

## Effect of intensity and interval levels of trapping circuit training on the physical condition of badminton players

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### Abstract:

The trapping circuit is a form of training that focuses on the lower limbs or legs to climb and descend stairs with a wide variety of movements. The objective of this research is to examine the influence of intensity and comparison of trapping circuit training intervals on the physical condition of badminton players. The research method used 2 x 2 factorial design; with an intensity of 60% or 80% and a training interval of 1:½ or 1:1. The sample size was determined by the formula from Isaac and Michael. There were 48 badminton players who were divided into 4 groups, with each group consisting of 12 samples. Leg strength was measured with a back and leg dynamometer, speed was measured by 30 meters running, and agility was measured by using the T-test. The data analysis technique used univariate analysis. The results of this research prove that there is an effect of the trapping circuit training method on strength, speed and agility abilities. Based on the results of the analysis, it is known that the group which achieved the best results was in group 3 (A1B2), which was given trapping circuit training with 80% intensity at 1:½ interval, with changes in strength increasing by 43.78%, speed increasing by 31.42% and agility increasing by 9.66. %. The group that showed the least results was group 2 (A2B1), which was given trapping circuit training with 60% intensity at 1:1 interval with changes in strength increasing by 1.75%, speed decreasing by 3.25% and agility decreasing by 4.43. %.

**Key Words:** Interval training, strength, speed, agility

### Introduction

Badminton is a game full of various abilities and complex movement skills (Robertson et al., 2018). The player must perform a variety of moves such as sprinting, stopping suddenly and immediately moving again, jumping, reaching, turning quickly and making wide steps without ever losing balance. These moves are done repeatedly and for an extended duration during the match. As a result of doing these moves, athletes may end up in fatigue, which will affect the work of the heart, lungs, circulatory system, breathing, muscle work and joints.

In an effort to support the improvement of badminton sports achievement, interval training cannot be separated from the process of coaching an athlete, especially in terms of the physical condition of the badminton athletes. Badminton sports coaching should be specially programmed, as the badminton athletes cannot only rely on their playing skills, but also take into consideration their physical condition. A badminton athlete is demanded to have excellent physical condition, since the physical condition is the most dominant basic preparation for maximum physical performance in order to gain the best achievement (Jones et al., 2018). Through a well-programmed physical training process, badminton players should have physical fitness qualities that have a positive effect on the mental and psychological fitness, which ultimately has a direct effect on the performance of playing techniques. Bompa and Buzzichelli (2015) stated that all programmed sports training must cover four basic training factors; physical training, technical training, tactical training, psychological and mental training.

Physical training with trapping circuit is a form of training that is done by optimizing the lower limbs by climbing and descending stairs with 15 cm height consisting of nine forms of exercises including; 1) sprint trapping, 2) one foot trapping, 3) right side jump trapping, 4) left side run trapping, 5) broad jump trapping, 6) right side run trapping, 7) left side jump trapping, 8) one foot side jump trapping, and 9) high jump trapping. Apart from circuit training, the interval training method can also help improve cardiovascular fitness, increase speed, increase agility and increase overall aerobic capacity. Interval training is a training implemented with high or low intensity training periods interspersed with rest periods (Syamsudin et al., 2021). Silva et al. (2019) stated that interval training can be done in various forms such as circuit training, interval running and interval swimming.

Bossi, et al (2020: 1) argued that high-intensity interval training can optimize the pressure of the oxygen transport system so it is important to give athletes a form of training that stimulates respiratory adaptation in the body. Arslan et al. (2020) determined that long interval training, working duration 2 to 5 minutes with an intensity of 80-90% of maximum performance, with a ratio of 1:1 or 1:2 to work-to-rest ratio would produce

optimal results. Sawyer, Cavalheri & Hill (2020) stated that 1: 1 interval training method is where work time is proportional to rest time, so that the 1:1 training method makes it easy for athletes to do exercises that are proportional to work time and rest time where the energy system used is ATP-PC + lactate (20-45 seconds). Guidelines in an interval training program based on the comparison between activity time and rest time are in accordance with the development of the energy system. Time used to develop an aerobic energy system can be done for 3 (three) minutes to 5 (five) minutes with a ratio of 1:1 and 1:½. Meanwhile, to improve the anaerobic energy system it can be done in 10 (ten) seconds to 2 (two) minutes, with a ratio of 1:3 and 1:2.

The basic training factors include physical, technical, tactical and psychological preparations, which are closely related, but each formation has its own way of improving the outcome. Out of the four basic factors of exercise, Trecroci et al. (2020) stated that physical formation is the most important factor in an exercise program that aims to achieve optimal physical abilities. Optimal physical formation requires regular, programmed and conditioned training so that it can create and improve physical condition permanently, effectively and efficiently. If the implementation of the form of physical exercise is not done effectively and efficiently in the correct way, then the training process is meaningless. The training process that only relies on efficiency without considering the aspect of effectiveness is feared of providing a portion or a measure of training that is not in accordance with the load or abilities possessed by the trainee. If the training load given is too heavy, it will damage the potential and ability of the athlete in the training (Kalkhoven et al., 2021).

In improving the physical condition, the implementation of the training program must be well planned, systematic and aimed at increasing the physical fitness and functional abilities of the body systems, so as to enable athletes to achieve better performance. Overall, the physical condition of an athlete is a biomotor component. Mkaouer et al. (2018) claimed that the basic components of physical condition in terms of the concept of muscle include; endurance, strength, explosiveness (power), speed, flexibility, agility, balance and coordination; whereas in terms of the metabolic process, it consists of aerobic power and anaerobic power. Physical ability is one of the most dominant components in badminton sport achievement (Khan, 2019). Badminton achievements cannot be separated from the elements of tactics, techniques and physical quality. Badminton requires the qualities of strength, endurance, flexibility, speed, agility and good movement coordination. These aspects are really needed in order to be able to move and react to explore every corner of the court during the match.

A badminton player who wants to progress or to maintain his achievements, besides having to practice technique, must also continue to train physically regularly. The right training method plays a very important role in improving the physical condition of badminton athletes is circuit training. From the results of the research, after doing circuit training which consisted of two programs, namely using body weight and an aerobic program, there was significant improvement in the health, cardiorespiration and muscle fitness of the athlete (Anitha et al., 2018). Ghasemnian, et al. (2020) found that high intensity circuit training (HICT) is an efficient way of training to help reduce body fat, increase insulin sensitivity, increase VO<sub>2</sub> Max and muscle fitness.

The important physical condition components in badminton include strength, endurance, speed and agility. The physical condition of the athlete contributes to the achievement of good performance. However, to ensure the good performance is consistently achieved, training must incorporate excellent technique, tactics as well as excellent physical condition (Moreno, 2020). In order to understand the required circuit training method, it is necessary to know the extent to which low-intensity and high-intensity circuit trapping training with a combination of training using different intervals can affect the strength, speed and agility abilities of badminton players.

### **Material & Method**

The method was based on a quasi-experimental research. The treatment group was measured by giving the type of exercise in the form of trapping circuits with 60% and 80% intensity with the ratio 1: ½ interval and 1: 1 interval to increase strength, speed and agility. Strength was measured by using a digital back and leg dynamometer, in which the participants wore a waist strap attached to the dynamometer leg, then they stood by bending their knees to an angle of ± 110-1200 (degrees) and tried their best in straightening their legs and then looked at the tool needle. The tool displayed a number that stated the amount of muscle strength of the tested leg. Speed was measured by 30 meters sprint, the participants stood behind the starting line on the signal "ready" the participants took a standing start stance, prepared to run and on the signal "yes" the participants ran as fast as possible to the finish line.

The results recorded was the time (in seconds) for the participants to cover the 30 m distance. Agility was measured by the T-test, where the participants stood behind the starting line with a standing stance, on the "yes" signal, the participants ran forward covering a distance of 10 meters, ran to the right side covering a distance of 5 meters, ran to the left side at a distance 10 meters, ran to the right side at a distance of 5 meters, then run back and forth covering a distance of 10 meters by following the line until they crossed the finish line. Measurements were taken once with a stop watch, and it was measured to one hundredth of a second.

This research used a factorial design as shown in the Table 1:

**Table 1. Factorial Design**

		Interval (B)	
		Interval 1:1/2 (B <sub>1</sub> )	Interval 1:1 (B <sub>2</sub> )
Method of Physical Exercise (A)	Trapping Circuit with 60% intensity (A <sub>1</sub> )	A <sub>1</sub> .B <sub>1</sub>	A <sub>1</sub> .B <sub>2</sub>
	Trapping Circuit with 80 % intensity (A <sub>2</sub> )	A <sub>2</sub> . B <sub>1</sub>	A <sub>2</sub> . B <sub>2</sub>
<i>Dependent Variable (C)</i>			
(1) Strength, (2) Speed, (3) Agility			

The research population was male students who took the badminton training. The sample size was determined by the formula from Isaac and Michael (Sugiyono, 2013: 128). The formula used was as described in Formula 1:

$$S = \frac{\lambda^2 \cdot N \cdot P \cdot Q}{d^2(N - 1) + \lambda^2 \cdot P \cdot Q}$$

**Formula 1. Isaac and Michael's Formula for Sample Size**

Detail:

- S = Total sample
- $\lambda^2$  = Chi Square, the value depends on the freedom degree and the mistake level. For the degree 1 and 5% mistake for the level of Chi Square = 3.841
- N = Total population
- P = Chances of True (0.5)
- Q = Chances of False (0.5)
- d = Gap between the expected sample and the actual sample. The gap could be 1%, 5%, and 10%. In this research it gained 5%.

After being calculated with the formula 1 with a population of 55 participants, the sample size was about 48 samples. The number of samples that had been determined were divided into 4 groups with 12 samples for each group.

The research data collection was gained through tests and measurements applied to the research sample. The data collection consisted of three (3) components of the physical condition to be measured, such as: (1) Strength test using back and leg dynamometer, (2) Speed test with 30 meters sprint and (3) Agility test with T-test. The data analysis techniques were as follows:

1. The normality test was done to determine whether the data had a normal distribution or not. The test used the Kolmogorov Smirnov test.
2. The variance homogeneity test was done to test the variance of the data variance in each group. Homogeneity test used the Levene's Test with the F-test.
3. The T-test was conducted to determine whether there were differences in variables between groups or not. The results of the analysis stated that there was a difference if the significance value was less than 0.05 (P < 0.05).

**Results**

The research results obtained the data relevant to the objectives and hypotheses. Presentation of research data can be in the form of tables, graphs, pictures or charts, arranged according to the stages of research implementation. This research aims to examine the effect of circuit trapping training with the intensity of 60% and 80% with 1:1/2 intervals and 1:1 intervals on increasing strength, speed and agility. The combination of these treatment groups can be described as follows:

1. Group 1 (A1B1), treated with 60% intensity trapping circuit training with 1:1/2 intervals
2. Group 2 (A1B2), treated with 60% intensity trapping circuit training with 1:1 intervals
3. Group 3 (A2B1), treated with 80% intensity trapping circuit training with 1:1/2 intervals
4. Group 4 (A2B2), treated with 80% intensity trapping circuit training with 1:1 intervals

The data of this research were obtained from four treatment groups using factorial experimental design which was observed twice, namely the pretest data to test the equality of data, and the post test data to prove the research hypothesis. The results of factorial analysis on the data of this study are as follows:

a. Result of Pretest Data

Result of the data equality before the treatment or pretest can be seen in Table 2:

**Table 2. Result of Pretest**

Data	Group	Mean
Strength	Group 1	201.95
	Group 2	200.45
	Group 3	196.33
	Group 4	219.79
Speed	Group 1	4.76
	Group 2	4.61
	Group 3	4.71
	Group 4	4.79
Agility	Group 1	11.73
	Group 2	11.74
	Group 3	11.39
	Group 4	12.13

Based on Table 2, it is observed that the mean value of the measurement results for the data of strength, speed and agility before the treatment was were all relatively the same.

The results of the factorial analysis on the pretest statistics including the strength, speed, and agility before given the treatment can be seen in Table 3.

**Table 3. Result of Pretest Statistics**

Method	Variable	F count	p	Detail
Method of Training	Strength	0.274	0.603	Insignificant
	Speed	0.322	0.573	Insignificant
	Agility	0.006	0.939	Insignificant
Interval	Strength	0.703	0.406	Insignificant
	Speed	0.072	0.790	Insignificant
	Agility	1.789	0.188	Insignificant
Interaction of training method, Interval	Strength	0.909	0.346	Insignificant
	Speed	0.890	0.351	Insignificant
	Agility	1.710	0.198	Insignificant

The factorial analysis on the pretest data indicated that, the results was insignificant on the method of training, interval and on the interaction of training method and interval. It shows that during pretest all groups have the same abilities, as seen from the measurement results on the strength, speed and agility before the given treatment. It means that the abilities in each group during the pretest or before given treatment is the same level.

b. Hypothesis Testing on Post Test Data

Hypothesis testing on the data after the given treatment or post test can be seen in Table 4:

**Table 4. Result of Post Test**

Data	Group	Mean
Strength	Group 1	258.75
	Group 2	203.95
	Group 3	282.29
	Group 4	255.58
Speed	Group 1	3.88
	Group 2	4.76
	Group 3	3.23
	Group 4	4.50
Agility	Group 1	10.59
	Group 2	12.26
	Group 3	10.29
	Group 4	10.97

The results of the factorial analysis on the influence of circuit trapping training with the intensity of 60% and 80% with the interval of 1:½ an with the interval of 1:1 on the strength, speed and agility is presented in Table 5.

**Table 5. Result of Post Test Statistics**

Method	Variable	F count	P	Detail
Method of Training	Strength	35.919	0.000	Significant
	Speed	44.281	0.000	Significant
	Agility	25.160	0.000	Significant
Interval	Strength	42.227	0.000	Significant
	Speed	250.813	0.000	Significant
	Agility	55.096	0.000	Significant
Method of Training, Interval	Strength	5.014	0.030	Significant
	Speed	7.827	0.008	Significant
	Agility	9.769	0.003	Significant

- 1) Method of training  
The results of factorial analysis on the training method attained a significance value of less than 0.05 ( $p < 0.05$ ) for all variables. This means that there is a significant effect of the trapping circuit training method on strength, speed and agility abilities.
- 2) Interval  
The results of factorial analysis on the training interval attained a significance value of less than 0.05 ( $p < 0.05$ ) for all variables. This means that there is a significant effect of interval training on strength, speed and agility abilities.
- 3) Interaction between Method of Training and Interval  
The results of factorial analysis on the interaction of the trapping circuit training method and the interval obtained a significance value of less than 0.05 ( $p < 0.05$ ) for all variables. This means that there is a significant interaction with the trapping circuit training method with an intensity of 60% and 80% with a difference of 1:½ and 1:1 intervals on the strength, speed and agility abilities, therefore the hypothesis in this study can be accepted.

c. Percentage of Improvement on Each Group

Percentage of improvement on each group can be seen in Table 6.

**Table 6. Percentage of Physical Condition Improvement**

Physical Abilities	Group	Mean of Pree test	Mean of Post test	Improvement (%)
Strength	Group 1	201.95	258.75	28.13
	Group 2	200.45	203.95	1.75
	Group 3	196.33	282.29	43.78
	Group 4	219.79	255.58	16.28
Speed	Group 1	4.76	3.88	18.49
	Group 2	4.61	4.76	-3.25
	Group 3	4.71	3.23	31.42
	Group 4	4.79	4.50	6.05
Agility	Group 1	11.73	10.59	9.72
	Group 2	11.74	12.26	-4.43
	Group 3	11.39	10.29	9.66
	Group 4	12.13	10.97	9.56

The results of this study as a whole prove that there is an effect of the trapping circuit training method with an intensity of 60% and 80% with a difference of 1:½ and 1:1 interval on strength, speed and agility abilities. Based on the results of the analysis by the percentage increase in the mean value of treatment results in each treatment group, it indicates that the group that gets the best results is in group 3 (A2B1), the group which was given treatment with trapping circuit training, with 80% intensity with 1:½ intervals. The changes were strength, which increased by 43.78%, speed, which increased by 31.42% and agility, which increased by 9.66%. The group that showed the least results was group 2 (A1B2), which was given 60% intensity trapping circuit training with 1:1 interval. The changes were strength, which increased by 1.75%, speed, which decreased by 3.25% and agility, which decreased by 4.43%.

**Discussions**

Based on the results of the research, the form of trapping circuit training with an intensity of 60% and 80%, the difference between the rest intervals of 1:½ and 1:1 has a significant effect on the increase in strength, speed and agility abilities. The ability of strength, speed and agility can be increased if the training is applied by stimulating the lower limbs which is given in sequence by applying the appropriate interval and loading system. These results are in accordance with the research of Ihsan, Mentara, and Kamarudin (2018: 54) that the application of interval training has a significant effect on increasing speed with the results obtained that  $t_{count} = 9.641$  and  $t_{table} = 2.201$ , because  $t_{count}$  is greater than  $t_{table}$  or  $9.641 > 2.201$  at a significant level of 5% with a degree of difference ( $db = N-1 (12-1) = 11$ ) or an increase in pre-test and post-test of 6.14 with a mean deviation of 0.511 or an increase of 1.02%. Furthermore, Fajrin et al. (2018) denoted that exercises of High Intensity Interval Training significantly effect the increase in power, limbs, speed and agility after being given the treatment for six weeks.

In addition, research by Rohman (2015) stated that training using the rope jumps with the interval training method showed that the average difference for agility before and after treatment obtaining a  $t_{count}$  of 0.866, the value of  $t_{table}$  with a significance level of 0.05 with  $df = 14$  at 2.977. As such, the agility variable has no difference before and after being treated, because  $t_{count}$  was smaller than  $t_{table}$  ( $0.866 < 2.977$ ). Meanwhile, Hardiansyah's research (2017: 83) concluded that there was a significant effect of the interval training method on improving physical fitness, which included cardiovascular endurance, muscle endurance, muscle strength, flexibility, speed and coordination, with the results of the dependent sample difference test obtaining a  $t_{count}$  of 3.56, while  $t_{table}$  at  $\alpha = 0.05$  and degrees of freedom ( $dk = n-1$ ) is 1.74, so that  $t$  is greater than  $t_{table}$  ( $3.56 > 1.74$ ).

One of the activities that can stimulate the lower limbs is a form of training by applying circuit trapping exercises (Beato et al., 2020). Circuit trapping exercise is a form of exercise that is done by climbing and descending stairs that are approximately knee-high with a variety of different types of exercises. Exercises are carried out sequentially, by applying a form of training such as circuit training. Circuit training is a form of training that consists of various activities combined into a programmed series of exercises with a rest during each post. Nasrulloh et al. (2020) stated that the circuit system consisted of a series of resistance exercises carried out consecutively with minimal rest between each exercise; by doing circuit training, the athlete can increase the time to lactate threshold, body composition and increase strength and endurance. Nagano et al. (2020) argued that a badminton player had 5 physical loads in his game, including (1) the type of domain motion function, (2) workload intensity, (3) load patterns, (4) duration (timeframe) of work, and (5) the predominant energy system. The motion functions that are very important in badminton are flexibility, speed, strength, agility and accuracy. Physiologically, the workload in badminton is a heavy workload. During game time, the heart rate of a single player can reach 180 beats per minute and the lactic acid level can reach 12-13 mM.

The workload pattern of badminton is double interval (Fu et al., 2021). At the time of the game, a short interval load pattern occurs, especially when the player chases and hits the shuttlecock and while waiting for the shuttlecock to return. This pattern lasts a few seconds. The second interval occurs when the shuttlecock is set. The time period lasts from 30 seconds to 2 minutes, while the rest period varies. One badminton game can last for about 15-20 minutes. The energy system used by muscles to carry out a work is influenced by the intensity, speed, and length of work. The workload intensity of badminton is quite heavy, the duration is ½ - 1 minute for one rally and requires high speed. From the nature of the workload, it can be estimated that the main energy system badminton is an anaerobic energy system, the ATP-PC-lactic acid system, while the aerobic power system serves as a support.

Based on research data, in doing the form of trapping circuit training with an intensity of 60% and 80% with a difference of 1:½ and 1:1 interval, it is acknowledged that the data on the results of the increase in strength abilities are as follows; group 1 is at 28.13%, group 2 is at 1.75%, group 3 at 43.78%, and group 4 at 16.28%. The speed ability showed an increase as follows; group 1 at 18.49%, group 3 at 31.42% and group 4 at 6.05%. Meanwhile, for group 2, it experienced a decrease of 3.25%. The agility ability obtained the following improvement data; group 1 was at 9.72%, group 3 was at 9.66% and group 4 was at 9.56%. Meanwhile, for group 2, the agility ability also decreased, at about 4.43%.

From these data it can be seen that the ability of strength, speed and agility that increased the most was found in group 3. Group 3 is a group that does 80% intensity trapping circuit training with 1:½ intervals, by doing exercises with maximum loading and taking a short restin between can increase the ability of strength, speed and agility to the maximum. One type of exercise that can improve the ability to be in optimal physical condition is an exercise which consists of a complete unity of components that cannot be separated, both in terms of its improvement and maintenance (Bherer et al., 2021). This means that in improving the physical condition, all components must be developed even though it is done with a priority system according to the required condition or status. Of the several types of physical condition components, most of them must be included in the circuit training program that will be given to every athlete in the sport of achievement (Bovas, 2020). A good physical condition will affect psychological aspects such as an increase in work motivation, work morale, self-confidence thoroughness and so on (Martino et al., 2008).

## Conclusion

Based on the discussion of the research, several conclusions can be drawn showing that there is an influence of the trapping circuit training method on strength, speed and agility abilities. Based on the analysis, it is known that the group which obtained the best results was group 3 (A2B1), which was given the trapping circuit training with 80% intensity at 1:½ intervals, with changes in strength increasing by 43.78%, speed increasing by 31.42% and agility increased by 9.66%. The group that showed the least result was group 2 (A1B2), which was given trapping circuit training with 60% intensity at 1:1 interval with changes in strength increasing by 1.75%, speed decreasing by 3.25% and agility decreasing by 4.43%.

## References

- Anitha, J., Kumaravelu, P., Lakshmanan, C., & Govindasamy, K. (2018). Effect of plyometric training and circuit training on selected physical and physiological variables among male Volleyball players. *International Journal of Yoga, Physiotherapy and Physical Education*, 3(4), 26-32.
- Arslan, E., Orer, G. E., & Clemente, F. M. (2020). Running-based high-intensity interval training vs. small-sided game training programs: effects on the physical performance, psychophysiological responses and technical skills in young soccer players. *Biology of Sport*, 37(2), 165.
- Beato, M., de Keijzer, K. L., Fleming, A., Coates, A., La Spina, O., Coratella, G., & McErlain-Naylor, S. A. (2020). Post flywheel squat vs. flywheel deadlift potentiation of lower limb isokinetic peak torques in male athletes. *Sports Biomechanics*, 1-14.

- Bherer, L., Langeard, A., Kaushal, N., Vranceanu, T., Desjardins-Crépeau, L., Langlois, F., & Kramer, A. F. (2021). Physical exercise training effect and mediation through cardiorespiratory fitness on dual-task performances differ in younger-old and older-old adults. *The Journals of Gerontology: Series B*, 76(2), 219-228.
- Bompa, T.O. and Buzzichelli, C. (2015). *Periodization Training for Sport*. United States: Human Kinetics.
- Bossi, A.H., Mesquida, C., Passfield, L., Rønnestad, B.R., and Hopker J.G. (2020). *Optimizing Interval Training Through Power-Output Variation Within the Work Intervals*. International Journal of Sports Physiology and Performance, (Ahead of Print. <https://doi.org/10.1123/ijspp.2019-0260>). © 2020 Human Kinetics, Inc
- Bovas, J. (2020). Effect of circuit training and interval training on change of achievement motivation in kabaddi players. *IJRAR-International Journal of Research and Analytical Reviews (IJRAR)*, 7(1), 967-976.
- Fajrin, F., & Kusnanik, N. W. (2018). Effects of high intensity interval training on increasing explosive power, speed, and agility. In *Journal of Physics: Conference Series* (Vol. 947, No. 1, p. 012045). IOP Publishing.
- Fu, Y., Chen, X., Li, Y., Li, B., Wang, X., Shu, Y., & Shang, L. (2021). Comparison of Energy Contributions and Workloads in Male and Female Badminton Players During Games Versus Repetitive Practices. *Frontiers in Physiology*, 12, 677.
- Ghasemnian, A., Usefpour, M., Rahmani, A., & Iddehloei, Z. (2020). Comparing the Effect of Two Methods of High-Intensity Interval Training (HIIT) and High-Intensity Continuous Training (HICT) on Damage and Antioxidant Indices of Liver in Male Wistar Rats. *Journal of Archives in Military Medicine*, 8(1).
- Hardiansyah, S. (2017). *Pengaruh Metode Interval training terhadap Peningkatan Kesegaran Jasmani mahasiswa Jurusan Pendidikan Olahraga*. Jurnal PENJAKORA. Volume 4 Nomor 1, Edisi September 2017.
- Ihsan, Mentara dan Kamarudin (2018). Pengaruh Latihan Interval Training Terhadap Kecepatan dalam Permainan Futsal Pada Atlet Orinity. *Tadulako Journal Sport Sciences and Physical Education* Volume VI Nomor 1 Januari – Juni 2017 ISSN 2337-4594.
- Jones, A. M., Thompson, C., Wylie, L. J., & Vanhatalo, A. (2018). Dietary nitrate and physical performance. *Annual review of nutrition*, 38, 303-328.
- Khan, M. T. (2019). Sports Achievement Motivation and Its Relation with Low and High Performers of Badminton Players. *History Research Journal*, 5(5), 2007-2011.
- Kalkhoven, J. T., Watsford, M. L., Coutts, A. J., Edwards, W. B., & Impellizzeri, F. M. (2021). Training load and injury: causal pathways and future directions. *Sports Medicine*, 1-14.
- Martino, G., Langher, V., Cazzato, V., & Vicario, C. M. (2019). Psychological factors as determinants of medical conditions. *Frontiers in psychology*, 10, 2502.
- Mkaouer, B., Hammoudi-Nassib, S., Amara, S., & Chaabène, H. (2018). Evaluating the physical and basic gymnastics skills assessment for talent identification in men's artistic gymnastics proposed by the International Gymnastics Federation. *Biology of sport*, 35(4), 383.
- Moreno, T. (2020). Quality sport coaching in action: The application of the national standards for sport coaches to the high-performance sport context. *Strategies*, 33(6), 36-41.
- Nagano, Y., Sasaki, S., Higashihara, A., & Ichikawa, H. (2020). Movements with greater trunk accelerations and their properties during badminton games. *Sports biomechanics*, 19(3), 342-352.
- Nasrulloh, A., Prasetyo, Y., Nugroho, S., Yuniana, R., Pratama, K. W., Mustapha, A., & Idrus, S. Z. S. (2020, April). Tricet Method to Increase the Hypertrophy Muscle. In *Journal of Physics: Conference Series* (Vol. 1529, No. 3, p. 032006). IOP Publishing.
- Robertson, K., Pion, J., Mostaert, M., Norjali Wazir, M. R. W., Kramer, T., Faber, I. R., ... & Lenoir, M. (2018). A coaches' perspective on the contribution of anthropometry, physical performance, and motor coordination in racquet sports. *Journal of sports sciences*, 36(23), 2706-2715.
- Rohman, S. (2015). *Pengaruh Pelatihan Rope Jump dengan Metode Interval Training Terhadap Kelincahan*. Jurnal Kesehatan Olahraga. Vol 3. Nomor 1 Tahun 2015 Halaman 207-214.
- Sawyer, A., Cavalheri, V., & Hill, K. (2020). Effects of high intensity interval training on exercise capacity in people with chronic pulmonary conditions: a narrative review. *BMC Sports Science, Medicine and Rehabilitation*, 12(1), 1-10.
- Silva, M., Baptista, L., Neves, R., França, E., Loureiro, H., Rezende, M., ... & Martins, R. (2019). High intensity interval training improves health-related quality of life in adults and older adults with diagnosed cardiovascular risk. *Journal of Physical Education and Sport*, 19(01), 611-618.
- Sugiyono. (2013). *Metode Penelitian Kombinasi (Mixed Methods)*. Bandung: Alfabeta.
- SYAMSUDIN, F., WUNGU, C. D. K., QURNIANINGSIH, E., & HERAWATI, L. (2021). High-intensity interval training for improving maximum aerobic capacity in women with sedentary lifestyle: a systematic review and meta-analysis. *Journal of Physical Education and Sport*, 21(4), 1788 – 1797. DOI:10.7752/jpes.2021.04226.
- Trecroci, A., Duca, M., Formenti, D., Alberti, G., Iaia, F. M., & Longo, S. (2020). Short-term compound training on physical performance in young soccer players. *Sports*, 8(8), 108.