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Iron tablets and vitamin C (1000 mg): Can they enhance haemoglobin levels and cardiovascular capacity in female martial athletes?

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ABSTRACT

Regarding nutrition, providing proper food intake can produce optimal physical conditions and provide sufficient energy. This research aimed to prove that combining iron tablets and 1000 mg of vitamin C can increase hemoglobin levels and maximum oxygen volume in female athletes in martial arts. This research used an experimental group design by using a randomized post-test-only control group design. It used 40 female athletes divided into four groups and carried out for 12 weeks. The control group was given a placebo, treatment group one was given iron tablets three times a week, treatment group two was given 1000 mg of vitamin C three times a week, and treatment group three was given a combination of iron tablets and 1000 mg vitamin C. The results show that the mean of hemoglobin levels in the group given iron tablets is 13.23 ± 1.09 g/dL, vitamin C is 12.69 ± 0.89 g/dL, and a combination of iron tablets and vitamin C is 14.50 ± 1.40 g/dL significantly higher ($p < 0.05$) than the control group, namely 11.93 ± 1.08 g/dL. The average maximum oxygen volume level in the group given iron tablets is 41.24 ± 0.52 ml/Kg/minute, vitamin C is 40.58 ± 0.66 ml/Kg/min, and a combination of iron tablets and vitamin C is 43.33 ± 0.41 ml/Kg/min which is significantly higher ($p < 0.05$) compare to the control group's average of 38.33 ± 0.42 ml/Kg/min. It concludes that giving iron and vitamin C tablets to female martial arts athletes can significantly increase hemoglobin levels and maximum oxygen volume. Therefore, iron and vitamin C tablets are proven to contribute to overcoming the problem of anemia in women and are able to increase the cardiovascular capacity of athletes.

Keywords: Iron tablets; vitamin c 1000 mg; hemoglobin; maximum oxygen volume; martial sports

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INTRODUCTION

The peak achievement of an athlete can be achieved by talented athletes who get good coaching gradually and continuously (Dewi & Wirjatmadi, 2017). Athlete development gradually aims to improve sports-specific physical conditions. Four important factors need to be considered for athletes to achieve maximum performance. These factors include the athlete's physical condition, skills and techniques, understanding of

tactics and strategy, and the athlete's mental readiness (Bompa & Buzzichelli, 2014). Within the scope of sports coaching, various disciplines support achievements, such as psychology, anatomy, physiology, education, sports health, nutrition, and others. Specifically regarding nutrition, providing proper food intake, both in quality and quantity, can produce optimal physical conditions and provide sufficient energy for athletes during their activities (Bompa & Carrera, 2015). The results of one study stated that almost 40% of adolescents had anemia (Tesfaye et al., 2015; Weyand et al., 2023). This is because the adolescent age group shows a very rapid growth phase called the "Adolescence Growth Spur", so it requires relatively large amounts of nutrients (Kosendiak et al., 2015). If the consumption of various nutrients is not increased, it may lead to relative deficiency, especially vitamin and mineral deficiency. One of the possible mineral deficiencies is iron deficiency (Fe).

Anemia of iron deficiency (Fe) is Indonesia's national nutritional deficiency problem (Kosendiak et al., 2015). Special attention to iron (Fe) deficiency has not been counted for a long time, not because the case just appeared recently, but because the experts to research and handle this case only existed after 1970 in Indonesia. The most common cause of iron deficiency anemia is a lack of intake of one of the essential micronutrients, namely iron (Fe) (Chong et al., 2020; Nguyen et al., 2016). Various clinical manifestations due to clinical iron deficiency anemia are growth disorders, decreased intelligence, and decreased physical abilities. Impaired growth can be seen in the large number of Indonesian children who have short bodies. Children with anemia cause a decrease in IQ by as much as 5-15 points (Ai et al., 2012). Another consequence caused by anemia can also be felt by the sufferer is a decrease in physical abilities such as fatigue, tiredness, lethargy, and weakness (Bompa & Carrera, 2015).

Both children and their parents may not know and feel iron deficiency anemia. The effect of anemia that causes a decrease in aerobic endurance will decrease physical ability. This will affect the children's growing process (Kosendiak et al., 2015). Aerobic endurance describes the ability of the large muscles to carry out activities of moderate intensity for a long time (Patel et al., 2017). A decrease in aerobic endurance is caused by a decrease in hemoglobin levels due to reduced oxygen binding (Paulsen et al., 2014). The absorption factor is an important concern when giving iron supplements. Many micronutrients are used together with iron to improve the absorption of nutrients, including folic acid, vitamin A, vitamin C, zinc, vitamin B12, and others (Das et al., 2019; Tam et al., 2020). Vitamin C helps accelerate iron absorption in the body (Dewi & Wirjatmadi, 2017). Vitamin C also plays a role in moving iron into the blood and mobilizing iron stores, especially hemosiderin in the spleen (Drouin et al., 2011).

Bompa and Carrera (2015) state that the achievement of an athlete's improvement is a result that is directly related to the amount and quality of training. This will also affect cardiovascular endurance, strength, speed, flexibility, power, and good agility. One of the parameters of a person's cardiovascular endurance is the maximum oxygen volume (VO2 max) (Umapathi & Nguyen, 2022). Maximum oxygen volume is the body's ability to consume, distribute and utilize oxygen maximally per unit of time, and in absolute terms, is expressed in ml/Kg body weight/minute (Berdejo-del-Fresno et al., 2015). Cardiovascular endurance, consisting of the ability of the lungs, heart, and blood vessels to provide oxygen for the continuity of muscle work, is one of the most important elements in supporting physical fitness (Booth et al., 2012). The adequacy of oxygen depends on the ability of hemoglobin to bind oxygen because 97% of oxygen is carried by hemoglobin (Berdejo-del-Fresno et al., 2015). Lack of hemoglobin automatically affects the amount of oxygen transported and the maximum oxygen volume (Bompa & Buzzichelli, 2014).

Previous research indicated that animal and human observational studies suggest that iron deficiency impairs physical exercise performance (Pasricha et al., 2014), but findings from randomized trials on the effects of iron are equivocal. Iron deficiency and anemia are especially common in women of reproductive age (WRA). Daily iron supplementation significantly improves maximal and submaximal exercise performance in WRA, providing a rationale to prevent and treating iron deficiency in this group (Parischa Rayn et al., 2014). On the other research, Paulsen concluded that vitamin C and E supplementation interfered with the acute cellular response to heavy-load resistance exercise and demonstrated tentative long-term negative effects on adaptation to strength training (Paulsen et al., 2014). However, something different found by Pompano and Haas about iron supplementation increases endurance performance at submaximal

and maximal (VO2 peak) exercise intensities in IDNA women. However, increasing iron status does not increase VO2 max (Pompano & Haas., 2019). Several previous studies involved samples of female who were not trained and mostly carried out a sedentary lifestyle. Studies on trained female, in this case athletes, still need deeper explanation, especially female athletes in martial arts.

Based on this background, the potential of giving a combination of iron tablets and vitamin C 1000 mg to female athletes in martial arts to increase hemoglobin levels and maximum oxygen volume is very interesting to study. Besides that, there has been no further research on combining iron tablets and 1000 mg of vitamin C to increase hemoglobin levels and maximum oxygen volume, especially in female athletes in martial arts, which is an added point in this study. This study aims at determining the effect of giving a combination of iron tablets and vitamin C 1000 mg on increasing hemoglobin levels and maximum oxygen volume in female martial art athletes. So that the results of this study can strengthen the theory of giving a combination of iron tablets and vitamin C 1000 mg to increase hemoglobin and volume of maximum oxygen. It can also provide additional insight and knowledge in developing sports science and technology, especially in increasing hemoglobin and maximum oxygen volume. This effort is expected to be able to presentation further research directions on provision of a combination of iron tablets and vitamin C and to provide useful data for designing research that examines the provision of nutritional combinations involving minerals and antioxidants.

METHOD

This research used an experimental group design by using a randomized post-test-only control group design. It used forty female athletes divided into four groups and carried out for twelve weeks. In this research, the control group was given a placebo, treatment group one was given iron tablets three times a week, treatment group two was given 1000 mg of vitamin C three times a week, and treatment group three was given a combination of iron tablets and 1000 mg vitamin C. In this research, the data obtained were quantitative. Data collection was obtained using test and measurement techniques. The instrument used in collecting data on cardiovascular endurance (maximum oxygen volume) was the Fit Mate Pro connected to the Cosmed T 150 model treadmill. Measuring hemoglobin levels was carried out in the Buleleng District Hospital clinical laboratory (Nieman et al., 2006, 2013).

Descriptive analysis was useful for presenting a summary of some statistical values that indicate the level of maximum oxygen volume (VO2 max). Then hemoglobin levels were presented in tabular form according to the treatment group. Descriptive analysis is in the form of calculating the average and standard deviation. The One Way ANOVA (Analysis of Variance) test was carried out at a significance level of $\alpha = 0.05$ to determine the average difference between groups. And differences that found between groups, proceed with the LSD (Least Significant Difference) test.

RESULTS AND DISCUSSION

This research was an experimental study in the form of a randomized post-test-only control group design. This study used forty female martial arts athletes as a sample. The forty female athletes were divided into four, namely, the control group (P0), who were given a placebo for twelve weeks; treatment group one (P1), who were given iron tablets three times a week for twelve weeks, treatment group two (P2) who were given vitamin C 1000 mg three times a week for twelve weeks, and treatment group three (P3) were given a combination of iron tablets and 1000 mg vitamin C. This section describes the data regarding the normality test, data homogeneity test, comparability test, and treatment effect test.

Table 1. Characteristics of the Sample Based on BMI

Variable	Category	N	Percentage
Body Mass Index	Thin	13	48.14
	Normal	27	51.86
	Overweight	0	0
	Obesity	0	0
Total		**40**	**100**

Table 2. Characteristics of the Sample Based on Hemoglobin (Hb)

Variable	Category	N	Percentage
Hemoglobin	Normal	32	80
	Less	8	20
Total		**40**	**100**

Table 3. Characteristics of the Sample Based on Maximum Oxygen Volume

Variable	Category	N	Percentage
Maximum Oxygen Volume	Excellent	2	5
	Good	8	20
	High Average	9	22.5
	Low Average	18	45
	Poor	3	7.5
Total		**40**	**100**

Table 4. Characteristics of the Sample Based on Age, Maximum Oxygen Volume (VO2 max), Hemoglobin (Hb), and Body Mass Index (BMI)

Variable	N	Mean	SD	Minimum	Maximum
Age	40	18.50	0.46	17	20
VO2 Max	40	71.97	35.25	35	42
Hb (g/dL)	40	11.56	1.02	9	14.2
BMI (kgBB/m2 TB)	40	18.63	1.47	15.6	22.9

Hemoglobin Levels in Various Treatments and Controls

Data on hemoglobin (Hb) levels were tested for normality using the Shapiro-Wilk test and homogeneity using Levene's test. The results show that the data are normally distributed ($p > 0.05$) and homogeneous ($p > 0.05$). The results of the significance analysis with the One Way Anova test are presented in the following table.

Table 5. Differences in Mean Hemoglobin (Hb) Between Groups After Being Given Iron Tablets, Vitamin C 1000 mg, and a Combination of Iron Tablets and Vitamin C 1000mg

Treatment	N	Mean Levels Hb	SB	*F*	P
Placebo (P0)	10	11.93	1.08		
Iron tablets (P1)	10	13.23	1.90	10.88	0.000
Vit c 1000mg (P2)	10	12.69	0.89		
A combination of Iron and Vit C (P3)	10	14.50	1.40		

To determine which groups are different, it is necessary to carry out a further test with the smallest difference or the Least Significant Difference-test (LSD). The results are as follows.

Table 6. Comparison of Mean Levels of Hemoglobin (Hb) after Treatment Between Groups

Treatment	Diff. Average (g/dL)	p	Interpretation
Placebo (P0) and Iron tablets (P1)	1.06	0.052	no different
Placebo (P0) and Vit C (P2)	0.89	0.000	Different
Placebo (P0) and combination (P3)	2.67	0.000	Different
Iron Tablets (P1) and Vit C (P2)	1.06	0.047	Different
Iron Tablets (P1) and combination (P3)	1.85	0.000	Different
Vit C (P2) and combination (P3)	2.08	0.002	Different

Maximum Volume of Oxygen (VO2 max) in Various Treatments and Controls

Data on maximum oxygen volume (VO2 max) were tested for normality using the Shapiro-Wilk test and homogeneity using Levene's test. The results show that the data are normally distributed ($p > 0.05$) and homogeneous ($p > 0.05$). Treatment effect analysis was tested based on the average maximum oxygen volume

(VO2max) between groups after being given treatment in the form of iron tablets, vitamin C, and a combination of iron and vitamin C tablets. The results of the significance analysis with the One Way Anova test are presented in the following table.

Table 7. Differences in Mean Maximum Oxygen Volume (VO2 max) Between Groups After Being Given Iron Tablets, Vitamin C, and Combinations of Iron and Vitamin C Tablets

Treatment	n	Average VO2max	SB	*F*	p
Placebo (P0)	10	38.33	0.42		
Iron Tablets (P1)	10	41.24	0.52		
Vit C (P2)	10	40.58	0.66	979.42	0,000
Combination of iron tablets and Vit C (P3)	10	43.33	0.41		

To find out which groups are different, it is necessary to do a follow-up test with the smallest difference or the Least Significant Difference-test (LSD). The results are as follows;

Table 8. Comparison of Average Maximum Volume Oxygen Levels (VO2 max) After Treatment Between Groups

Treatment	Average difference (VO2 max level)	p	Interpretation
Placebo (P0) and Iron Tablets (P1)	38.4	0.000	Different
Placebo (P0) and Vit C (P2)	33.7	0.000	Different
Placebo (P0) and combination (P3)	38.25	0.000	Different
Iron Tablets (P1) and Vit C (P2)	35.45	0.000	Different
Iron Tablets (P1) and combination (P3)	33.8	0.000	Different
Vit C (P2) and combination (P3)	34.8	0.000	Different

Iron Tablets and Hemoglobin (Hb) Levels

The study results show that the average Hb level in the group given iron tablets is 13.23 ± 1.09 g/dL, which is significantly higher ($p < 0.05$) compared to the mean Hb level in the control group, namely 11.93 ± 1.08 g/dL. This was also found in a study by Susanti et al. (2016), which stated that weekly iron tablet supplementation had good effectiveness for increasing hemoglobin levels in menstruating adolescent girls. The total amount of iron in the body averages about 4 g, 65% of which is in the form of hemoglobin. About 4% is in the form of myoglobin, 1% is in the form of various heme compounds that monitor intra-cell oxidation, 0.1% binds to the protein transferrin in blood plasma, and 15-30% is mainly stored in the liver in the form of ferritin. The average amount of iron that comes from food each day should equal the amount of iron lost from the body. Iron deficiency will result in iron deficiency, resulting in low Hb levels, which is often called anemia (Nwagha et al., 2023).

Vitamin C and Hemoglobin Levels (Hb)

From the results of the study, it shows that the average Hb level in the group given vitamin C is 12.69 ± 0.89 g/dL, which is significantly higher ($p < 0.05$) compared to the average hemoglobin (Hb) level in the control group, namely 11.93 ± 1.08 g/dL. This is also consistent with research conducted by Agusmayanti et al. (2020), which stated that giving vitamin C can increase Hb levels in pregnant women, so pregnant women were expected to consume vitamin C regularly. However, a cross-sectional study conducted by Habibie et al. (2018) stated that there was no relationship between vitamin C intake and hemoglobin (Hb) levels in female adolescents. Vitamin C, ascorbic acid, is a 6-carbon compound soluble in water. Humans do not have the enzyme gluconolactone oxidase, which is essential for synthesizing the precursor of vitamin C, namely 2-keto-1-gluconolactone, so humans cannot synthesize vitamin C in their bodies (Li et al., 2020).

The dose of vitamin C used in this study was 1000 mg. This is supported by previous studies, which state that a dose of 1000 mg does not negatively impact the body. As revealed by Tirla et al. (2022), using 1000 mg of vitamin C was beneficial for athletes at risk of vitamin deficiency, such as martial arts athletes who used body weight as a parameter for competition or were not optimal in eating food. Paulsen et al. (2014) also revealed that the use of 1000 mg of vitamin C combined with 250 mg of vitamin E did not have an

acute impact on strength training to increase muscle strength. However, there is also a questionable view of the dosage of vitamin C, as explained by Paulsen et al. (2014), that 1000 mg of vitamin C does not have an impact on the physiological adaptation of strength training for young people, but has a positive impact on the elderly.

Combination of Iron Tablets and Vitamin C on Hemoglobin (Hb) Levels

From the results of the study, it shows that the average hemoglobin (Hb) level in the group given a combination of iron and vitamin C tablets is 14.50 ± 1.40 g/dL, which is significantly higher ($p < 0.05$) than the average Hb level in the control group, namely 11.93 ± 1.08 g/dL. This is in line with research conducted by Skolmowska and Głąbska (2022), which stated that there was a significant effect on changes in Hb levels by administering a combination of iron and vitamin C tablets. It is also recommended that the administration of the combination is accompanied by supervision so that the effect can be seen. Likewise, Li et al. (2020) stated that the supplementation of iron tablets is equivalent to a combination of iron tablets and vitamin C in improving the recovery of hemoglobin (Hb) levels and iron deficiency. Iron (Fe) is very influential in increasing hemoglobin levels and ultimately felt by subjects with increased aerobic endurance (Low et al., 2016).

Iron Tablets and Maximum Oxygen Volume (VO2 max)

The results show that the average maximum oxygen volume level (VO2 max) in the group given iron tablets is 41.24 ± 0.52 ml/Kg/minute, which is significantly higher ($p < 0.05$) compared to the average maximum oxygen volume level (VO2 max) for the control group was 38.33 ± 0.42 ml/Kg/minute. This is in line with research conducted by Pompano and Haas (2019), which found that iron supplementation increased endurance performance at submaximal and maximum training intensity (VO2 peak) in IDNA women. However, this is different from the results found by Wati (2021), which found that the level of hemoglobin (Hb) in the blood with the value of maximum oxygen volume (VO2 max) was not related or uncorrelated so that hemoglobin does not contribute to increases or decreases in values maximum oxygen volume. Iron is an essential component of hemoglobin which is bound to red blood cells. Hemoglobin supplies oxygen to muscles to metabolize carbohydrates and fats to produce energy. Iron adequacy figures are 15-18 mg per day for women and 10 mg per day for men. Meanwhile, an athlete requires 30% more iron than the average adult requirement (Pasricha et al., 2014).

From a physiological point of view, theoretically, it can be explained that iron tablets can increase hemoglobin levels. The Hb level in the blood is closely related to cardiorespiratory endurance. The oxygen carried by hemoglobin to the tissues is used for burning energy. The energy produced in this combustion is used in physical activity. Thus, the number of red blood cells and the amount of hemoglobin in the cells is very important in determining the number of erythrocytes transported to the muscles.

Vitamin C and Maximum Volume of Oxygen (VO2 max)

The results of the study show that the mean maximum oxygen volume level (VO2 max) in the group given vitamin C is 40.58 ± 0.66 ml/Kg/min, significantly higher ($p < 0.05$) compared to the average VO2 levels. The max score of the control group is 38.33 ± 0.42 ml/Kg/min. Judging from the role of vitamin C as an exogenous antioxidant, vitamin C plays a role in inhibiting oxidative stress. Vitamin C, or ascorbic acid, is a 6-carbon compound soluble in water. Humans do not have the enzyme gluconolactone oxidase, which is essential for synthesizing the precursor of vitamin C, namely 2-keto-1-gluconolactone, so humans cannot synthesize vitamin C in their bodies (Drouin, G et al., 2011). Vitamin C is an electron donor and reducing agent. It is called an antioxidant because by donating its electrons, this vitamin prevents other compounds from being oxidized. However, vitamin C is oxidized in antioxidants to produce dehydroascorbic acid (Paulsen et al., 2014).

Combination of Iron and Vitamin C Tablets to Maximum Oxygen Volume (VO2 max)

From the results of the study, it shows that the mean maximum oxygen volume level (VO2 max) in the group given a combination of iron and vitamin C tablets is 43.33 ± 0.41 ml/Kg/min, significantly higher ($p < 0.05$) than with the average VO2 max level in the control group, namely 38.33 ± 0.42 ml/Kg/min. This is in line with a study conducted by Skolmowska and Głąbska (2022), which identified that iron and vitamin C supplementation given simultaneously significantly increased hemoglobin (Hb) and aerobic endurance. An increase in hemoglobin levels has a significant relationship with an increase in aerobic endurance. Meanwhile, according to Dewi and Wirjatmadi (2017), different facts were found, namely, the adequacy level of vitamin C and iron affected the relationship with the level of physical fitness of IPSI Lamongan martial arts athletes. Skolmowska and Głąbska (2022) also stated that iron (Fe) was very influential in increasing Hb levels, and in the end, it was felt by the subject with increased aerobic endurance. Iron, as the main ingredient in the formation of hemoglobin, makes iron an essential element in the formation of hemoglobin. Many factors influence the formation of hemoglobin, one of which is iron in the body. 70% Fe is in hemoglobin, while 26% is stored as iron in the liver, spleen, and bones (Kiss et al., 2015).

The results show a significant effect on hemoglobin levels, which in the end also significantly affected aerobic endurance. This is related to previous studies by Chen et al. (2022), which stated that iron supplements can increase hemoglobin levels and learning achievement. These results support previous studies which stated that vitamin C increases aerobic endurance. Another study stated that giving vitamin C alone could increase aerobic resistance. Hemoglobin was proven to influence aerobic endurance (Li et al., 2020).

CONCLUSION

Based on the research results and discussion, it can be concluded that administering iron tablets to female athletes in martial arts is proven to significantly increase hemoglobin levels and maximum oxygen volume. Administration of a combination of iron and vitamin C tablets is also shown to significantly increase hemoglobin levels and a higher maximum oxygen volume than iron and vitamin C alone. This shows that giving iron and vitamin C tablets has an additive effect on female athletes in martial arts.

This additive effect is supported based on research results in increased hemoglobin levels and maximum oxygen volume in female athletes in martial arts after being given 1000 mg of iron and vitamin C tablets. Hemoglobin levels in female martial arts athletes are higher after being given iron tablets, 1000 mg of vitamin C, and a combination of iron tablets and 1000 mg of vitamin C compared to those not given treatment. The maximum oxygen volume (VO2 max) in female martial arts athletes is higher after being given iron tablets, 1000 mg of vitamin C, and a combination of iron tablets and 1000 mg of vitamin C compared to those not given treatment. In addition, hemoglobin levels and maximum oxygen volume (VO2 max) in female athletes in martial arts are higher after being given a combination of iron tablets and 1000 mg of vitamin C compared to those given only 1000 mg of iron or vitamin C tablets.

There are limitations in this study, namely the limited number of samples and the difficulty of controlling behavior in consuming food. So for further research it is recommended to use a more representative number of samples and exercise tighter control over behavior in consuming food. In addition, it is advisable to study other combinations of both minerals and other antioxidants. A new finding in this study is that giving a combination of iron tablets and Vitamin C 1000 mg can increase hemoglobin levels and cardiovascular capacity in female athletes in martial arts. This happens because Vitamin C can accelerate the absorption of iron so that hemoglobin levels increase. In addition, with increasing hemoglobin levels, it will be able to increase the distribution of oxygen throughout the body. With the combination of supplementation of iron tablets and 1000 mg vitamin C, it is indirectly able to increase VO2 max capacity.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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