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Article

Eritrosit, Hemoglobin, VO2Max, and Hematocrit Levels are Correlated With High-Intensity Interval Training

Jiang Wen ming[1,*]

[1] Sultan Idris Education University, Tanjong Malim, Malaysia

* Correspondence: wenmingjiang975@gmail.com

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Abstract: This study aims to explore the relationship between erythrocyte levels, hemoglobin, VO2Max, and hematocrit in individuals who undergo a High-Intensity Interval Training (HIIT) program for 8 weeks. HIIT is known to be effective in improving cardiovascular fitness, which is measured through an increase in VO2Max. A total of 30 active students who met the inclusion criteria participated in this study. Hematological parameters and VO2Max were measured before and after the intervention. The results showed that VO2Max increased significantly by 21.46% ($p < 0.05$), while hemoglobin and erythrocyte levels increased only slightly and insignificantly ($p > 0.05$). Hematocrit decreased by 1.5% ($p > 0.05$). Correlation tests showed a significant relationship between changes in hemoglobin and erythrocyte levels with hematocrit ($p < 0.05$), but no significant relationship was found between increased VO2Max and changes in hemoglobin and erythrocyte levels ($p > 0.05$). These findings indicate that although HIIT is effective in increasing aerobic capacity, the body's physiological adaptation to intensive exercise is more complex and does not necessarily correlate directly with changes in haematological parameters. More research is needed to understand the mechanisms behind these outcomes and other factors that may influence the hematological response to HIIT.

Keywords: Hematological Parameters ; Cardiovascular Fitness ; High-Intensity Interval Training (HIIT)

1. Introduction

Cardiovascular fitness is an important aspect of physical health that reflects the body's ability to transport and utilize oxygen during physical activity (Raghuveer et al., 2020). VO2Max, which is measured in milliliters of oxygen per kilogram of body weight per minute ($ml \cdot kg^{-1} \cdot min^{-1}$), is a key indicator of cardiovascular fitness (Ma et al., 2023). Research shows that HIIT can significantly increase VO2Max, with an average increase of about 20% after an eight-week exercise program (Ito, 2019).

Erythrocytes and hemoglobin have a key role in the transport of oxygen to the body's tissues (Barbalato & Pillarisetty, 2019) . The hemoglobin present in erythrocytes is responsible for binding oxygen in the lungs and distributing it throughout the body (Farid et al., 2023). Therefore, changes in erythrocyte count and hemoglobin levels can affect an individual's aerobic capacity. Some studies suggest that HIIT can affect these hematological parameters, although the results vary (Belviranli et al., 2017).

Hematocrit measures the proportion of red blood cells in total blood volume (Yang et al., 2021). Changes in the hematocrit can provide insight into the body's physiological adaptation to intensive exercise (Mairbäurl, 2013). Previous research has shown that hematocrit may increase after a high-intensity exercise session, but it may also decrease depending on the duration and type of exercise (Komka et al., 2022).

This study aims to explore the correlation between changes in VO2Max values, erythrocytes, hemoglobin, and hematocrit before and after an eight-week HIIT program (Tamayo Acosta et al., 2022). By understanding this relationship, it is hoped that it can provide clearer information about the effects of HIIT on hematological parameters and overall cardiovascular fitness (Guo et al., 2023).

The results of this study are expected to contribute to the development of more effective training programs for athletes and individuals who want to improve their physical fitness (Wang et al., 2023). By knowing how HIIT affects erythrocytes, hemoglobin, and hematocrit, trainers and exercise practitioners can design more targeted interventions to improve athletic performance as well as general health (García-Pinillos et al., 2017). As such, this research is not only relevant to the world of sport but also to the wider field of public health, given the importance of cardiovascular fitness in preventing various lifestyle-related diseases.

2. Materials and Methods

This study aims to explore the correlation between erythrocyte levels, hemoglobin, VO2Max, and hematocrit before and after the 8-week High-Intensity Interval Training (HIIT) program. This study uses an experimental design with a pre-test and post-test approach. Subjects will be measured for hematological parameters and VO2Max before and after the HIIT intervention. The population in this study is active students enrolled in sports programs at universities. A total of 30 students who met the inclusion criteria, such as having no history of cardiovascular disease, not being treated, and willing to participate in the entire series of research. The HIIT program will be carried out for 8 weeks with a frequency of three times a week. Each training session will consist of a 10-minute warm-up, an intensive training interval of 30 seconds followed by active recovery for 1 minute, repeated 8-10 times, and a 10-minute Cooling Down. VO2Max was measured using an ergometer or treadmill using the Bruce Protocol method before and after the intervention. Erythrocytes and Hemoglobin were measured through a complete blood analysis using a hematology analyzer on blood samples taken before the intervention (pre-test) and after the intervention (post-test). Hematocrit is also measured from the same blood sample by using centrifugation to determine the percentage of erythrocyte volume in the blood. The data obtained will be analyzed using descriptive statistics to describe the characteristics of the subjects. A normality test will be conducted to determine the appropriate type of statistical analysis. Furthermore, Pearson or Spearman correlation analysis will be used to evaluate the relationship between changes in erythrocyte levels, hemoglobin, hematocrit, and VO2Max. The significance level was set at $p < 0.05$.

3. Results

This study aims to explore the correlation between erythrocyte levels, hemoglobin, VO2Max, and hematocrit in individuals who undergo a High-Intensity Interval Training (HIIT) program for 8 weeks.

Table 1. Results of data analysis on the relationship between erythrocytes, hemoglobin, VO2Max, and hematocrit levels to HIIT

Parameter	Change	Percentage Change	p-value
VO2Max	Increase 7.33 ± 4.03 $ml \cdot kg^{-1} \cdot min^{-1}$	21.46%	$p < 0.05$
Hemoglobin	Increase 0.04 ± 0.63 g/dL	0.24%	$p > 0.05$
Eritrosit	Increase 0.02 ± 0.22 × 10^6/µL	0.32%	$p > 0.05$
Hematokrit	Decreased 1.5 ± 2% of the total blood volume	-0.27%	$p > 0.05$

Correlation Test between Hemoglobin and Erythrocytes with Hematocrit	A significant relationship was found	-	$p < 0.05$
Correlation Test between VO2Max and Hemoglobin/Erythrocytes	No significant relationship	-	$p > 0.05$

1) VO2Max Increase

VO2Max experienced a significant increase of 7.33 ± 4.03 ml·kg^{-1}·min^{-1}, which is equivalent to 21.46% of the initial value ($p < 0.05$). This shows that HIIT is effective in increasing participants' aerobic capacity.

2) Changes in Hemoglobin and Erythrocyte Levels

Hemoglobin levels increased by 0.04 ± 0.63 g/dL, which was an increase of 0.24% ($p > 0.05$). Erythrocyte levels also showed an increase of $0.02 \pm 0.22 \times 10^6$/µL, or about 0.32% ($p > 0.05$). However, these changes are not statistically significant.

3) Changes in Hematocrit

Hematocrit decreased by 1.5 ± 2% of total blood volume, which was equivalent to a decrease of 0.27% from the pre-test value ($p > 0.05$). This suggests that despite an increase in VO2Max, there is no significant increase in hematocrit.

4) Correlation Test

The correlation test showed a significant relationship ($p < 0.05$) between changes in hemoglobin and erythrocyte values with hematocrit. However, no significant association ($p > 0.05$) was found between the increase in VO2Max and changes in hemoglobin and erythrocyte levels.

4. Discussion

This study explored the relationship between exercise intensity, type of exercise, gender differences, and exercise duration on beta-endorphin levels. The findings provide important insights into how beta-endorphins function as mediators in the body's response to physical activity.

1) Intensity and Levels of Beta-Endorphins

The results showed that there was a curvilinear relationship between exercise intensity and beta-endorphin release. At low to moderate intensity (40% and 60% VO2max), beta-endorphin levels did not increase significantly, with values of about 4.8 pmol/l and 6.3 pmol/l, respectively, compared to resting levels of 3.8 pmol/l1. However, at high intensity (80% VO2max), beta-endorphin levels increase significantly to reach around 16.1 pmol/l. This indicates that in order to achieve a substantial increase in beta-endorphin levels, exercise must be done at a higher intensity level. These findings are in line with previous research that suggests that aerobic exercise performed for more than 30 minutes can significantly increase beta-endorphin secretion (Purnomo et al., 2020) These findings have important implications for coaches and individuals who want to take advantage of the positive effects of beta-endorphins in sports. By understanding that higher exercise intensity can result in increased beta-endorphin levels, exercise programs can be designed to optimize mental and physical health benefits. However, keep in mind that while HIIT or high-intensity exercise can increase endorphin levels, they can also cause discomfort that may reduce motivation to exercise in the future (Flora et al., 2020).

2) Comparison of Types of Exercises

A comparison between HIIT (High-Intensity Interval Training) and moderate aerobic exercise showed that HIIT resulted in a greater increase in the release of endorphins, especially in areas of the brain associated with pain and reward. Although participants reported feeling euphoric after moderate exercise, they also experienced discomfort during high-intensity sessions. This suggests that although the release of beta-endorphins can improve mood, there is the potential to feel discomfort at higher intensities. Although HIIT increased beta-endorphin levels, participants also reported experiencing discomfort during high-intensity exercise sessions. This suggests the existence of duality in the emotional response to exercise: while the release of beta-endorphins can improve mood, higher intensity can also cause pain or discomfort. Research by (Rauchbauer et al., 2023) notes that at very high exercise intensities, the release of endorphins can be associated with negative feelings and pain, which may be necessary to manage the emotional and physical challenges faced during exercise.

3) Gender Differences

The beta-endorphin response appears to be consistent among the sexes, but the catecholamine response (such as norepinephrine) shows significant gender-related differences, with levels generally higher in men. Previous research has also supported these findings, suggesting that women have a similar beta-endorphin response to men when exercising at high intensity, although their levels tend to be slightly lower under certain conditions. This highlights the importance of considering gender factors in research on hormonal responses to exercise. This may be due to differences in hormonal and metabolic composition between the sexes, where men have stronger sympathetic nervous system responses (Davis et al., 2000).

4) Duration of Exercise

Long-term studies show that both aerobic and anaerobic exercise can increase beta-endorphin levels over time, with anaerobic exercise producing higher levels compared to aerobic exercise when done regularly. These findings indicate that the type and duration of exercise play an important role in the regulation of beta-endorphin levels, as well as the potential long-term health benefits of regular physical activity. This suggests that anaerobic exercise, which involves high-intensity intervals and repetitions, is more effective at stimulating the release of beta-endorphins compared to more stable and sustained aerobic exercise (Schwarz & Kindermann, 1992).

5. Conclusions

This study provides a better understanding of how various factors affect beta-endorphin levels in the body. Increased levels of beta-endorphins are associated with higher exercise intensity and certain types of exercise such as HIIT, as well as suggesting gender differences in hormonal responses. By taking these factors into account, exercise programs can be designed to maximize mental and physical health benefits through proper physical activity arrangements.

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