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Özgün Araştırma / Research Article

EFFECTS OF SODIUM BICARBONATE INTAKE ON PERFORMANCE IN MIDDLE DISTANCE RUNNING WITH ADDITIONAL WEIGHT

İsmail DUT[1], Orkun PELVAN[2] , Hüseyin AKBULUT[3]

ABSTRACT

In this study, the effects of external sodium bicarbonate ($NaHCO_3$) intake on performance in middle-distance running with additional weight were investigated. Male athletes (n=13) with an average age of 26.38 ± 2.81 (years) and 5.92 ± 1.84 (years) of sport experience, and with bodyweight of 77.83 ± 8.13 (kg) involved voluntarily. Performance measurements were made by Cooper run test, while the athletes carried a load with the additional weight of 20% of their body weight. One group of athletes were given 300 ml fruit juice mixed with 20 gr. starch and the other group was given sodium bicarbonate ($NaHCO_3$) at a dosage of 0.3 g / kg mixed with 300 ml fruit juice given as single-blind. Anthropometric measurements, blood lactate, running distance and heart rate were measured on the test days. The analysis was examined by repetitive measures ANOVA at $p<0.05$ significance level via SPSS 14 program. The results revealed that running distances with the intake of sodium bicarbonate ($NaHCO_3$) increased and there was a significant difference in blood lactate levels ($p <0.05$).In the Cooper test, it was observed that the performance of athletes who run with 20% of their body weight and use sodium bicarbonate ($NaHCO_3$) increases.

Keywords: *Sodium Bicarbonate, Additional Weight, Cooper Test, Performance, Tactical Athlete*

İLAVE AĞIRLIK İLE YAPILAN ORTA MESAFE KOŞULARDA SODYUM BİKARBONAT ALIMININ PERFORMANS ÜZERİNE ETKİSİ

ÖZET

Çalışmamızda ilave ağırlık ile yapılan orta mesafe koşularında dışarıdan sodyum bikarbonat ($NaHCO_3$) alınmasının performansa etkileri araştırılmıştır. Çalışmaya ortalama yaşları 26,38 ± 2,81 (yıl), spor yaşları 5,92 ± 1,84 (yıl), vücut ağırlığı 77.83 ± 8.13 (kg) olan erkek sporcular (n=13) gönüllü olarak katılmıştır. Çalışmada sporcuların vücut ağırlığının yüzde yirmisine (%20) eşit olan ağırlık sırt çantasına içerisine konularak yapılan Cooper koşu testi ile performans ölçümleri yapılmıştır. Sporculara koşudan 90 dk önce plasebo grubuna 20 gr. nişasta karıştırılmış 300 ml meyve suyu ve diğer gruba ise 0,3 gr/kg dozajında sodyum bikarbonat ($NaHCO_3$) 300 ml meyve suyuna karıştırılarak tek kör (single blind) yöntemi uygulanarak verilmiştir. Test günlerinde antropometrik ölçümler, kan laktatı, koşu mesafesi ve kalp atım hızları ölçülmüştür. Çalışmada elde edilen sonuçlar SPSS 14 programı kullanılarak Tekrarlayan Ölçümler ANOVA analizi ile 0,05 anlamlılık düzeyinde incelenmiştir. Ölçümler sonucunda dışarıdan sodyum bikarbonat ($NaHCO_3$) alımında koşu mesafelerin arttığı ve kan laktat seviyelerinde anlamlı bir fark olduğu bulunmuştur ($p<0,05$). Sporcuların vücut ağırlığının yüzde yirmisi oranında ilave

[1] Marmara Üniversitesi Sağlık Bilimleri Enstitüsü, İstanbul/TÜRKİYE.
efesat@windowslive.com, ORCID iD: 0000-0002-5693-7308
[2] Marmara Üniversitesi Spor Bilimleri Fakültesi, İstanbul/TÜRKİYE.
orkunpelvan@gmail.com, ORCID iD: 0000-0001-7809-0788
[3] Marmara Üniversitesi Sağlık Bilimleri Enstitüsü, İstanbul/TÜRKİYE.
huseyinakbulut71@gmail.com, ORCID iD: 0000-0002-4735-8574

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FBU-JSS e-ISSN: 2791-7096

ağırlık kullanarak yaptığı Cooper koşu testinde sodyum bikarbonat ($NaHCO_3$) kullanan sporcularda performans artışı meydana gelmiştir.

Anahtar Sözcükler: *Sodyum Bikarbonat, İlave Ağırlık, Cooper Testi, Performans, Taktik Atlet*

1. INTRODUCTION

In this study, the effects of sodium bicarbonate intake in middle distance running with additional weight on physiological and performance were examined.

It was observed that previous studies on this topic were usually conducted on anaerobic performance. In this study, Cooper Running Test, one of the aerobic fitness tests, was used as the running test to investigate the effect of sodium bicarbonate ($NaHCO_3$) intake on performance in middle distance running. Moreover, Cooper Running Test was modified with additional weight equivalent to 20% of body weight load during the test to expand the scope of the study.

The results of this study is considered as conducive to sports branches (i.e. ultra marathon, hiking, cross-fit, trekking) using additional weight (e.g., soldiers, police, firefighters, divers who are required to perform higher, due to dynamics of their profession).

It is suggested the fact that tactical athletes, a term used to describe those in service professions, are supposed to have less recovery or resting time in their training/exercise unlike the general performance athletes because they are always asked to perform their duty under any circumstances whatsoever with no exact deadline, and to overcome exhaustion due to their physical performance affecting their survival for life-or-death situation. Tactical athletes are supposed to carry several equipments so as to achieve their duty safely, which affects their performance adversely due to the weight of the equipments.

Decrase in performance in such adverse conditions results in failure to achieve their duty and even in deadly incident affecting human life.Therefore, this study is considered as vital especially for tactical athletes in terms of prevention of decreasing in their performance on duty.

2. MATERIAL AND METHODS

This study was conducted with the protocol number 09.2017.420 on 02/06/2017, after the approval of the Ethics Committee of Marmara University Faculty of Medicine in Istanbul, Turkey. In addition, project support from Marmara University Scientific Research Projects Commission was received on 20/03/2018 with the date and number SAG-C-YLP 200318-0107.

2.1 PARTICIPANT' PROFILE

A total of 13 (n=13) athletes living in Istanbul were included in the study. The participants for the research were selected from athletes with at least 4 years of active athletes, no health problems, body weight with not more than 100 kilograms, who run 3000 meters or above in the Cooper running test, participated in national competitions and whose sports experiences and performances were close to each other.

FBU-JSS e-ISSN: 2791-7096

The mean age of the participants was 26.38±2.81 (years), and the mean sports age was 5.92±1.84 (years). The athletes participated the study voluntarily. Before the tests were carried out, the participants were informed about the scope of the study, and they signed written consent forms.

2.2. METHODS

Before the measurements, the warm-up protocol was applied and tests were carried out on three different days, with at least 48 hours between the test days. Athletes were given 20 gr in the placebo group 90 minutes before running. starch was mixed with 300 ml of fruit juice and sodium bicarbonate ($NaHCO_3$) at a dosage of 0.3 g/kg was mixed into 300 ml of fruit juice and given to the other group by the single blind method. Anthropometric measurements, blood lactate, running distance and heart rate were measured on the test days (Table 1).

1. Test Day			**2.Test Day**			**3.Test Day**	
Without additional weight (n=13)			**Placebo or $NaHCO_3$ With additional weight (n=13)**			**Placebo or $NaHCO_3$ With additional weight (n=13)**	
Before Run	Anthropometric measurements, Blood lactate, Heart rate	**Rest Day**	**Before Run**	Blood lactate, Heart rate	**Rest Day**	**Before Run**	Blood lactate, Heart rate
After Run	Blood lactate, Heart rate, Running distance		**After Run**	Blood lactate, Heart rate, Running distance		**After Run**	Blood lactate, Heart rate, Running distance

2.3. MEASUREMENTS

2.3.1. BODY COMPOSITION TEST

Body weight,body height and body girths are measured to identify the participants' physical characterics.

2.3.2. Height and body weight measurement (cm/kg)

The participants stood in front of a 0.01-precision-range height chart. The height measurement was made when the foot heels were adjacent, the head was upright, and the eyes were facing forwards. The participants' body weight measurements were conduct bare feet using the “Tanita” SC-330 Digital Scale. The body weight measurements of the participants were taken 2 hours prior to the test.

2.3.3. Body Mass Index (BMI/kg/m²) (BMI) measurements

The Body Mass Index, which is one of the measurement methods used for weight control, was calculated by dividing the body weight (kg) by the square of the height (m).

BMI= Body Weight (kg) / Height (m)²

2.3.4. Body fat percentage measurement

The body fat percentage measurements were made with the “Tanita” SC-330 Digital Scale, while participants were barefoot with only underwear on them in athlete program, and were then recorded.

2.3.5. Cooper running test

One of the most frequently used aerobic fitness measurement methods is the 12-Minute Running Test popularized by Dr. Kenneth Cooper. The test is applied on a 400-meter track, and athletes start to run in the designated field with the “Start” command. The athletes determined their running speed themselves. Athletes can complete the test at a fast running pace or at a slow running pace within 12 minutes. By counting each running round of athletes, the test is ended by giving a command again after the end of the 12-minute period, and the distances the athletes run are measured and recorded (Cooper,1968).

2.3.6. The VO_2max ($ml.kg^{-1}.min^{-1}$)= value

It was found by using the following formula with the distance ran according to the Cooper Test (Cooper,1968; Maliqueo et al., 2018).

VO_2max ($ml.kg^{-1}.min^{-1}$)= (22.351 x Distance run in km) – 11.288

2.3.7. Heart Rates (HR)

The Polar (RS 800 Model) Watch Heart Rate Monitor was used to record the participants' Heart rates (HR). The recording was started before the test, and HR was recorded during and immediately at the end of the run the test.

2.3.8. Blood Lactate Value Measurement

The participants' blood lactate levels were measured at every 1-3-5 minutes interval just before the warm-up, right before the loaded test (Cooper Running Test), and immediately after the test. Lactate Scout+ Kit and Lactate Analyzer Device were used for lactate measurements.

FBU-JSS e-ISSN: 2791-7096

2.3.9. Extra Weight Backpack

A 25-liter backpack designed for running with soft, adjustable back and waist straps was used in the study. The loaded bag's weight was equal to twenty percent (20%) of the participant's body weight. The material placed in the bag was provided with the necessary fixing system to prevent shaking during the test.

2.3.10. Warm-up Protocol

The Warm-Up Protocol was applied with a free sports suit before each test for a total of 25 minutes, including dynamic and static stretching, and 15-minute slow running without extra weight. Passive rest was given for at least 10 minutes at the end of the warm-up until the test.

2.3.11. Analysis of Data

The differences between the results obtained in the measurements using the single-blind study model were examined at 0.05 level with ANOVA Analysis of Repetitive Measurements using the SPSS 14 Program.

3. RESULTS

The descriptive characteristics of the participants are given in Table 2.

Table 2. The age, body weight, body fat percentage and lean body weights of the participants

	n	Min	Max	Mean	SD
Height (cm)	13	168	189	178.76	6.41
Body weight (kg)	13	70	91	77.83	8.13
Body fat percentage (%)	13	6.80	12	9.93	1.97
Lean body weight (kg)	13	61.01	81.35	68.72	5.95
Body Mass Index (BMI)	13	21.60	25.80	23.7	1.71
VO_2max (ml/kg/min)	13	56.88	63.58	60.49	2.18

The measurements of body weight, lean body weight, and fat percentage were determined using the "Tanita"-brand SC-330 Digital Scale, and Body Mass Index was calculated. VO_2max values were calculated using the formula over the distance the participant ran according to the Cooper Test.

FBU-JSS e-ISSN: 2791-7096

Table 3. Cooper Running Test performance measurements of the participants

		n	Min	Max	Mean	SD
Without additional weight	12 Min Running (m)	13	3050	3350	3211	97.92
	Running Speed (m/sec)	13	4.23	4.65	4.45	0.13
Placebo	12 Min Running (m)	13	2650	2940	2832	94.48
	Running Speed (m/sec)	13	3.68	4.08	3.93	0.13
$NaHCO_3$	12 Min Running (m)	13	2640	3075	2949	109.58
	Running Speed (m/sec)	13	3.66	4.27	4.09	0.15

Table 4. Differences between the distances in Cooper Running Test

					95% Confidence Interval Limits for Differences	
Measurements		**Average Difference**	**Std. Error**	**Sig.**	**Lower Limit**	**Upper Limit**
Without additional weight	Placebo	379.154*	20.617	.000	321.850	436.457
	$NaHCO_3$	262.462*	20.318	.000	205.989	318.934
Placebo	Without additional weight	-379.154*	20.617	.000	-436.457	-321.850
	$NaHCO_3$	-116.692*	14.671	.000	-157.471	-75.914
$NaHCO_3$	Without additional weight	-262.462*	20.318	.000	-318.934	-205.989
	Placebo	116.692*	14.671	.000	75.914	157.471

According to table it was found that running distances increased significantly with sodium bicarbonate ($NaHCO_3$) intake (Table 4) ($p>0.05$).

FBU-JSS e-ISSN: 2791-7096

Table 5. Maximum Heart Rates (HR) of the participants (beat/min)

			n	Min	Max	Mean	SD
Heart Rates (HR)		Without additional weight	13	169	205	192.50	11.04
		Placebo	13	183	214	194.76	8.31
		$NaHCO_3$	13	171	214	190.92	9.77

Table 6. Differences between Heart Rates (HR) in Cooper Running Tests

					95% Confidence Intervals Limits for Differences	
Measurements		**Average Difference**	**Std. Error**	**Sig.**	**Lower Limit**	**Upper Limit**
Without additional weight	Placebo	1.462	2.311	1.000	-4.962	1.462
	$NaHCO_3$	3.923	1.723	.126	-.865	3.923
Placebo	Without additional weight	-1.462	2.311	1.000	-7.885	-1.462
	$NaHCO_3$	2.462	1.960	.699	-2.986	2.462
$NaHCO_3$	Without additional weight	-3.923	1.723	.126	-8.711	-3.923
	Placebo	1.462	2.311	1.000	-4.962	1.462

*p>0.05

The arithmetic mean value of the participants' maximum heart rate in 12-minute running test without additional weight was 192.5±11.04 (beats/min). The arithmetic mean value of maximum heart rate in 12-minute placebo measurements was 194.76±8.31 (beats/min). The arithmetic mean value of maximum heart rate was 190.92±9.77 (beats/min) after sodium bicarbonate ($NaHCO_3$) intake (Table 6). As shown in Table 5, the heart rate changes were not statistically significant (p>0.05).

FBU-JSS e-ISSN: 2791-7096

Table 7. **Blood lactate values of the participants (mmol/l)**

		n	Min	Max	Mean	SD
Without additional weight	Before warm-up	13	1.10	2	1.55	0.27
	Before the run	13	1.50	3.30	2.22	0.63
	After the run	13	9.80	17.80	12.94	2
	1 min	13	10.10	15	12.24	1.78
	3 min	13	7.50	16.10	11.97	2.44
	5 min	13	6.30	14.90	10.57	2.36
Placebo	Before warm-up	13	0.90	2.20	1.27	0.35
	Before the run	13	1.20	2.10	1.64	0.26
	After the run	13	6.80	14.60	12.23	2.45
	1 min	13	6.70	15	11.95	2.26
	3 min	13	5.80	14.80	11.33	2.70
	5 min	13	5.30	13.20	10.89	2.54
$NaHCO_3$	Before warm-up	13	1.10	2.40	1.45	0.36
	Before the run	13	1.30	2.50	1.82	0.39
	After the run	13	12.20	18.60	15.46	1.94
	1 min	13	12.40	19.70	15.60	2.15
	3 min	13	11.90	18.70	15.16	1.97
	5 min	13	10	16.80	14.60	2.11

In the study, the blood lactate measurements during aerobic running test with additional weight were made as 6 measurements before warm-up, before the run, after the run, at minute 1, minute 3, and minute 5. At the end of the measurements, it was determined that there was an increase in blood lactate levels, especially after sodium bicarbonate intake (Table 7) ($p<0.05$).

4. DISCUSSION

In the present study, the participants' mean body weight was 77.83± 8.13 kilograms, and the mean Body Mass Index was 23±7 71. In different studies conducted by using sodium bicarbonate, although the average body weight was reported to be 67±5.03 kilograms, the mean Body Mass Index was 20.3 ± 2.6 (Maliqueo et al., 2018), in studies conducted on tactical athletes, the average body weight was 79.6±7.7 kilograms, and the average body mass index was 24.1±3.7 (Beekley,2007; Swain et al.,2011).

In the 12-Minute Cooper Running Test without additional weight, the arithmetic mean value of the participants in VO_2max was 60.49±2.18 (ml/kg/min). Although Maliqueo et al. found VO_2max at the end

of Cooper Running Test as 70.76±6.5 (ml/kg/min), in a study conducted with tactical athletes, VO_2max was 52.6±6.2 (ml/kg/min) (Maliqueo et al., 2018).

The descriptive data obtained from the participants in our study were similar to the data obtained in studies conducted with tactical athletes. As a result, running distances increased significantly with the intake of sodium bicarbonate ($NaHCO_3$) (Table 4) ($p<0.05$).

In a previous study, 11 cyclists and triathletes participated in the study, which examined the effect of daily sodium bicarbonate ($NaHCO_3$) intake on endurance. The athletes were given sodium bicarbonate ($NaHCO_3$) for five days. They showed that the intake of a single dose of sodium bicarbonate ($NaHCO_3$) before multiple tournament competitions or ongoing daily races could increase performance (Mueller et al., 2013).

Another study conducted on 13 athletes used the Yo-Yo Level 2 Test with sodium bicarbonate ($NaHCO_3$) loading as high as the bodyweight of 400 mg/kg. Finally, the authors found that the performance test results of the group using sodium bicarbonate were significant (Krustrup et al., 2015). In a similar study, the Yo-Yo Level 1 Test was used with sodium bicarbonate ($NaHCO_3$) as high as the bodyweight of 300 mg/kg, and it was also found that there were positive effects on performance (Dixon et al., 2017).

In the study conducted on swimmers, the authors reported that 0.3 gr/ kg $NaHCO_3$ intake 2.5 hours before the test increased the blood buffering potential and positively affected swimming performance (Siegler & Siddal, 2010). Another study examined the performance with sodium bicarbonate use on boxers and reported that 0.3 gr/kg $NaHCO_3$ intake 1.5 hours before the test improved 4-round boxing performance (Siegler & Kristian, 2010). Caffeine and sodium bicarbonate intake, and when combined, 2000-meter rowing performance was found to increase by approximately 2.3% (Carr et al., 2011).

In a study conducted on cyclists, the effect of sodium bicarbonate ($NaHCO_3$) loading before 30-minute bicycle ergometer test on high-intensity endurance performance was examined. They ensured that the placebo group took 4 g of sodium chloride content with 0.7 ml water. Finally, the authors reported that the ergogenic effect of sodium bicarbonate, shown definitely in previous studies for anaerobic exercise, could also be seen with long-term exercise (Egger et al., 2014).

When the lactate threshold of sodium bicarbonate ($NaHCO_3$) intake at a dosage of 300 mg/kg in middle distance runs and its effect on performance were examined they said that sodium bicarbonate intake could improve performance for endurance athletes (Maliqueo et al., 2018).

The study also found that when a load equivalent to twenty percent of body weight was carried, there would be an 11.81% loss in performance, which can be reduced by 3.6% using external sodium bicarbonate.

When the blood lactate levels of $NaHCO_3$ in short-term exercise were examined in a study conducted on rowers, the blood lactate levels were 1.0+0.2 and 16.2+1.2 mmol/l before and after exercise,

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respectively for the placebo group, and the blood lactate levels of those who took $NaHCO_3$ loading before and after the exercise were 0.9+0.1 and 25.7+2.1 mmol/l (McGinley & Bishop, 2016). In another study, when rowers perform short-term submaximal exercise, the blood lactate level was 10.3 mmol/l after warm-up and 17.9 mmol/l immediately after exercise for the placebo group, but the blood lactate level of those who took $NaHCO_3$ was 14.9 mmol/l after warm-up, 20.2 mmol/l immediately after the exercise (Mueller et al., 2013). In another study, placebo measurements in middle-distance runners found that the blood lactate was 13.32±2.5 mmol/l, but the measurement result of sodium bicarbonate intake was 16.6±0.8 mmol/l (Maliqueo et al., 2018).

In a study investigating the effect of sodium bicarbonate supplementation on fatigue in maximal exercises, the blood lactate value measured after the exercise was 11.64±1.86 mmol/l in the placebo group, and 13.67 ± 1.87 mmol/l in the sodium bicarbonate group (Ramos, 2015).

When the effects of sodium bicarbonate intake were examined in short-term speed performance, the blood lactate was 6.2±1.6 mmol/l for the placebo group, and 6.7 ±1.3 mmol/l for the sodium bicarbonate intake group (Saunders et al., 2014).

When the literature was reviewed, blood lactate values of the groups using sodium bicarbonate at the end of blood lactate measurements were higher than the results obtained at the end of the exercise and this shows a similarity to the results which were obtained after the counclusion of our study. Also it was found that there was a statistically significant difference in blood lactate levels ($p < 0,05$). The reason for this can be explained by stating that the increase in the amount of bicarbonate in the extracellular fluid, increases the buffer capacity, and the release of lactate and H^+ ion through the cell. The transport of lactate and H^+ ions in the muscle membrane is provided by MCT1 and MCT4, which are two monocarboxylate transporter proteins (Juel et al., 2004). MCT1 and MCT4 proteins are the most important carriers of lactate in the heart and skeletal muscles. MCT1 is a protein which is effective in intracellular transport and MCT4 is a protein which is effective in extracellular transport (Fox et al., 2000). The transport of lactate with MCT proteins is in an H^+ dependent system (Dimmer et al., 2000). The lactate and H^+ transport ratios are 1/1, indicating that a H^+ ion is transported against each lactate molecule. Lactate is bound to this carrier protein after the first H^+ ion. The direction in which the lactate moves through the MCT protein depends on the concentration of the H^+ ion between the intracellular and extracellular compartments. According to this, the flow direction of the lactate transport is also indicated to be from the side where the H^+ ion concentration is high to the low side. On the other hand, if the H^+ ion concentration is high, the binding rate to the carrier protein is high on that side (Hazır & Açıkada, 2005). In addition, the rate of transport of lactate in the cell membrane affects the pH difference between muscle and blood, muscle fibril type and aerobic training. (Hazır & Açıkada, 2005). The presence of monocarboxylate carriers in the mitochondrial membrane, as well as the presence of lactate

FBU-JSS e-ISSN: 2791-7096

and H^+ ions in the mitochondria, as well as the presence of the lactate oxidation complex in the mitochondria, said that mitochondria also had an effect on the rate of removal of intracellular lactate (McGinley & Bishop, 2016). As a result, due to the increase of sodium bicarbonate level outside the cell, the pH value increases and by decreasing H^+ ions concentration. We believe that that the lactate level is found to be high in the sodium bicarbonate measurements due to the increase of the lactate transport through the cell.

In the present study, the mean maximum heart rate in the 12-Minute Running Test without additional weight was 192.5±11.04 (beats/min), and the mean maximum heart rate in placebo measurement in 12-minute running test with additional weight was 194.76±8.31 (beats/min). The mean maximum heart rate of the group who used sodium bicarbonate ($NaHCO_3$) was 190.92±9.77 (beats/min). The changes in heart rates were not found to be statistically significant ($p>0.05$). In the study conducted with boxers, when the effect of sodium bicarbonate intake on the performance of four-round boxing was evaluated, the mean heart rate in the placebo group was 177±3 beats/min, and the heart rate of the sodium bicarbonate group was 176±3 beats/min (Siegler & Kristian, 2010).

In the study which was conducted to investigate the effect of sodium bicarbonate on tennis performance, mean heart rate was 173±13 beats/min in the placebo group, and for the sodium bicarbonate group, it was 170 ± 20 beats/min (Wu et al., 2010).

When the effect of sodium bicarbonate intake on heart rate was examined in female futsal players, the mean heart rate was 172.90±3.78 beats/min in the placebo group, but the mean heart rate in the sodium bicarbonate group was 165.40±7.36 beats/min (Karavelioğlu et al., 2016).

The mean heart rate was lower in sodium bicarbonate intake during exercise than in placebo measurement in our measurements, which is similar to the results of other studies. The reason for this was that the increase in the amount of sodium bicarbonate in the blood causes expansion in the plasma volume. As a result, it was reported that there would be drops in the heart rates with the increases in the pumping capacity of the blood (Mueller et al., 2013; Karavelioğlu et al., 2016; Aubert et al., 2003).

5. CONCLUSION

The findings of the present study revealed that one of the causes of the fatigue in increased exercise intensity and time is the increase in H+ ions concentration . The increasing amounts of bicarbonate, which is one of the buffering systems in the skeletal area of the resulting fatigue, can delay the formation of fatigue quickly by helping to eliminate the lactate and H+ ions from inside and outside the cell. To avoid the performance drops of 11.8% in athletes by using an additional weight of twenty percent of their body weight, it is assessed that sodium bicarbonate support intaken at 0.3 g/kg dose 90 minutes before the exercise can provide positive benefits by reducing performance drops, contributing to the success by preventing performance losses especially in tactical athlete groups.

FBU-JSS e-ISSN: 2791-7096

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