

Original Research Article

The Effect of Beetroot (Beta Vulgaris) on Hemoglobin Levels and Vo2max Atlet Value

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Abstract: This study aims to determine the effect of beetroot juice on hemoglobin levels and the VO2Max value of an athlete. This research is an experimental study using a true experimental design with a pretest-posttest control group design approach. This study used 36 badminton athletes divided into 3 groups. The results showed that there were significant differences in hemoglobin levels in badminton athletes after consuming beetroot juice, the 200 ml beetroot juice group ($p = 0.001$), the 300 ml beetroot juice group ($p = 0.002$). There was a difference in the levels of Hemoglobin in badminton athletes after treatment between consuming 200 ml beetroot juice and a group consuming 300 ml beetroot juice but not significant ($p = 0.744 > p = 0.05$). There were significant differences in VO2Max values after consumption of beetroot juice in the 300 ml group ($p = 0.000$), but there were no significant differences in VO2Max values in the control group ($p = 0.007$) and the 200 ml group ($p = 0.007$). There was a significant difference in the value of VO2Max badminton athletes between the group consuming 200 ml beetroot juice and the group consuming 300 ml beetroot juice after treatment ($p = 0.031 < p = 0.005$). Beetroot juice can be highly recommended for athletes to maintain stamina in optimal conditions.

Keywords: Beetroot Juice, Hemoglobin Level, Vo2max Value, Athlete.

INTRODUCTION

An athlete is required to always have the stamina that does not get tired. But in reality, not a few athletes have decreased stamina during the competition in a short amount of time so that this can reduce the performance of an athlete. Indicators of decreased performance can be seen from the level of physical fitness of athletes when competing. Quantitatively the athlete's physical fitness can be measured through cardiorespiratory endurance during exercise activities [1].

Cardiorespiratory resistance is the ability of the heart, lungs, and blood vessels to function optimally at work when taking maximum oxygen (VO2Max) and channeling it throughout the body, especially in active tissues so that it can be used for metabolic processes. Measuring cardio respiration endurance can be done by measuring maximum oxygen consumption. VO2Max is the maximum amount of oxygen that can be consumed during intense physical activity until fatigue occurs. VO2Max measurement can be used to analyze an athlete's stamina level [2- 4].

Cardiorespiratory endurance in men reaches its peak at the age of 18-25 years together with the peak of muscle mass growth [5]. Cardiorespiratory endurance in males is said to be good if the VO2Max score is 44-52.9 ml/kg/minute [6]. Several studies have shown that the cardio respiration endurance of a young athlete in Indonesia is not good enough. Research conducted by Permadi, 2017, a survey of VO2Max endurance in badminton athletes shows results that are categorized as moderate with an average VO2Max value of 38.49 ml/kg/minute. The percentage of the endurance of each athlete is 20% good category, 30% medium category, 20% less category, and 30% with very less category.

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Decreased cardiorespiratory endurance (VO₂Max) will disrupt aerobic capacity, especially during physical activity or exercise with long duration so that it will be easily tired due to reduced oxygen supply in the muscles and the formation of lactic acid which can cause or cause fatigue in the muscles [7].

One factor that can affect the level of physical fitness of a person is Hb levels. To increase Hb levels, more iron consumption is needed to form blood Hb. There are several factors that support the formation of Hb by iron, one of which is zinc which has the role of forming transferrin as a means of transporting iron to where it is needed [8]. Low levels of Hb a person has a bad impact on one's physical fitness because the activities needed enough Hb to bind O₂ in the air. Therefore, iron and zinc are important nutrients for hemoglobin and physical fitness.

Hemoglobin has an important role in cardiorespiratory endurance, namely as a carrier of oxygen from the lungs and then distributed throughout the body's tissues. Hemoglobin has a role as a sender of oxygen to the entire network so that it affects the value of VO₂Max [9, 10]. Research conducted by Huldani states that in the group that has normal Hb on average has a VO₂Max value of 47.59 ml/kg/min, higher than the average VO₂Max value in the group that has a low hemoglobin level of 37.84 ml/kg/minute [11]. One of the substances that can optimize VO₂Max levels is the nitrate content found in food ingredients. Beet tubers are one food source that has a high nitrate content [12].

Utilization of beetroot (*Beta vulgaris*) in sports is still very few and even very rarely an athlete knows about the benefits of beetroot. One of the potential or benefits of beetroot that has not been utilized in the field of sports nutrition is beetroot able to increase the stamina of an athlete with an indication that beetroot can increase the VO₂Max of an athlete with nitrate content which biologically affects the regulator of O₂ utilization by muscle contractors so that the distribution of O₂ is in accordance with muscle needs [13].

Beet tubers are one food ingredient that contains nitrates. Beets derived from beet plants (*Beta vulgaris*) have a distinctive purplish-red color due to the presence of betalain pigments. Several studies have proven the effect of beet tubers on pulmonary oxygen uptake (VO₂). Research conducted in 2010 in the United Kingdom which stated that consumption of inorganic nitrates (5.1 mmol nitrate/day) in the form of 500 ml beetroot juice for 6 days can reduce pulmonary oxygen uptake (VO₂) in heavy intensity exercise so that it can delay fatigue time in an athlete [13].

Research conducted by Bailey *et al.* [15] states that beetroot can increase VO₂Max in the subject of 8 healthy men (not athletes) aged 19-38 years after consuming 500 ml of beetroot/day for 6 days. Research conducted by Fillah Fithra Dieny et al stated that there was no significant effect on beetroot juice administration on VO₂Max and Hb levels, but the increase in VO₂Max in the group consuming 300 ml beet tubers was greater than the group consuming 200 ml beet tubers [4]. in addition to the nitrate content found in beetroot, beetroot also contains vitamins and minerals which are iron, folic acid and vitamin C which can increase an athlete's Hb level [16, 17]. Research conducted by A.M Jones says supplementing nitrate or beetroot juice can improve sports performance in moderate caliber athletes and individuals among the elite population [18].

Based on the background description, researchers are interested in examining the effect of beetroot juice on hemoglobin levels and the VO₂Max value of an athlete. This research was conducted on badminton athletes.

METHODS

Research design

This research is an experimental study using a true experimental design with a pretest-posttest control group design approach. This research was divided into 3 research groups namely treatment group I, treatment group II, and placebo. Treatment group, I was given 300 ml beetroot juice and treatment group II was given 200 ml beetroot juice. The independent variable in this study is the administration of beetroot juice and the dependent variable in this study is the hemoglobin level and VO₂Max value.

The research location used is the Badminton Sports Hall of the Faculty of Sport Science UNM. Researchers chose the UNM Sports Faculty Badminton GOR as a research location on the grounds that the UNM Sports Badminton Faculty GOR as a place for researchers usually practiced badminton and there were many students who were active and practicing regularly.

Population and Sample

The population in this study were all students of badminton athletes who are members of BKMF Badminton FIK UNM. Samples to be used in this study were 30 athletes, which were divided into three groups, namely the 300 ml treatment group, the 200 ml treatment group, and the control group. This study used 36 badminton athletes who were divided into 3 groups.

Data Analysis

Data analysis using SPSS for windows software program to see the effect of beetroot juice on hemoglobin levels and VO2Max values of badminton athletes. Univariate analysis Bivariate analysis was used to analyze differences in Hb levels and post VO2Max values, increase in Hb levels and VO2Max values, and confounding variables between the three groups. Multivariate analysis uses a multiple linear regression test to analyze confounding variables that most influence the increase in Hb levels and VO2Max values. After that, ANCOVA Test was performed to see the effect of beetroot juice administration after being controlled with confounding variables [19].

RESULTS

Table-1: Characteristics of Research Subjects in All Three Groups

Subject Description	Beetroot Juice 300 (n = 12)				Beetroot Juice 200 (n = 12)				Control (n = 12)				p
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	
Age (years)	20,08	2,11	18	25	19,50	1,24	18	21	19,58	0,90	18	21	0.915**
Body Weight	59,63	10,70	39	73,6	62,09	6,09	54	72,7	57,53	4,67	50	63,1	0.409**
Height	166,92	6,83	151	176	166,58	5,14	160	180	165,75	5,03	153	171	0.793**
IMT	21,21	2,64	17,1	25,9	22,42	2,63	19	26,7	20,93	2,43	18	27	0.331*

*One Way ANOVA

**Kruskal Wallis

Analysis of Hemoglobin (Hb) Levels in Badminton Athletes

The results of hemoglobin analysis in badminton athletes BKMF FIK UNM before and after treatment can be seen in the following table:

Table-2: Results of Hemoglobin Analysis in Badminton Athletes Before and After Treatment

Group		Beetroot Juice 300 (n = 12)		Beetroot Juice 200 (n = 12)		Control (n = 12)		
		Mean	SD	Mean	SD	Mean	SD	P**
Hb	Pre test	12,71	1,62	12,65	1,21	11,41	1,90	0.096**
	Hari Ke-7	14,03	1,54	13,65	1,31	12,35	1,29	0,014**
	Hari Ke-16	14,76	1,12	14,92	1,22	13,14	1,54	0,003**
	P*	0,002*		0,001*		0,001*		

*Repeated ANOVA

**One-Way ANOVA

The control group, the 200 ml treatment group and the 300 ml treatment group each consisted of 12 respondents. Differences in the effect of beetroot juice administration on Hb levels, then Hb levels were measured three times, namely before treatment, one week after treatment and on the 16th day after 15 treatment days. Before the treatment of the average Hb levels of the control group was 11.41 ± 1.90 gr/dl, the treatment group was 200 ml 12.65 ± 1.21 gr/dl and for the treatment group 300 ml 12.71 ± 1.62 gr/dl. After treatment, the average Hb levels in the three groups experienced an increase of 13.14 ± 1.54 gr/dl in the control group, 14.92 ± 1.22 gr/dl in the 200 ml treatment group and 14.76 ± 1.12 gr/dl in the 300 ml treatment group.

Repeated ANOVA statistical test results ($\alpha = 0.05$) there were significant differences in the increase in Hb levels before and after treatment in the three groups. It can be interpreted that both the treatment group and the control group both experienced significant increases in Hb levels before and after treatment ($p < 0.05$). However, the mean increase in Hb in the 300 ml treatment group (14.74 ± 1.12 gr/dl), the 200 ml group (14.76 ± 1.22 gr/dl) was higher than the control group ($13.14 \pm 1, 54$ gr/dl). One-way ANOVA test results showed no significant difference in hemoglobin levels in the three groups after the intervention for 7 days with a value of $p = 0.014 > 0.05$ but after 15 days of intervention, there was a significant difference in hemoglobin levels in the three groups in the name p-value = $0.003 < 0.05$.

Table-3: Results of Analysis of Hemoglobin Levels in the 300 ml Group and 200 ml Group

Group		Beetroot Juice 300 (n = 12)		Beetroot Juice 200 (n = 12)		p
		Mean	SD	Mean	SD	
Hb	Pre Test	12,708	1,6155	12,65	1,2072	0.921*
	Hari Ke-7	14,033	1,5412	13,65	1,3063	0.518*
	Hari Ke-16	14,758	1,1212	14,917	1,2187	0.744*

*Independent Samples T-test

Based on Table 3 the results of the analysis show that there is no significant difference in the Hb pre-test levels in the 200 ml group and the 300 ml group with a p-value = 0.921 > 0.05. On the seventh day of the treatment also there was no significant difference in Hb levels between the two treatment groups with a value of p = 0.518 > 0.005. On the 15th day after treatment there was also no significant difference between the 200 ml treatment group and the 300 ml treatment group where the p value = 0.744 > 0.05.

To see more clearly the difference between the mean Hb levels before and after treatment in each treatment group and the control group can be seen in Figure 1.

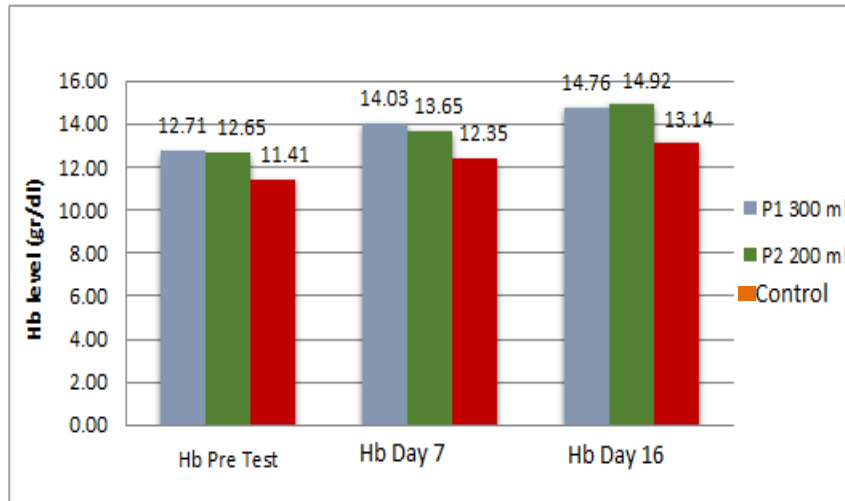


Fig-1: Mean Changes in Hemoglobin Levels before and After Treatment

Analysis of VO2Max Value for Badminton Athletes

The results of the analysis of VO2Max values in badminton athletes BKMF FIK UNM before and after treatment can be seen in the following table:

Table-4: Results of VO2Max Value Analysis of Badminton Athletes Before and After Treatment

Group		Beetroot Juice 300 (n = 12)		Beetroot Juice 200 (n = 12)		Control (n = 12)		
		Mean	SD	Mean	SD	Mean	SD	P**
VO2Max	Pre test	43,69	5,92	39,85	6,94	38,53	7,21	0,164**
	Post test	49,39	6,17	43,57	6,28	41,28	5,90	0,008**
		P*		0,000*				0,007*

*Paired T-test

** One-Way ANOVA

Based on Table 4. shows the VO2Max value before treatment in the control group is 38.53 ± 7.21 ml/kg/min, the 200 ml group is 39.85 ± 6.94 ml/kg/min and the 300 ml group is 43.69 ± 5.92 ml/kg/minute. After treatment, each group experienced an increase in VO2Max value to 41.26 ± 5.90 ml/kg/min in the control group, 43.57 ± 6.26 ml/kg/min in the 200 ml group and the 300 ml group the VO2Max value is increased to 49.39 ± 6.17 ml/kg/min.

Based on Table 4. the results of the paired T-test showed that there was no significant increase in VO2Max values in the control group and in the 200 ml group where the p-value = 0.007 > 0.05. However, the 300 ml group experienced a significant increase in VO2Max with a value of p = 0,000 < 0.05. One-way ANOVA test results showed no significant difference in VO2Max values in the three groups after consumption of beetroot juice where p = 0.008 > 0.05.

Table-5: Results of Analysis of VO2Max Values in the 300 ml Group and 200 ml Group

Group		Beetroot Juice 300 (n = 12)		Beetroot Juice 200 (n = 12)		p
		Mean	SD	Mean	SD	
VO2Max	Pre Test	43,692	5,918	39,85	6,9426	0,159*
	Post Test	49,392	6,1654	43,567	6,2564	0,031*

*Independent Samples T Test

Based on Table 5 the results of the analysis show that there is no significant difference in VO2Max values between the 200 ml group and the 300 ml group before treatment where the p-value = 0.159 > 0.05. But after giving treatment there was a significant difference between the two groups with a value of p = 0.031 < 0.05.

To see more clearly the difference in mean VO2Max values before and after treatment in each group in Figure 4.2. Based on Table 4.5 the results of the analysis show that there is no significant difference in VO2Max values between the 200 ml group and the 300 ml group before treatment where the p value = 0.159 > 0.05. But after giving treatment there was a significant difference between the two groups with a value of p = 0.031 < 0.05.

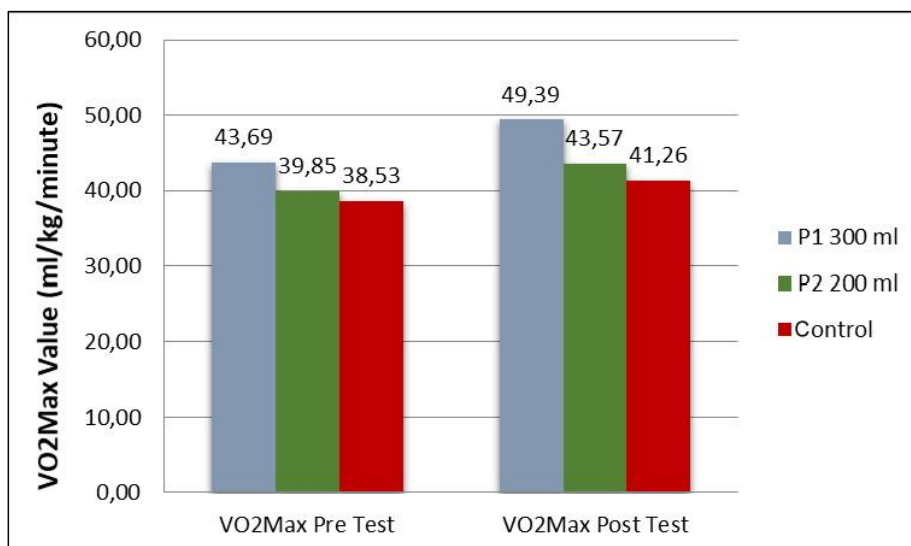


Fig-2: Mean Change in VO2Max Value before and After Treatment

Figure 2 shows that after the mean treatment of VO2Max the value of badminton athletes increased in all three groups, but the highest increase occurred in the group consuming 300 ml of beetroot juice whose pre-test VO2Max value was 43.69 ± 6.17 ml/kg/minute increasing to 49.39 ± 6.17 ml/kg/minute and the mean increase in VO2Max values was lowest in the control group, which was VO2Max pre-test at 38.53 ± 7.21 ml/kg/minute and in the post-test it increased to 41, 26 ± 5.90 ml/kg/minute.

Analysis of Confounding Variables

Table-6: Overview of Confounding Variables during Interventions in the Control and Treatment Group

Subject Description	Beetroot Juice 300 (n = 12)				Beetroot Juice 200 (n = 12)				Control (n = 12)				p
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	
calories	1485,92	184,89	1143	1697	1527,58	77,26	1433	1668	1499,83	89,68	1325	1646	0.717*
energy	2104,17	610,09	1171	3372	1860,83	367,22	1293	2594	2047,92	295,07	1271	2420	0.184**
carbohydrate	263,16	79,09	161,1	459,08	225,48	46,97	149,2	281,6	2535,09	8116,41	115,89	28308	0.089**
protein	85,44	36,26	33,5	149,93	85,01	25,51	33,59	124,4	174,38	285,07	41,27	1075	0.490**
fat	84,90	30,30	43,4	155,02	75,88	27,12	44,7	125,5	93,15	26,15	30,37	126,27	0.329*
iron	11,14	4,69	0,8	18,6	13,00	7,59	0,8	27,9	12,22	7,02	2,1	24,4	0.785*
vit C	64,67	111,05	0	364	14,75	36,67	0	118	9,83	34,06	0	118	0.128**
Nitrate	0,08	0,29	0	1	0,00	0,00	0	0	0,00	0,00	0	0	0.368**
total calories	2581,08	753,78	1551,32	4136,73	2274,96	440,20	1581,96	3101,9	2459,89	334,58	1554,73	2916,4	0.351**

*One Way ANOVA

**Kruskal Wallis

Based on the results of the analysis using the One Way ANOVA test and the Kruskal Wallis test of all confounding variables there were no significant differences from the three groups (p > 0.05). From the results of the analysis of Table 4.6 from the three groups shows that the intake of nitrate, Vit C, and iron which is lacking, this is influenced by the consumption patterns that consume less vegetables or fruits, in addition to the habit of eating fast food which is more in demand by athletes because it is easy in the manufacturing process, so the intake of nitrates, Vit C is very less. So that the intake of nitrate, Vit C and also iron is mostly only obtained from the consumption of beetroot juice during the administration of the intervention.

DISCUSSION

Proper nutrition is the main basis for an athlete's prime performance when competing, nutrition is also needed to repair or replace damaged body cells [20]. The most frequently consumed foodstuffs are instant noodles and processed meats such as meatballs, high-calorie food items but lacking nutritional value, while the optimal performance of athletes must meet the adequacy of macro and micronutrients so that during interventions it can be said that micronutrients are primary substances iron, folic acid and vitamin C which are theoretically known to increase hemoglobin levels are mostly only obtained from beetroot and certainly contribute most to athlete hemoglobin levels. The results of this study provide a different picture from the results of research conducted by Dieny, *et al.* [4] conducted in 18 UNNES Football Club athletes aged 18-22 years, beetroot juice given for 7 days and concluded there was no significant effect from beetroot juice administration is done to increase the value of Hemoglobin, but this can occur because of the length of the intervention which is only 7 days and a relatively smaller number of samples because in several other studies prove that beetroot contributes to improving hemoglobin levels in the blood, such as the results research conducted by Anggraini *et al.* [21] by providing beetroot juice therapy in adolescents with anemia for 7 days, obtained significant results on increasing hemoglobin levels after beetroot juice therapy.

The post-test measurement of the VO₂Max value was carried out on the 16th day after the intervention for 15 consecutive days. The VO₂Max measurement test was carried out twice, namely at the beginning before giving the intervention and on the 16th day after giving the intervention for 15 days. Cardiovascular endurance (VO₂Max) values in 3 groups each experienced a significant increase, but the highest increase in VO₂Max value was in the group that was given the intervention of 300ml beetroot juice. The value obtained is in the group with the intervention of 300ml beetroot juice the average VO₂Max value before the intervention is 43.69 ml/kg/minute and after the intervention, it becomes an average of 49.39 ml/kg/minute. In the 200ml group, VO₂Max values averaged before 39.85 ml/kg/min and after the intervention averaged 43.57 ml/kg/min. The control group VO₂Max initial value averaged 38.53 ml/kg/min and after an average of 41.26 ml/kg/min. The increase in VO₂Max value was due to an increase in hemoglobin levels and high nitrate content in beetroot given during the intervention. Vegetables provide more than 80 percent of nitrate intake, while based on recall 24 obtained by almost all athletes in the three groups studied do not have the habit of consuming vegetables, other than because there are no eating arrangements, fast food is more attractive to athletes because it is easy in the manufacturing process, thus nitrates and the positive effects that occur during the intervention are only obtained from beetroot juice given.

Nitrates in the body will be converted into nitrogen monoxide (NO), which is a chemical that can activate other chemicals in the process of vasodilation of blood vessels caused by the relaxation of smooth muscle cells in the walls of arteries and veins. When blood vessels dilate, blood circulation will increase and increase cardiac output. Vasodilation of blood vessels also determines the distribution of oxygen in the blood can be distributed throughout the body optimally, this prevents fatigue and muscle cramps as well as various other risks of sports injuries, in other words, the high nitrate content in beetroot juice is capable of increasing the athlete's VO₂Max which biologically affects the regulator utilization of O₂ by muscle contractors so that the distribution of O₂ according to muscle requirements and nitrate supplementation until the 15th day can increase mitochondrial mass so that it also increases the use of NO (Nitric oxide) in the mitochondria in producing energy [22], therefore, the recommended duration of beetroot extract is more than 15 days for endurance athletes such as badminton athletes.

Increased hemoglobin levels also play a role in increasing the value of VO₂Max, the adequacy of protein in the blood that functions as a carrier of oxygen to all body tissues allows an increase in the capacity of VO₂Max athletes. The iron that is in each hemoglobin molecule is very important in carrying out its function in binding and releasing oxygen.

The results of this study are in line with research conducted by Bailey *et al.* [14] which states that beetroot can increase VO₂Max in the subject of 8 healthy men (not athletes) aged 19-38 years after consuming 500 ml of beetroot/day for 6 days, also relevant to from the results of research Vanhatalo *et al.* [22] after the intervention of beetroot extract 500 ml/day in 8 athletes continued from 5 days to 15 days, VO₂Max treatment group increased significantly compared to the control group, it can be concluded that beetroot juice gave a significant effect large endurance measured with a significant increase in the measurement of VO₂Max values and according to the results of previous studies, this does not only apply to athletes but also to non-athletes who routinely consume beetroot juice.

It has been described in several previous theories that the better the value of maximal oxygen uptake will allow the athlete to be able to do his sports activities longer. Especially in aerobic sports, excellent VO₂Max conditions will certainly produce excellent endurance or endurance. These conditions will certainly benefit athletes. Puype *et al.* [23], conducted on 11 athletes, states that the optimal dose of nitrate that is indicated to increase plasma nitrite is between 5 - 8 mmol of nitrate contained in 500 ml of beetroot juice. The dose is given more than three times a day ie 1.7 mmol nitrates each at breakfast, lunch and at dinner, and given 2-3 hours before exercise. This dosage can optimize the nitrate - nitrite -

NO pathway by increasing plasma nitrite so that it can improve the efficiency of oxygen use during training and increase tolerance to fatigue when exercising in conditions of oxygen deprivation, although in this study athletes were only given a dose of 300 ml and 200 ml at a time consumption before exercise for 15 days, it was enough to give a significant increase in hemoglobin levels, especially in the athlete's VO2Max value.

The contribution of various confounding variables one of which is calorie intake, energy, carbohydrate, protein, fat, iron, vitamin C and nitrate apart from beetroot in research statistically there is no effect on changes in hemoglobin levels or VO2Max values of badminton athletes in all three groups, and based on the results of the analysis there were no significant differences between the confounding variables in the three groups.

CONCLUSION

There were significant differences in hemoglobin levels in badminton athletes after consuming beetroot juice, the 200 ml beetroot juice group ($p = 0.001$), the 300 ml beetroot juice group ($p = 0.002$). There was a difference in the levels of Hemoglobin in badminton athletes after the treatment between consuming 200 ml beetroot juice and the group consuming 300 ml beetroot juice but it was not significant ($p = 0.744 > p = 0.05$). There was a significant difference in VO2Max value after consumption of beetroot juice in the 300 ml group ($p = 0.000$), but there were no significant differences in the VO2Max value in the control group ($p = 0.007$) and the 200 ml group ($p = 0.007$). There was a significant difference in the value of VO2Max badminton athletes between the group consuming 200 ml beetroot juice and the group consuming 300 ml beetroot juice after treatment ($p = 0.031 < p = 0.005$).

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