous circuit training with 6 posts ie; 1) vault over the buck, 2) double-footed jumps over a bench, working forward, 3) two forward rolls on mats, working forwards, 4) steeplechase jump, 5) sprint ten meters between two skittles, 6) continuous run up three boxes, [4].

Sports coaching to achieve maximum performance, in addition to based on physical conditions, environmental factors are also very important in achieving sports preparation. Residential environments such as temperature, climate, altitude, will have an impact on a person's physiological changes, the immediate environment will have an impact on one's physiological adaptation [5]. One environmental adaptation can be made in comparison with the difference in

partial pressure of oxygen (PO₂), both in the lowlands and highlands. In addition, differences in coastal areas and mountains in terms of air temperature and oxygen (O₂) is also different. The higher an area of the sea surface the oxygen (O₂) level is less. Given the differences in partial pressure of oxygen (PO₂) found in lowland and high plains, it will also affect the amount of hemoglobin (Hb) in red blood cell grains. Plateau or mountainous areas of oxygen (O₂) in the air will decrease. Similarly, what is being observed by [6], says that the exercise and exposure gained while practicing at altitude will increase the maximum oxygen volume and skeletal muscle characteristics.

2. Method

The samples in this study were basketball athletes living in the highlands and lowlands of the province of Bali. Sampling was conducted randomly in both areas. Samples of highland areas were taken in Bangli district with an altitude of 800-1000 meters above sea level of 36 people, while lowland samples were taken in Buleleng district of 36 people with altitude 0-100 meters above sea level.

The entire sample is divided into two groups. The experimental group was given circuit training with 1: 1 interval ratio and control group was given circuit training with 1: 3 interval ratio. The exercise program is held 3 times a week for 8 weeks. The circuit training program is carried out with the following designs: 1-6 practice meetings with 4 sets of 5 reps with 75% intensity, 7-12 meetings with 80% intensity, 13-18 meetings with 90% intensity, 19-24 meetings with 95%.

In this study, the data obtained is quantitative data. Data collection was obtained by using Test and Measurement Technique. While the instrument used in data collection is with Multi Stage Fitness Test (MFT). This physical fitness test has a reliability level of 0.98 and a Validity value of 0.77 [7].

3. Data Analysis

The collected data will be analyzed using statistical analysis. That is prerequisite test and hypothesis test. Prerequisite test in the form of normality test and homogeneity test. Normality test using Lilliefors Kolmogorov Smirnov test and homogeneity test using Levene's test on SPSS 16.0 program. If the population is normally distributed and homogeneous then the statistical analysis used is parametric statistical analysis. And if not normally distributed using non parametric statistical analysis.

Hypothesis Testing

In this research hypothesis testing using analysis of variance (anova) two way by using formula:

$$F = \frac{MSp}{MSc}$$

F= value of F test statistic

MSp: Average squared treatment

MSc: Average squared score

The data obtained was the tabulated using 2x2 factorial design and analyzed using F tes statistics (using two way Anova)

Table 1: Factorial Design 2x2

Altitude	Circuit training programe	
	Interval ratio 1:1 (A1)	Interval ratio 1:3 (A2)
High Land (B1)	A1.B1	A2.B1
Low Land (B2)	A1.B2	A2.B2

A1B1: sel group of athletes given a circuit training program with a 1:1 interval ratio on the plateau.

A2B1: sel group of athletes given a circuit training program with a 1:3 interval ratio on the plateau.

A1B2: sel group of athletes given a circuit training program with a 1:1 interval ratio in the lowlands.

A2B2: sel group of athletes given a circuit training program with a 1:3 interval ratio in the lowlands.

After done, then consulted with the F test distribution table, Ho is rejected if $F < F_{\alpha}$, then if there is interaction between variables of circuit training program with 1: 1 and 1: 3 working ratios with altitude of training site, then continued with Tukey Test to know the significant difference between cell groups.

4. Results

A. Descriptive Analysis

	Min	Max	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Std. Error	Statistic
VO ₂ max	26.80	55.60	40.7125	.69924	5.93327
circuit ratio 1:1	26.80	55.60	42.3417	1.12031	6.72184
circuit ratio 1:3	30.00	46.90	39.0833	.75957	4.55741
circuit ratio 1:1 high land	39.90	55.60	47.3167	.97747	4.14704
circuit ratio 1:1 low land	26.80	43.90	37.3667	1.14049	4.83869
circuit ratio 1:3 high land	30.00	41.90	36.9278	.83540	3.54431
circuit ratio 1:3 high land	33.60	46.90	41.2389	1.06354	4.51222

1. Maximum Oxygen Volume

The maximum oxygen volume level overall has a range of 28.80 with the lowest score of 26.80 and the highest score of 55.60. The maximum oxygen volume in this group has a mean score of 40.71, and standard deviation (standard deviation) of 13,198 (these statistical values are computed with computer program SPSS 16).

2. Maximum Oxygen volume trained with a 1: 1 ratio

Maximum oxygen volume of athletes trained with a 1: 1 ratio with no difference in the height of the exercise site, overall has a range of 28.80 with a low score of 26.80 and a high score of 55.60. The maximum oxygen volume in this group has a mean score of 42.34 and standard deviation (standard deviation) of 6.72 These statistical values are calculated by computer SPSS 16 program.

3. Maximum oxygen volume trained at a ratio of 1: 3

Maximum oxygen volume of athletes trained at a 1: 3 ratio by not differentiating the height of the exercise site, overall has a range of 16.90 with a low score of 30.00 and a high score of 46.90. The maximum oxygen volume in this group has a mean score of 39.08 and standard deviation (standard deviation) of 4.55 of these statistical values is calculated by computer program SPSS 16.

4. Maximum oxygen volume trained with a 1: 1 ratio in the highlands

Maximum oxygen volume of athletes trained with a 1: 1 ratio in the highlands, overall has a range of 15.70 with a low of 39.90 and a high score of 55.60. The maximum oxygen volume in this group has a mean score of 47.31 and standard deviation (standard deviation) of 4.14. These statistical values are calculated by computer program SPSS 16.

5. Maximum oxygen volume trained with a 1: 1 ratio in the lowlands

Maximum oxygen volume of athletes trained with a 1: 1 ratio in the low lands, overall has a range of 17.10 with a low score of 26.80 and a high score of 43.90. The maximum oxygen volume in this group has a mean score of 37.37 and standard deviation (standard deviation) of 4.83 of these statistical values is calculated by computer SPSS 16 program.

6. Maximum oxygen volume is dialed with a ratio of 1: 3 in the highlands

Maximum oxygen volume of athletes trained with a 1: 3 ratio in the highlands, overall has a range of 11.90 with a low score of 30.00 and a high score of 41.90. The maximum oxygen volume in this group has a mean score of 36.92 and standard deviation (standard deviation) of 3.54 of these statistical values is calculated by computer SPSS 16 program.

7. Maximum oxygen volume trained with a 1: 3 ratio in the lowlands.

Maximum oxygen volume of athletes trained with a 1: 3 ratio in the lowlands, overall has a range of 13.30 with a low of 33.60 and a high score of 46.90. The maximum oxygen volume in this group has a mean score of 41.29 and standard deviation (standard deviation) of 4.51 of these statistical values is calculated by computer SPSS 16 program.

B. Testing Requirement Analysis

1) Test the normality of data distribution

Calculation of data normality tes using Lilliefors Kolmogorov Smirnov test on maxymum oxygen volume data trained with 1:1 and 1:3 ratio in up land and low lan can be seen in table 3 below.

Table 3: Normality test results of data distribution

	Kolmogorov-Smirnova		
	Statistic	df	Sig.
A1B1	.145	18	.200*
A1B2	.132	18	.200*
A2B1	.146	18	.200*
A2B2	.167	18	.198

Based on the results of calculations on the group trained with a 1: 1 ratio in the highlands obtained a statistical value of 0.145 and a significance value of 0.200 (> 0.05), in groups trained with a ratio of 1: 1 in the lowlands obtained statistical value of 0.132 and value significance of 0.200 (> 0.05), in the group trained with a 1: 3 ratio in the highlands obtained statistical value of 0.146 and a significance value of 0.200 (> 0.05), in the group trained with a ratio of 1: 3 in the lowlands obtained value statistic 0,167 and significance value 0,198 (> 0,05) with significance value of all group> 0,05 hence can be concluded that data of maximal oxygen volume trained with ratio of 1: 1 and 1: 3 in highland and lowland come from data normally distributed populations.

2) Test the homogeneity of variance

Testing homogeneity of variance in this research using Levene's test. The results of Levene's test calculation yielded a statistical value of F of 0.407 with a significance of 0,748. Because the significance value >0,05 means insignificant, the variance of maximum oxygen volume score based on intercellular group is homogenous so it can be concluded tha the maxymum oxygen volume data of the athlete comes from the homogenous data.

Table 4: homogeneity test results of variance

F	Sig.
.407	.748

C. Hypothesis Testing

To prove the hypothesis of research, hence used by analysis of two path Anova. The results of the analysis can be seen in table 5 below:

Source	Mean Square	F	Sig.
Circuit training with ratio interval	191.101	10.395	.002
Altitude	143.087	7.784	.007
Interaction between circuit training and altitude	915.207	49.785	.000

From the table above can be interpreted as follows

1. Effect of circuit training method with interval ratio to VO2 Max.

Based on the calculation of variance analysis of two paths obtained value of F = 10,395 with significance 0.002. Because of the significance of 0.002 (<0.05) so it can be said there is significant influence from the use of circuit training method with the interval ratio to VO2 Max. Based on the result of data analysis, it is seen that the method of circuit training with 1: 1 inetrvl ratio has a better mean VO2 Max (Mean = 42.3417) compared to the Max VO2 level trained by circuit training method with interval ratio of 1: 3 (Mean = 39.0833)

2. Effect of circuit training in high altitude

To the hypothesis that there is influence of training place height on VO2 Max is used two-lane variance analysis. Based on the calculation of two-lane variance analysis, obtained value of F = 143,087 with significance 0.000. Because of the significance of 0.007 (<0.05), so it can be said there is a significant influence from the height of the venue of training against VO2 Max. Based on the results of the data analysis, it was observed that higher ground exercises obtained a better mean VO2 Mole (mean =

42.1225) compared with the attainment of VO2 Max trained in the lowlands (mean = 39.3028)

3. Interaction of influence between circuit training method with interval ratio and altitude on VO2 Max

To test the hypothesis that there exists an interaction effect between the circuit training method with the interval ratio and the height of the training site on VO2 Max is used a two-lane variance analysis. Based on the calculation of two-lane variance analysis, obtained value of $F = 49,785$ with significance 0.000. Because of the significance of 0.000 (<0.05) so that it can be said there is a significant influence of the interaction between the method of circuit training with the interval ratio and the height of the vocational training site. From the above conclusions there is a significant difference between antarkoloms, namely that maximal VO2 athletes trained by circuit methods with a 1: 1 ratio are higher when compared to VO2 Max trained by circuit method with a ratio of 1: 3. To see the differences between cell groups, the post-Anova test is performed, in which case the Tukey test is used as can be seen in table 6 below:

Circuit training with ratio interval	Altitude	Mean	Std. Deviation
Circuit training with interval ratio 1:1	High land	47.3167	4.14704
	Low land	37.3667	4.83869
	Total	42,3417	10.79624
Circuit training with interval ratio 1:3	High land	36.9278	3.54431
	Low Land	41.2389	4.51222
	Total	39,08335	10.20320
Total	High land	42,12225	4.19144
	Low land	39,3028	6.37959
	Total	40,7125	13.20611

From the table above can be interpreted as follows:

There is a difference between groups of exercise cell circuits with interval ratios viewed from the height of the exercise site at the athlete. From the Tukey test the results obtained in the circuit training group with a 1: 1 trained ratio in the highlands had a higher mean compared to the results in the circuit training group with a 1: 3 ratio in the highlands (47.32 > 36.92). On the other hand, the low-level 1: 1 training group had a lower average compared to the 1: 3 circuit training group in the lowlands (37.36 < 41.24)

5. Discussion

Based on the calculation of variance analysis of two paths obtained value of $F = 10,395$ with significance 0.002. Because of the significance of 0.002 (<0.05) so it can be said there is significant influence from the use of circuit training method with the interval ratio to VO2 Max. Based on the result of data analysis, it is seen that the circuit training method with the 1: 1 interval ratio has a better mean VO2 Max (Mean = 42.3417) compared to the Max VO2 level trained by the circuit training method with the interval ratio of 1: 3 (Mean = 39.0833). Acceptance of the first hypothesis that there is an effect of the circuit training method with 1: 1 interval ratio to VO2 Max indicates that the circuit training method with a 1: 1 ratio is more effective

than the 1: 3 circuit training method. This is because circuit training is an exercise with a variety of workloads done continuously for a long time and moderate intensity, at least will provide a good impact and changes in muscle changes quickly and slowly, the potential increase in aerobic capacity in both types of muscle fibers, and the occurrence increased glycolytic capacity in fast muscle fibers [8]. In addition, the application of an exercise method that combines the exercise of the circuit with interval training allows the athlete to exercise more eagerly. Due to the varied training variations that keep the athletes from boredom. To test the hypothesis that there is an influence of the height of the vocational training site on VO2 Max is used a two-lane variance analysis. Based on the calculation of variance analysis of two paths, obtained value of $F = 143.087$ with significance 0.007. Because of the significance of 0.007 (<0.05), so it can be said there is a significant influence from the height of the venue of training against VO2 Max. Based on the results of the data analysis, it was observed that higher ground exercises obtained a better mean VO2 Mole (mean = 42.1225) compared with the attainment of VO2 Max trained in the lowlands (mean = 39,3028). This is due to an increase in the blood haemoglobin period occurring in high altitude exercises. This increase in blood haemoglobin period contributes positively to the distribution of oxygen to tissues, especially muscle tissue (Saunders et al, 2015). With the effectiveness of the cardiovascular system then the utilization of oxygen to meet the needs of muscle contraction will be optimal. This is characterized by an increase in cardiovascular endurance parameters of VO2 Max.

To test the hypothesis that there exists an interaction effect between the circuit training method with the interval ratio and the height of the training site on VO2 Max is used a two-lane variance analysis. Based on the calculation of two-lane variance analysis, obtained value of $F = 49,785$ with significance 0.000. Because of the significance of 0.000 (<0.05) so that it can be said there is a significant influence of the interaction between the method of circuit training with the interval ratio and the height of the vocational training site. From the above conclusions there is a significant difference between cell groups, namely that maximal VO2 athletes trained by circuit methods with a 1: 1 ratio are higher when compared to VO2 Max trained by circuit method with a ratio of 1: 3. To see the differences between cell groups, then tested after Anova, in this case used Tukey test. From the Tukey test the results obtained in the circuit training group with a 1: 1 trained ratio in the highlands had a higher mean compared to the results in the circuit training group with a 1: 3 ratio in the highlands (47.32 > 36.92). On the other hand, the low-level 1: 1 training group had a lower average compared to the 1: 3 circuit training group in the lowlands (37.36 < 41.24).

Altitude training is used by athletes in order to improve their physical endurance and movement economics after they have returned to sea level. This practice has been used for decades. Different environmental conditions with a reduction in ambient oxygen cause adaptive changes to sportsmen's organisms, which can be describe as "natural doping" [9].

Acclimatisation to environmental hypoxia initiates a series of metabolic and musculocardiopulmonary adaptation that influence oxygen transport and utilisation. Whilst it is clear that adequate acclimatisation, or better still, being born and raised at altitude, is necessary to achieve optimal physical performance at altitude, scientific evidence to support the potentiating effects after return to sea level is at present equivocal. Despite this, elite athletes continue to spend considerable time and resources training at altitude, misled by subjective coaching opinion and the inconclusive findings of a large number of uncontrolled studies [10].

There is still much controversy about the optimal altitude and duration required for athletes to train in an attempt to optimise endurance performance at sea level. Much attention has focused on the erythropoietic response to hypoxia and subsequent haematological adaptation. Considering the inverse relationship between PO₂ and resting Hb concentration, it would seem logical that the higher the athlete can train the better. However, other factors that inhibit exercise performance are exacerbated with a reduction in PO₂. Acute mountain sickness presents at altitude above 2000 to 3000 m, with the possibility of the elite athlete suffering physiological symptoms at even lower altitudes. Prolonged exposure to altitudes above 4500 m has been shown to result in a reduction in muscle mass, the underlying physiological mechanisms for which have been recently reviewed by Kayser. Finally, the effect of training at lower PO₂ may result in a reduction in work rate, so that detraining may override the potential benefits of altitude acclimatisation [10].

Endurance athletes have been using altitude training for decades to improve near sea level performance. The predominant mechanism is thought to be accelerated erythropoiesis increasing haemoglobin mass resulting in a greater maximal oxygen uptake (VO₂ max). The conclusion of the study was that altitude training of endurance athlete will result in an increase in VO₂ max of more than half the magnitude of the increase in haemoglobin mass, which supports the use of altitude training by athletes [11].

Aerobic training increases maximal O₂ consumption by increasing the rate at which O₂ is supplied to the exercising muscles, largely through an increase in cardiac output secondary to the increase in stroke volume, and by improving the extraction of O₂ by the contracting muscles [12].

While in studies conducted on mice showed that body mass-corrected residuals of VO₂ max were significantly correlated with an index of cardiopulmonary size (summed standardized residuals of lung volume and heart mass) under both hypoxic and normoxic conditions. This research show that phenotypic plasticity in lung volume and heart mass plays an important role in maintaining aerobic performance under hypoxic conditions, and accounts for up to 55% of the variance in aerobic performance [13].

Besides that in meta-analysis revealed that for elite athletes in Korea, altitude/hypoxic training appears more effective than sea-level training for improvement of oxygen delivery capacity of the blood and aerobic exercise capacity [14].

6. Conclusion

The combination of the circuit training method with the interval ratio and the height of the exercise site contributes to each other. Given the influence of the interaction between the circuit training method with the interval ratio and the elevation of the exercise site on the increase in VO₂ Max indicates that grouping athletes in the highlands and lowlands can affect the effectiveness of the exercise method.

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