Application of exercise methods and body mass index (BMI) has an effect on increasing maximum oxygen consumption

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Authors’ Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

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DOI: https://doi.org/10.58962/HT.2023.1.3.29-37

How to site

Ilyas NNL, Hidayatullah MF, Riyadi S. Application of exercise methods and body mass index (BMI) has an effect on increasing maximum oxygen consumption. Health Technologies. 2023;1(3):29-37. https://doi.org/10.58962/HT.2023.1.3.29-37

Abstract

Rationale and purpose The purpose of this study is to determine the application of exercise methods and body mass index has an effect on increasing maximum oxygen consumption

Material and Methods The study involved 62 volunteers aged 20-25 who ran at the amateur level 3 times a week for 40-60 minutes. Thirty-two of the study participants had a body mass index less than 25. 30 participants had a body mass index greater than 25.

This research refers to a quantitative approach. This study employed an experimental approach with a 2x2 factorial design. Experiments with factorial design are defined as experiments where factors are crossed with other factors in the experiments carried out.

Results According to the research, there is a significant relationship between Body Mass Index and High Intensity Interval Circuit Training (HIICT) when it comes to increasing VO2max. High Intensity Interval Circuit Training (HIICT) with a work-to-rest ratio of 1:3 makes players with a BMI of less than 25 more suitable. High Intensity Interval Circuit Training (HIICT) with a work-to-rest ratio of 1:5 is more suitable for players with a BMI below 25.

Conclusions It was found that there is a significant relationship between body mass index and high intensity interval circuit training (HIICT) when it comes to increasing VO2max. High-intensity interval circuit training (HIICT) with a 1:3 work/rest ratio makes participants with a BMI of less than 25 more fit. High-intensity interval circuit training (HIICT) with a work-to-rest ratio of 1:5 is more suitable for participants with a BMI below 25.

Keywords Exercise Methods, Body Mass Index (BMI), VO2max
Анотація

Нурна Ніса Лістіоваті Ільяс, М. Фуркон Хідаятулла, Сламет Ріяді. Вплив застосування методів фізичних вправ та індексу маси тіла (ІМТ) на збільшення максимального споживання кисню

<table>
<thead>
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<th>Обґрунтування і мета</th>
<th>Мета: визначити, як застосування методів фізичних вправ та індексу маси тіла впливає на збільшення максимального споживання кисню.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Матеріал і методи</td>
<td>У дослідженні взяли участь 62 добровольці 20-25 років, які займалися бігом на аматорському рівні 3 рази на тиждень по 40-60 хвилин. 32 учасники дослідження були з індексом маси тіла менше 25. 30 учасників були з індексом маси тіла більше 25. Це дослідження відноситься до кількісного підходу. У цьому дослідженні використовувався експериментальний підхід із факторним дизайном 2х2. Експерименти з факторним дизайном визначаються як експерименти, у яких фактори схрещуються з іншими факторами в проведених експериментах.</td>
</tr>
<tr>
<td>Результати</td>
<td>Результати дослідження показали, що учасники, які мають файл ваги ≥ 25, мають розширення результатів VO2max, які не зовсім такі, як учасники, які мають список ваги &lt; 25. Це підтверджується значенням Fcount = 11,9158 &gt; Ftable = 4,11. Таким чином недійсні спекуляції (H0) відхилюються. І це означає, що учасники, які мають файл ваги ≥ 25, мають розширення результатів VO2max, які не зовсім такі ж, як учасники, які мають рекорд ваги &lt; 25, можна визнати. Подальше дослідження показало, що учасники з індексом маси тіла нижче 25 покращили свої результати VO2max більше, ніж учасники з індексом маси тіла вище 25, із середнім збільшенням 4467 і різницею 3310.</td>
</tr>
<tr>
<td>Висновки</td>
<td>Визначено, що існує значний зв’язок між індексом маси тіла та високоінтенсивним інтервальним круговим тренуванням (НІГТ), коли йдеться про збільшення VO2max. Високоінтенсивне інтервальне кругове тренування (НІГТ) із співвідношенням роботи та відпочинку 1:3 робить учасників з IMT менше 25 більш придатними. Високоінтенсивне інтервальне кругове тренування (НІГТ) із співвідношенням роботи до відпочинку 1:5 більше підходить для учасників з IMT нижче 25.</td>
</tr>
<tr>
<td>Ключові слова</td>
<td>методи виконання вправ, індекс маси тіла (IMT), VO2max</td>
</tr>
</tbody>
</table>


Introduction

Sport is defined as a way of developing competitive traits in individuals that produce winners or losers in the games played. Sport connects with any type of active work or serious play, pointed toward utilizing, keeping up with or improving actual capacities and abilities. Sport can be done through casual or organized participation to improve one's physical health [1]. Human exercises that include effort and actual abilities as the fundamental focal point of action, with components of rivalry or social cooperation where there are rules and examples of conduct that administer these exercises, are for the most part perceived as sports [2]. Participation in a sport or physical activity will often depend on how the activity is observed and perceived by the individuals participating [3]. Participation can be for relaxation, health, well-being or pleasure with the main activity requiring physical exertion.

Sport is an interesting field of study so that many sports circles devote their attention to efforts to increase fitness and achievement [4]. The rise in sports achievement is progressive and dynamic, and it tends to rise in tandem with the advancement of science and technology in every era. The maximum oxygen uptake during exercise is known as VO2max [5]. Compared to those with poor fitness, people with good fitness can perform activities more vigorously and have higher VO2max values [6]. VO2max is limited by the limit of the cardiorespiratory system to pass oxygen on to the muscles [7]. VO2max can be used as a marker of current health and a predictor of future health against various risk factors for non-communicable diseases [8]. A low VO2max value is an important predisposing factor in the increase in premature mortality due to cardiovascular disorders [9].

VO2max alludes to how much oxygen the body can retain and use while working out [10]. The breathing system is fundamentally fixed by oxygen. The lungs absorb oxygen and transform it into a form of energy known as adenosine triphosphate (ATP) when a person breathes in. ATP helps the breathing system release carbon dioxide and controls the phones. The more noticeable the VO2max, the more oxygen the body can consume, and the more actually the body uses oxygen to make the most drastic action of ATP energy [11]. Before and after a training cycle, VO2max is typically used to measure an athlete's aerobic endurance or cardiovascular fitness [12]. Lactate edge, the place where lactate develops in the circulation system quicker than the body can eliminate it during exercise, is connected with VO2max [13]. At the point when a competitor arrives at the lactate limit, the competitor will get a consuming or squeezing feeling.

In addition to considering the ratio between work time and rest time, the determinants of VO2max are also considered, one of which is Body Mass Index (BMI) [14]. Excess body weight directly affects VO2max decline [15]. This happens because the increased body weight in athletes is caused by the accumulation of fat stores in adipose cells, muscle glycogen, and bone strengthening and bone density so that it can shrink VO2max [16]. Therefore athletes must avoid weight gain to keep VO2max high [17]. So it is necessary to measure BMI in athletes so that they can know the increase in VO2max athletes who have been trained with High Intensity Interval Circuit Training (HIICT) [18]. Based on the background that has been described, it is known that exercise and Body Mass Index (BMI) have an effect in achieving an increase in VO2max. High Intensity Interval Circuit Training (HIICT) with a ratio of work time and rest time of 1:3 and 1:5 has not been applied.

Material and Methods

Particnance

The study involved 62 volunteers aged 20-25 who ran at the amateur level 3 times a week for 40-60 minutes. Thirty-two of the study participants had a body mass index less than 25. 30 participants had a body mass index greater than 25.

Procedure

This research refers to a quantitative approach. This study employed an experimental approach with a 2x2 factorial design. Experiments with factorial design are defined as experiments where factors are crossed with other factors in the experiments carried out. In this study, a 2x2 factor design was used where there were 2 ratio factors and 2 body mass index factors, so that each ratio factor was crossed with the body mass index factor. The accompanying portrays the examination configuration in table 1.
Based on table 1, it can be seen that there are 2 ratio factors and 2 body mass index factors. Because this study uses a 2x2 factorial design, each factor will be crossed with other factors, so that 4 groups will be obtained, namely:

- Group $a_1b_1$
  - In this group, samples whose body mass index $\geq 25$ will be trained with High Intensity Interval Circuit Training (HIICT) with a ratio of 1:3 (1 for work time and 3 for rest time).

- Group $a_2b_1$
  - In this group, samples with body mass index $\geq 25$ will be trained with High Intensity Interval Circuit Training (HIICT) with a ratio of 1:5 (1 for work time and 5 for rest time).

- Group $a_1b_2$
  - In this group, samples whose body mass index $< 25$ will be trained with High Intensity Interval Circuit Training (HIICT) with a ratio of 1:3 (1 for work time and 3 for rest time).

- Group $a_2b_2$
  - In this group, samples whose body mass index $< 25$ will be trained with High Intensity Interval Circuit Training (HIICT) with a ratio of 1:5 (1 for work time and 5 for rest time).

The maximum capacity of a person's body to distribute oxygen (O2) and consume oxygen (O2) when a person carries out intense sports activities, and reflects how much a person's physical fitness level is obtained after carrying out maximum load on a Kettler Giro P static bicycle and is measured using a bicycle Static Kettler Giro P. VO2max is expressed in ml/kg body weight/minute, and is determined by age, body weight and sex.

Body Mass Index (BMI) is a ratio of weight and height that is often used in the field. BMI is a measure of body composition, particularly used on a large scale in public health studies, but is also an alternative item in the youth fitness fitness gram battery. Measure the height of the testicles in meters. Measure the weight of the testicles in kilograms. To determine Body Mass Index (BMI), divide weight by the square of height:

$$\text{Body Mass Index (BMI)} = \frac{\text{Weight (kg)}}{\text{Height (cm)}^2}$$

The data analysis technique used was a two-way analysis of variance (ANOVA) at $\alpha = 0.05$. If the obtained F value ($F_0$) is significant, the analysis is continued with the newman-keuls range test. To fulfill the assumptions in the Anava technique, the normality test (Lilliefors test) and the Homogeneity of Variance test (with the Bartlett test) are carried out.
Results

Data analysis

The portrayal of the aftereffects of the information examination of the VO2max test results did by the looked at bunches is introduced as follows (Table 3).

Every cell (treatment bunch) has an alternate expansion in VO2max results. The worth of the expansion in VO2max results for every cell (treatment bunch) should be visible in table 4 underneath.

Data on the VO2max Test Results for Each Group Using High Intensity Interval Circuit Training (HIICT) and the Level of Body Mass Index

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Body Mass Index Level (kg/m²)</th>
<th>Statistics</th>
<th>Initial Test Results (ml/kg body weight/minute)</th>
<th>Final Test Results (ml/kg body weight/minute)</th>
<th>Enhancement (ml/kg body weight/minute)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Intensity Interval Circuit Training (HIICT) with a ratio of work and rest time 1:3</td>
<td>BMI ≥ 25</td>
<td>Total</td>
<td>250,1</td>
<td>265,1</td>
<td>15,0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Average</td>
<td>50,013</td>
<td>53,021</td>
<td>3,008</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>7,024</td>
<td>6,909</td>
<td>0,579</td>
</tr>
<tr>
<td></td>
<td>BMI &lt; 25</td>
<td>Total</td>
<td>305,3</td>
<td>333,5</td>
<td>28,1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Average</td>
<td>61,066</td>
<td>66,692</td>
<td>5,626</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>8,751</td>
<td>9,225</td>
<td>1,116</td>
</tr>
<tr>
<td>High Intensity Interval Circuit Training (HIICT) with a ratio of work and rest time 1:5</td>
<td>BMI ≥ 25</td>
<td>Total</td>
<td>284,1</td>
<td>302,1</td>
<td>18,1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Average</td>
<td>56,814</td>
<td>60,426</td>
<td>3,612</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>6,601</td>
<td>6,517</td>
<td>0,551</td>
</tr>
<tr>
<td></td>
<td>BMI &lt; 25</td>
<td>Total</td>
<td>303,4</td>
<td>320,0</td>
<td>16,5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Average</td>
<td>60,688</td>
<td>63,997</td>
<td>3,309</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>1,567</td>
<td>1,398</td>
<td>0,605</td>
</tr>
</tbody>
</table>

Table 4

VO2max Result Worth of Every Cell (Treatment Gathering)

<table>
<thead>
<tr>
<th>Number</th>
<th>Treatment Group</th>
<th>Gain Score (ml/kg body weight/minute)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>a₁b₁ (KP₁)</td>
<td>3,01</td>
</tr>
<tr>
<td>2</td>
<td>a₂b₂ (KP₂)</td>
<td>5,63</td>
</tr>
<tr>
<td>3</td>
<td>a₁b₁ (KP₁)</td>
<td>3,61</td>
</tr>
<tr>
<td>4</td>
<td>a₂b₂ (KP₂)</td>
<td>3,31</td>
</tr>
</tbody>
</table>

Information:

a₁ = High Intensity Interval Circuit Training (HIICT) with a ratio of working time to rest time ratio of 1:3.
a₂ = High Intensity Interval Circuit Training (HIICT) with a ratio of working time to rest time of 1:5.
b₁ = Group of players who have Body Mass Index ≥ 25
b₂ = Group of players with Body Mass Index < 25
Summary of Mean Values of VO2max Results Based on the Use of High Intensity Interval Circuit Training (HIICT) and Body Mass Index Levels

<table>
<thead>
<tr>
<th>Variable Average VO2max</th>
<th>a1 (ml/kg body weight/minute)</th>
<th>a2 (ml/kg body weight/minute)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b1 (ml/kg body weight/minute)</td>
<td>b2 (ml/kg body weight/minute)</td>
</tr>
<tr>
<td>Preliminary test results</td>
<td>50,01</td>
<td>61,07</td>
</tr>
<tr>
<td>Final test results</td>
<td>53,02</td>
<td>66,69</td>
</tr>
<tr>
<td>Enhancement</td>
<td>3,01</td>
<td>5,63</td>
</tr>
</tbody>
</table>

Information:

a1 = High Intensity Interval Circuit Training (HIICT) with a ratio of working time to rest time ratio of 1:3.
a2 = High Intensity Interval Circuit Training (HIICT) with a ratio of working time to rest time of 1:5.
b1 = Group of players who have Body Mass Index ≥ 25
b2 = Group of players with Body Mass Index < 25

Normality Test

Before conducting data analysis, it is necessary to test the normal distribution. The data normality test in this study used the Lilliefors method. The results of the data normality test performed in each group are as follows (Table 6):

<table>
<thead>
<tr>
<th>Group Treatment (KP)</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>L_count</th>
<th>L_table 5%</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>KP1</td>
<td>5</td>
<td>3,008</td>
<td>0,579</td>
<td>0,3028</td>
<td>0,396</td>
<td>Normal Distribution</td>
</tr>
<tr>
<td>KP2</td>
<td>5</td>
<td>5,626</td>
<td>1,116</td>
<td>0,2031</td>
<td>0,396</td>
<td>Normal Distribution</td>
</tr>
<tr>
<td>KP3</td>
<td>5</td>
<td>3,612</td>
<td>0,551</td>
<td>0,1430</td>
<td>0,396</td>
<td>Normal Distribution</td>
</tr>
<tr>
<td>KP4</td>
<td>5</td>
<td>3,309</td>
<td>0,605</td>
<td>0,2950</td>
<td>0,396</td>
<td>Normal Distribution</td>
</tr>
</tbody>
</table>

From the results of the normality test conducted on KP1, the value of L_count = 0,3028 was obtained. Where this value is smaller than the rejection limit at the 5% significance level, namely 0,396. Thus it can be concluded that the data on KP1 is normally distributed. From the results of the normality test conducted on KP2, the value of L_count = 0,2031 was obtained, which was smaller than the limit for rejecting the null hypothesis using a significance of 5%, namely 0,396. Thus it can be concluded that the data on KP2 is normally distributed. From the results of the normality test conducted on KP3, the value of L_count = 0,1430 was obtained. Where this value is smaller than the rejection limit number using a significance of 5%, namely 0,396. Thus it can be concluded that the data on KP3 is normally distributed. As for the results of the normality test conducted on KP4, the value of L_count = 0,2950 was obtained, which was also smaller than the limit for rejecting the null hypothesis using a significance of 5%, namely 0,396. Thus it can be concluded that the data on KP4 is also normally distributed.

Homogeneity Test

The homogeneity test is intended to test the similarity of variance between group 1 and group 2. The homogeneity test in this study was carried out by the Bartlett test. The results of the data homogeneity test between group 1 and group 2 are as follows (табл. 7).

From the results of the homogeneity test, the value of $\chi^2_o = 3,074$ was obtained. Whereas with $k - 1 = 4 - 1 = 3$, the $\chi^2_{table 5\%} = 7,81$, which turns out that the $\chi^2_o$ value = 3,074 is smaller than the $\chi^2_{table 5\%} = 7,81$. So it can be concluded that between groups in this study has a homogeneous variance (табл. 8).
Table 7

Summary of Data Homogeneity Test Results

<table>
<thead>
<tr>
<th>∑ Group</th>
<th>N_i</th>
<th>SD_{gab}</th>
<th>χ^2_o</th>
<th>χ^2 table 5%</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>5</td>
<td>0.562</td>
<td>3.074</td>
<td>7.81</td>
<td>Homogeneous variance</td>
</tr>
</tbody>
</table>

Table 8

Summary of Analysis of Variance Results for Body Mass Index Levels

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>dk</th>
<th>JK</th>
<th>RJK</th>
<th>F_{count}</th>
<th>F_{table}</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>1</td>
<td>6,7002</td>
<td>6,700</td>
<td>11,9158</td>
<td>4,11</td>
</tr>
<tr>
<td>Mistake</td>
<td>16</td>
<td>8,9967</td>
<td>0,562</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The results showed that players who have a Body Mass Index ≥ 25 have an increase in VO2max results that are different from players who have a Body Mass Index < 25. This is evidenced by the value of F_{count} = 11,9158 > F_{table} = 4,11. Thus the null hypothesis (H0) is rejected. Which means that players who have a Body Mass Index ≥ 25 have an increase in VO2max results that are different from players who have a Body Mass Index < 25 can be accepted.

From further analysis, it was found that players who had a Body Mass Index < 25 had a better increase in VO2max results than players who had a Body Mass Index ≥ 25, with an average increase of 4,467 and 3,310 respectively. When the second hypothesis was tested, it was found that players with a BMI of 25 or less had a significantly different effect on increasing VO2max than players with a BMI of 25 or less. There is a greater increase in VO2max results among players with a BMI below 25 than among players with a BMI above 25. Players with a BMI of 25 or lower have a better chance than players with a BMI of 25 or lower.

**Discussion**

The consequence of partitioning one's level in meters squared by one's load in kilograms is known as the weight record [19]. Makes sense of that an individual's weight file (BMI) can be utilized to decide if a competitor is underweight, typical, or overweight. An individual's weight file (BMI) is remembered to demonstrate or depict their degree of adiposity. BMI doesn't gauge muscle to fat ratio straightforwardly. Nonetheless, research shows that BMI relates with direct estimations of muscle versus fat, for example, submerged gauging and double energy xray absorptiometry. With an ideal weight list, it very well may be utilized as a significant capital in supporting the presence of a competitor in accomplishing accomplishment. The purpose of BMI is to describe a person's body type. A person's nutritional status is closely related to his body composition. The nutritional status of an athlete greatly affects physical fitness during sports activities [20]. The activity and fat content of an athlete is certainly different from people who have different professions [21]. So to measure the body mass index of an athlete, it is not appropriate to use the IMT that is commonly used in general. One factor that affects VO2max is the Body Mass Index (BMI). Athletes with an increase in lean body mass may have a lower fat content condition, but their body mass index status is above the recommended limit [22]. Research related to body mass index of athletes was conducted by identifying the physical condition and body fat levels of various sports [23]. It was found that fat content among successful athletes from different sports varies widely. Therefore, no rigid justification can be made regarding body fat levels for all athletes from different sports.

Increased body weight in a person occurs due to the accumulation of fat stores in adipose cells, muscle glycogen, and bone strengthening and bone density can shrink VO2max. Therefore a person must avoid weight gain so that VO2max remains maximum. The results with a BMI less than 25 have an average increase in VO2max of 1,158, which is higher than the group of players with a BMI less than 25.
Conclusions

According to the research, there is a significant relationship between Body Mass Index and High Intensity Interval Circuit Training (HIICT) when it comes to increasing VO2max. High Intensity Interval Circuit Training (HIICT) with a work-to-rest ratio of 1:3 makes players with a BMI of less than 25 more suitable. High Intensity Interval Circuit Training (HIICT) with a work-to-rest ratio of 1:5 is more suitable for players with a BMI below 25.

Conflict of interest

The author declares no conflict of interest.

References

17. Anam K, Adiamuki IPG, Griadi IPA, Mulia IM, Sundari LPR, Purnawati S. Pelatihan pukulan bayangan lebih baik dari pada pukulan biasa dalam meningkatkan vo2max dan daya tahan otot lengan pada atlet tinju amatir Kabupaten Lombok Tengah (NTB). Sport Fit J. 2019;
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