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The Effect of Circuit Training and Fartlek Training on the VO_2max of Handball Athletes

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ABSTRACT

Purpose: This research aims to determine; (1) Is there an effect of circuit training on VO2Max of handball athletes; (2) Is there an effect of fartlek training on VO2Max of handball athletes; (3) Is there a difference in the effect of circuit training and fartlek training on VO2Max of handball athletes. **Methods:** This research is an experimental research type that uses a "pre test and post test group design" research design. The population is all handball athletes. The sample used is 20 handball athletes. The sampling technique is a sample population divided into 2 groups using a block system. **Results:** The data analysis technique used is descriptive analysis, inferential analysis of the t-test at a significance level of $\alpha = 0.05$. The results of the study show that; (1) There is an effect of circuit training on VO2Max of handball athletes, with an observation value = -5.093 ($P < 0.05$); (2) There is an effect of fartlek training on VO2Max of handball athletes, with an observation value = -5.750 ($P < 0.05$); (3) There is a difference in the effect of circuit training and fartlek training on VO2Max of handball athletes, with tobservation value = 2.205 ($P < 0.05$). Conclusion: Based on the results of the study and discussion, it can be concluded that: Circuit training has a significant effect on VO2Max in handball athletes. Fartlek training has a significant effect on VO2Max in handball athletes. There is a significant difference between the effects of circuit training and fartlek training on VO2Max in handball athletes, with circuit training being more effective than fartlek training.

1. Introduction

Sports are a form of physical activity involving play, competition, and intensive activities aimed at achieving victory and optimal performance. According to Law Number 11 of 2022 concerning the National Sports System, Article 1 paragraph 1 states that “Sport is any activity that utilizes reason, body, and soul systematically and integratively to encourage, foster, and develop physical, mental, social, and cultural potential” (Pemerintah Republik Indonesia, 2022).From the explanation above, it can be seen that sports are productive activities essential for maintaining health and fitness. In addition to promoting optimal health and fitness, sports can also serve as a competitive arena, whether performed individually or collectively.

Handball is also a sport with a long and well-documented history. Historians suggest that because most men have better arm mobility than leg mobility, handball was played long before football (IHF, 2022). Handball is essentially a combination of football and basketball, and therefore, many of its rules are derived from both sports. There are currently three well-known types of handball: outdoor handball played with eleven players on a football-sized field, beach handball played with four players, and indoor handball played with seven players, also known as team handball. This sport requires considerable physical exertion in every movement and training session. Through systematic and continuous training, athletes can develop or improve their physical condition to reach an optimal level, which in turn enhances athletic performance (Wirda et al., 2017). For maximum achievement, it is advisable to start training from an early age, as physical fitness largely determines one's performance ability. The higher a person's physical fitness level, the greater their physical work capacity. In other words, higher fitness leads to greater productivity. Moreover, good fitness can also reduce the risk of injury during intense physical activity.

To improve endurance, specific types of training are necessary to enhance performance in sports activities. Training is a systematic process aimed at improving performance (Montero, 2020). To achieve this, training must be guided by a well-structured program aligned with the intended goals. Circuit training is one form of exercise that can be used to improve endurance. This type of training involves several stations, with athletes performing specific exercises at each station. In addition to circuit training, Fartlek training is another method suitable for endurance development. Fartlek is a continuous training method in which the athlete alternates between fast and slow paces throughout the session.

The novelty of this research lies in its direct examination of the comparative effects between circuit training and fartlek training on improving VO_2Max among handball athletes. Studies with this specific focus are still rare in the context of handball, as most previous research has primarily emphasized sports such as football or athletics. However, handball has distinct characteristics high intensity, rapid movement patterns, and complex energy demands that require a different training approach. Therefore, this study is expected to provide a new scientific contribution to the development of physical training methods, particularly in enhancing aerobic endurance (VO_2Max) among handball athletes, as well as serve as a reference for coaches in designing more effective, specific, and measurable training programs.

Based on the explanation above, it can be concluded that systematic and continuous training contributes to achieving optimal physical fitness. To further enhance endurance, both circuit training and Fartlek training can be applied. These two types of training are particularly effective for improving VO_2max. However, it remains unclear which of the two methods produces a more significant and positive improvement in VO_2max. Therefore, this study aims to determine the extent to which circuit training and Fartlek training have a positive and significant effect on the VO_2max of handball athletes. With this consideration, the researcher conducted a study entitled "The Effect of Circuit Training and Fartlek Training on the VO_2max of Handball Athletes."

2. Methods

In this study, the researcher used an experimental method, which is a data collection process aimed at solving problems through the use of training and testing techniques. According to Alawi et al, (2021), experimentation in a broad sense is "an activity carried out to observe a result, which serves to confirm the causal relationship between the variables under investigation."

The research was conducted at Lapangan Goro, Makassar City, involving several handball athletes as participants, and it took place in March. The research design used was a Pre-test Post-test Group Design. According to Syamsunie (2018), this design involves two groups of subjects, both of which are measured or observed twice before (pre test) and after (post test) treatment. In other words, this design involves two data collection stages: one before and one after the intervention. The purpose of this design is to verify whether the assumptions and hypotheses proposed by the researcher are supported and achieved according to the collected data.

The first step conducted by the researcher was administering the pre-test. Afterward, the researcher provided the treatment (X), consisting of leg explosive power training and arm explosive power training. The population in this study was drawn from a limited population, meaning that the number of data sources was quantitatively defined and could be accurately counted. The population consisted of 20 handball athletes.

The sampling technique used was ordinal pairing, which divides the subjects into two groups with the goal of ensuring that both groups have similar or equivalent abilities (Hasanuddin & Syahruddin, 2022). Thus, the sample of this study consisted of 20 handball athletes from Bantaeng Regency. The research instruments refer to the tools or means used by the researcher to collect data, making the work easier and the results more accurate, complete, and systematic (Shafwatul Anam, 2017). The main instrument used in this research was the Bleep Test (Multi Stage Fitness Test). According to Ishak (2018), the Bleep Test instrument has a validity coefficient of 0.915 and a reliability coefficient of 0.868, indicating that the instrument is both valid and reliable for measuring VO_2max.

To analyze the data obtained from measurements, several statistical tests were conducted to ensure the accuracy and validity of the findings. These included the normality test, homogeneity test, and hypothesis testing. The normality test was used to determine whether the data followed a normal distribution. This test was performed using SPSS software. The testing criteria were as follows: If the significance value (p) is below 0.05, the data differ significantly from a normal distribution, meaning the data are not normally distributed. The homogeneity test was conducted to ensure that the sample groups originated from a homogeneous population. This test was carried out using the F-test on pre-test and post-test data for both groups through SPSS. Finally, hypothesis testing was conducted using the t-test in SPSS to compare the mean scores between groups before and after treatment. The decision criteria were: If t-count < t-table, then Ha is rejected. If t-count > t-table, then Ha is accepted.

3. Results

The results and discussion of this study are presented sequentially as follows: (1) research data, (2) prerequisite analysis tests, and (3) hypothesis testing. The hypothesis testing is presented in the following order: (a) the effect of circuit training on the VO_2max of handball athletes; (b) the effect of Fartlek training on the VO_2max of handball athletes; and (c) the difference in the effect between circuit training and Fartlek training on the VO_2max of handball athletes.

The complete results are presented as follows. The research data obtained consisted of pre-test and post-test VO_2max scores from two groups the circuit training group and the Fartlek training group. The summary of these results is presented in Table 1 below.

Table 1. Descriptive Statistics of Circuit Training and Fartlek Training

Descriptive Statistics	Circuit Training Pre-test	Circuit Training Post-test	Fartlek Training Pre-test	Fartlek Training Post-test
Number of Samples	10	10	10	10
Lowest Score	21	25	20	24
Highest Score	29	30	27	29
Mean	24.60	28.10	23.90	26.50
Range	8	5	7	5
Standard Deviation	2.63	1.66	2.55	1.58
Median	24.00	28.50	24.50	26.50

Based on Table 1, the pre-test data of VO_2max for the handball athletes in the circuit training group, consisting of 10 samples, showed a mean score of 24.60, a standard deviation of 2.63, a median of 24.00, and a variance of 6.93. The range was 8, obtained from the minimum score of 21 and the maximum score of 29. For the post-test data of the same group, with 10 samples, the mean score increased to 28.10, with a standard deviation of 1.66, a median of 28.50, and a variance of 2.76. The range was 5, obtained from a minimum score of 25 and a maximum score of 30.

In the Fartlek training group, the pre-test VO_2max scores of 10 handball athletes yielded a mean score of 23.90, a standard deviation of 2.55, a median of 24.50, and a variance of 6.54. The range was 7, calculated from the minimum score of 20 and the maximum score of 27. For the post-test data, the mean score increased to 26.50, with a standard deviation of 1.58, a median of 26.50, and a variance of 2.50. The range was 5, obtained from a minimum score of 24 and a maximum score of 29. The descriptive results indicate that both training methods led to improvements in VO_2max performance, with the circuit training group showing a slightly higher increase compared to the Fartlek training group.

Normality Test

A Lilliefors test was conducted to determine whether the pre-test and post-test VO_2max data for both the circuit training and Fartlek training groups were normally distributed. The results of the normality test are summarized in Table 2 below.

Table 2. Normality Test Results of Circuit Training and Fartlek Training Groups

Data Group	Probability	Sig. Value	Description
Circuit Training	0.200	0.190 > 0.05	Normal Distribution
Fartlek Training	0.200	0.206 > 0.05	Normal Distribution

Based on Table 2, the results of the normality test show that the Kolmogorov–Smirnov (Lilliefors) values obtained indicate that the data are normally distributed. The normality test results for the pre-test VO_2max of handball athletes in the circuit training group (n = 10) showed a Lilliefors value of 0.190 (p = 0.200 > 0.05).

Similarly, the post-test VO_2max data for the Fartlek training group (n = 10) showed a Lilliefors value of 0.206 (p = 0.200 > 0.05). These findings indicate that the VO_2max data for both the circuit training and Fartlek training groups are normally distributed, fulfilling the normality assumption required for further statistical analysis using parametric tests.

Homogeneity Test

The homogeneity test was conducted to examine whether there was equality of variance in the VO_2max scores of handball athletes between the circuit training group and the Fartlek training group. This test is an essential prerequisite to ensure that the data used in the analysis come from a homogeneous population. The results of the homogeneity test are presented in below.

Table 3. Homogeneity Test Results of Circuit Training and Fartlek Training Groups

Data Group Comparison	Levene Statistic	Df1	Df2	Sig.
Circuit Training VO_2max	2.377	1	18	0.141
Fartlek Training VO_2max	3.094	1	18	0.096
Circuit and Fartlek VO_2max	0.969	1	18	0.278

Based on Table 3, the results of the homogeneity test of VO_2max scores of handball athletes in the circuit training and Fartlek training groups were analyzed using Bartlett's test, as follows:

Circuit Training: The Bartlett statistic is 2.377 with a probability value of 0.141. Since the probability value is greater than α = 0.05, the VO_2max data for the circuit training group, including both pre-test and post-test scores, are considered homogeneous, indicating similar ability and results within the group. Fartlek Training: The Bartlett statistic is 3.094 with a probability value of 0.096. Since the probability value is greater than α = 0.05, the VO_2max data for the Fartlek training group, including both pre-test and post-test scores, are considered homogeneous, indicating similar ability and results within the group. Circuit and Fartlek Training: The Bartlett statistic is 0.969 with a probability value of 0.278. Since the probability value is greater than α = 0.05, the VO_2max data comparing post-test scores between the circuit and Fartlek training groups are considered homogeneous, indicating similar ability and results across the two groups.

Thus, the data meet the assumption of homogeneity, allowing the use of parametric tests for hypothesis testing.

Hypothesis Test

The hypothesis test was conducted to determine the effect of circuit training and Fartlek training on VO_2max in handball athletes. The results of the hypothesis test are summarized in Table 4 below:

Table 4. Hypothesis Test Results of Circuit Training and Fartlek Training Groups

Variable	t-count	t-table	Sig. (p)
VO_2max Circuit Training	-5.093	0.576	0.001
VO_2max Fartlek Training	-5,759	0,576	0,000
VO_2max Circuit and Fartlek Training	-5.759	0.576	0.000

Based on Table 4, the summary of the t-test results for pretest (initial test) and posttest (final test) VO2Max data of handball athletes for the circuit training and fartlek training groups shows: the observed t-value is -5.093 with a significance value of 0.001, which is smaller than α = 0.05. Therefore, Ho is rejected and H1 is accepted, meaning that there is an effect of circuit training on increasing VO2Max in handball athletes.

The summary of the t-test results for the pretest and posttest of the fartlek training group in handball athletes shows: the observed t-value is -5.750 with a significance value of 0.000, which is smaller than α = 0.05. Thus, Ho is rejected and H1 is accepted, indicating that fartlek training significantly affects the VO2Max of handball athletes. For the summary of the posttest t-test results for VO2Max in handball athletes between the circuit and fartlek training groups, the observed t-value is 2.205 with a significance value of 0.041, which is smaller than α = 0.05. Therefore, Ho is rejected and H1 is accepted, indicating a difference in the effect of circuit and fartlek training on VO2Max in handball athletes.

4. Discussion

There is a significant effect of circuit training on increasing VO2Max in handball athletes. According to the t-test results for VO2Max, the observed t-value is -5.093 with a significance of 0.001, smaller than α = 0.05, indicating a significant effect after the circuit training intervention. To demonstrate the increase in VO2Max, the average values before and after the treatment were 24.60 and 28.10, respectively.

This shows an increase of 3.50 points, indicating a significant improvement in VO2Max following circuit training. Additionally, the average VO2Max after approximately one month of training showed a significant difference. Therefore, the difference in mean VO2Max values is significant. Circuit training should be designed to improve physiological capacities, including muscular strength, muscular endurance, flexibility, and cardiovascular endurance (Aprilianto & Fahrizqi, 2020).

Both training types are suitable for improving VO2Max, which is a major factor supporting endurance, though they differ in execution. Training should be cyclical to prevent boredom (Rajšp & Fister, 2020). Circuit training typically consists of several exercise elements performed for a certain duration. Circuit training aims to maximize time efficiency and provide greater and faster physiological benefits. Loop training involves a series of different exercises performed consecutively in one round (Dantas et al., 2022), emphasizing quick transitions between stations to maximize efficiency and save time. Circuit training enhances cardiovascular systems. Therefore, based on the discussion above, circuit training is recommended for athletes, particularly squats, to increase VO2Max.

Circuit training impacts the training process by focusing the athlete on movements that enhance VO2Max in handball players.There is a significant effect of fartlek training on VO2Max in handball athletes. According to the t-test results for the pretest and posttest of the fartlek training group, the observed t-value is -5.750 with a significance value of 0.000, smaller than α = 0.05, indicating a significant effect after the fartlek training intervention. The increase in VO2Max is demonstrated by the mean values before and after treatment: 23.90 and 26.50, respectively, showing an increase of 2.60 points, which is significant. Fartlek training involves aerobic work, where oxygen supply still meets the muscular demand during exercise. Fartlek training varies speed phases in a session: slow, moderate, and fast. Both training methods share similarities but differ in emphasis.

Fartlek training emphasizes the energy system to increase reserve capacity, while circuit training emphasizes work during specific exercises adapted to the sport without necessarily combining energy

systems. Fartlek is an excellent training system for sports requiring endurance. Exercise physiology explains changes in function due to single or repeated training sessions aimed at improving physiological responses to intensity, duration, frequency, environmental conditions, and individual status (Griwijoyo, 2017). Repeated training induces muscle tissue growth, including through fartlek training (Eko Supriyono, 2015). Thus, fartlek training can be applied to further improve VO2Max in handball athletes based on the results of this study.

Posttest analysis of the circuit and fartlek training groups in handball athletes shows an observed t-value of 2.205 with a significance of 0.041, smaller than $\alpha = 0.05$, indicating a difference between the two groups. The mean VO2Max values for each group confirm this: the circuit training group averaged 28.10, and the fartlek group averaged 26.50. This indicates that circuit training produced a higher mean VO2Max compared to fartlek training, suggesting that circuit training is more effective.

The difference in VO2Max improvement between circuit and fartlek training is evident in the training process. Both methods train endurance, but the movement patterns and physical components match the requirements for increasing VO2Max in handball players. Circuit training allows longer activity duration and is more effective in improving VO2Max because it closely aligns with the movement patterns and characteristics needed for handball. Physical components to be improved include cardiovascular endurance, muscular endurance, strength, flexibility, speed, stamina, agility, and power (Tanjung Yoga Nugraha & Imam Syafi'i, 2022). Training programs aim to maintain athletes' physical capacity before competitions.

Fartlek training, which involves running at varied speeds, benefits both physical conditioning and mental strength, enhancing willpower and persistence (Sukma et al., 2020). Therefore, for athletes with low motivation, fartlek training is suitable for increasing VO2Max over a 30-minute session. The study shows that circuit and fartlek training have significantly different effects on VO2Max in handball athletes. This suggests that for endurance training, circuit training is more effective in improving VO2Max, although fartlek training also significantly enhances VO2Max in handball players.

5. Conclusion

Based on the results of the study and discussion, it can be concluded that: Circuit training has a significant effect on VO2Max in handball athletes. Fartlek training has a significant effect on VO2Max in handball athletes. There is a significant difference between the effects of circuit training and fartlek training on VO2Max in handball athletes, with circuit training being more effective than fartlek training.

6. Author Contribution

1 wrote the manuscript with support from 2. 3conducted the experiment. 4 collected the XY data sample. 5 helped supervise the project. 5 also conceived the original idea and supervised the overall project.

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