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ORIGINAL ARTICLE

The Effects of Beetroot Juice Supplementation on Balance Performance of Wrestlers

ALI TATLICI[1*], YAVUZ LIMA[2], SERCAN YILMAZ[1], ABDULKADIR EKİN[3], SEDAT OKUT[4], EBRU CEVİZ[5]

[1]Faculty of Sport Sciences, Selcuk University, Konya, Turkey.

[2]Sport Medicine Clinic, Balıkesir Ataturk City Hospital, Balıkesir, Turkey

[3]School of Physical Education and Sports, Siirt University, Siirt, Turkey.

[4]Faculty of Sport Sciences, Muş Alparslan University, Muş, Turkey.

[5]Faculty of Sport Sciences, Bingöl University, Bingöl, Turkey.

*Corresponding author: alitatlici@selcuk.edu.tr (Ali TATLICI)

ABSTRACT

Aim: This study assessed the effect of beetroot juice supplementation on the dynamic and static balance performance of wrestlers at rest and fatigue conditions.

Material and methods: The study was conducted with 3 trial days. The study is a double-blind, randomized, crossover design in which eight trained male Greco-Roman wrestlers (age 21.87±2.3 years; height 176.87± 4.1 cm; body weight 76.75± 5.4 kg) consumed beetroot juice (BRJ) (140 ml) or placebo (PLA) (140 ml, cherry juice with lemon juice) 150-min before performing balance performance test. Subjects were administered standard warm-up and then dynamic and static balance tests were performed to the dominant leg with by Biodex Balance System (BBS, Biodex Medical Systems Inc., Shirley, NY) at rest. Following balance testing, each subject got into a fatigue strength exercise (FSE) to create fatigue for the dominant leg. Immediately after the (FSE), subjects were applied to dynamic and static balance test to the dominant leg again at fatigue. The same trial procedure was repeated with the other supplement (BRJ or PLA) in the third testing trial five days later. Paired sample T-test was used for comparison of BRJ and PLA balance performance values.

Result: Although there were no significant changes in static OSI, APSI balance scores, Static MLSI improved significantly in favor of BRJ in rest. Dynamic OSI and APSI parameters improved significantly but not MLSI in the BRJ trial. While all static and dynamic balance parameters improved statistically, only static MLSI was not changed by the BRJ trial at fatigue.

Conclusion: Consuming BRJ can be useful to maintain balance performance and prevent sports injuries in training or competition.

Keywords: Beetroot Juice, Dietary Nitrate, Balance, Wrestlers.

INTRODUCTION

Wrestling is a physically demanding sport that requires a good level of fitness (1). The wrestling rules emphasize aggressive wrestling and scoring by exhibiting repetitive bouts of high-intensity moves (e.g., attacks and counterattacks) instead of blocking or holding the opponent (2, 3). Wrestlers have to control their bodies in different positions and provide foot wrestling mat stabilization to show their agility-quickness skills in competitions (4). In wrestling nature, especially balance, strength, and stabilization are the parameters that are important (1). In the literature, there are studies stating that beetroot juice (BRJ) supplementation (due to its high-rich nitrate source) increases strength (5). Based on this, it is thought that BRJ supplementation can improve stabilization by increasing strength.

A performance increase of 0.6% is considered sufficient to make a difference nowadays because of the increase in competitive equality in high-level sport (6). Although traditional and evidence-based methods have been applied for a long time, beet juice has been a popular topic in recent years as it provides significant gains in athletic performance in the short term. Dietary supplements are used to increase performance in a short time. BRJ has recently been widely used in dietary supplements research due to containing high amount of inorganic nitrate (NO_3^-) (7). When BRJ is consumed, some of the NO_3^- in BRJ is converted into nitrite (NO_2^-) by anaerobic bacteria and then subsequently in the stomach and gut, can be converted into nitric oxide (NO) and be absorbed under hypoxic conditions (8). Exercise performance (i.e. the regulation of blood flow and producing muscle strength) can be improved by the NO (9). NO can stimulate the conversion of cyclic guanosine monophosphate so an increase of cGMP increases the rate of contraction of muscle fibers and thus may affect maximal strength (10). In addition, NO can increase the efficiency of exercise and delay fatigue by making ATP expenditure more efficient in muscle contraction (11).

The literature shows that after the consumption of beet juice, the contractility of type 2 muscle fibers and calcium (Ca^{2+}) handling increases after consumption of beet juice

(12). Also, ATP cost of force production is decreased with BRJ consumed (13). Jonvik et al. Jonvik, Hoogervorst (10) found improvement in knee flexion and extension peak isokinetic strength. Rodríguez-Fernández et al, (14) reported that BRJ increased eccentric contractions besides concentric contractions. In their study, Ibrahim et al. Ibrahim, Muaidi (15) stated in their study that as knee extension and flexion strength increase, balance performance increases. Also, Oliviera et al, (16) stated that BRJ supplementation prevents force decline in response to exercise in jiu-jitsu athletes. Oliviera et al, (17) also reported that BRJ supplementation improves strength recovery in combat sports athletes. Studies show that BRJ supplementation can help improving strength, recovery. Therefore, this study aimed to examine the effects of acute BRJ supplementation on the balance performance of trained Greco-Roman wrestlers at rest and fatigue.

MATERIALS AND METHODS

2.1. Subjects: Eight Greco-Roman wrestlers (age 21.87±2.3 years; height 176.87± 4.1 cm; body weight 76.75± 5.4 kg) from Konya Selcuklu municipality wrestling club volunteered for this study. All subjects have regularly trained 3 days a week in wrestling club. Only trained Greco-Roman wrestlers participated in the study. Subjects were required to fulfill the following inclusion criteria: an absence of disease or an orthopedic disorder that fatigue strength exercise and balance test; no medication; no nutritional supplements; no smoking in the six months before the study beginning.

Subjects were informed about the risks of the study. All subjects provided written informed consent. The study was approved by the local ethics committee (Protocol number 78, 19.10.2020, Ethics Committee of Selcuk University, Faculty of Sports Science, Konya, Turkey).

2.2. Study Design: The experiment was conducted in Selcuk University Faculty of Sports Sciences laboratory. Subjects came to the laboratory three times at 10 am (on 1st, 4th, and 9th days) on different days but within the same frame. In the first visit to the laboratory for getting used to all test sections but they did not take the PLA or BRJ. In the second visit, as soon as they arrived at the laboratory, double-blind fashion, subjects were given BRJ or PLA supplements. It was ensured half of the subjects took BRJ and PLA in the second visit, in the third visit vice versa. 150 minutes later intake of the supplement, subjects carried out warm-up and stretching (18). Following that, the dynamic and static balance of the dominant leg was measured by Biodex Balance System at rest. After the resting balance test, athletes were taken to fatigue strength exercise (FSE). FSE was not conducted for measuring their strength but for creating muscular fatigue. Immediately after FSE athletes have performed dynamic and static balance tests again. Subjects did not involve any exercise sections 24 hours prior to the end of the test section (19). All tests were administered by the same laboratory personnel. There were 5 days wash-out period between the experimental trial days.

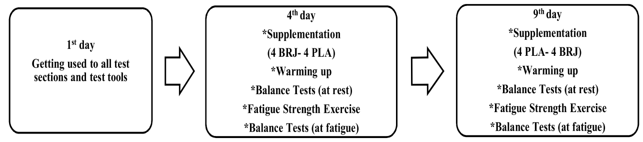

Figure 1. Study Design.

2.2.1. Nutritional Intervention and Dietary Control: Subjects were informed about the amount and type of food (55% carbohydrates, 25% lipids, and 20% protein due to energy metabolism) that they had to take 24 hours prior to the tests trial days (9). Since $NO2^{-}$ is gotten highest level after ingestion (18) the supplement was applied 150-min before the test sections. Subjects were also informed about not brushing their teeth, not using a mouthwash, chewing gum, or sweets to refrain from losing bacteridal effect of bacteria in the mouth before 24 hours to tests (19).

Each subject randomly consumed beetroot juice from 2x70 ml shots (Beet it, James White Drinks Ltd., Ipswich, UK) or placebo (Placebo was made of cherry juice with lemon juice (Cappy, Coca-Cola Company, Turkey) (9). For beetroot juice and placebo supplementation, the same (500ml) black bottle was used.

2.2.2. Dynamic and Static Balance Testing: The subject's dynamic balance (open eyes) and static balance (closed eyes) were measured by Biodex Balance System (BBS, Biodex Medical Systems Inc., Shirley, NY). Two balance tests were performed on each subject for getting used to tests tools. Then, the balance test was administered for the dominant leg. Subjects were subjected to the balance test on one foot by holding their hands on the shoulders of the crossed position after standing on the BBS's mobile platform. The level of difficulty of the measuring instrument was set to "Level 4" for the open eyes condition. The other leg did not touch the ground and the subject was not allowed to look at the BSS monitor. 3 separate balance scores were obtained after the automatically completed test [Overall Stability Index (OSI), Anterior-Posterior Stability Index (APSI), Medial-Lateral Stability Index (MLSI)]. Higher balance scores mean worse balance performance.

2.2.3. Fatigue Strength Exercise: The fatigue strength exercise was performed with an isokinetic dynamometer (Cybex, Humac Norm 2004) in the laboratory of the sports science faculty of Selcuk University. Subjects were seated in the correct position in the test seat. The subjects' holders and the middle sections of the thighs were stabilized to the seat by the tapes. In addition, they were allowed to support by holding the handles on the right and left sides of the seat during the exercise. Maximal contractions knee extension (hamstring) and flexion (quadriceps) torque values were obtained at the speed of 60° sec-1 (5 times) and 180° sec-1 (15 times). Each subject was given a 90 seconds rest between sets. Only the dominant leg performed the test. Verbal encouragement was given during the test.

2.3. Statistical Analysis: To assess the normal distribution the Shapiro-Wilk test was used. The data from balance parameters of both supplementations were analyzed with the paired sample T-test (BRJ vs. PLA). Cohen's d effect sizes (d ≤ 0.2, small; 0.5–0.79, moderate; ≥0.8, large) (20) were calculated to assess the magnitude of difference between experimental trials. All statistical tests were performed using the software package SPSS version 24.0 (SPSS Inc, Chicago, IL). An alpha value of <.05 was considered to be statistically significant.

RESULTS

Table 1. Comparison of Balance Performances of PLA and BRJ Supplementation at Rest

Parameters	Supplementations	Mean (score)	Std. Deviation	Confidence Interval Lower	Upper	p
Static OSI	PLA	2,41	0.35	-0.28	1.01	0.22
	BRJ	2,05	0.79			
Static APSI	PLA	1.82	0.37	-0.49	1.04	0.42
	BRJ	1.55	0.73			
Static MLSI	PLA	1.30	0.29	0.08	0.41	0.00*
	BRJ	1.05	0.27			
Dynamic OSI	PLA	2.28	0.51	0.07	1.15	0,03*
	BRJ	1.67	0.28			
Dynamic APSI	PLA	1.57	0.43	0.20	1.09	0,01*
	BRJ	0.92	0.24			
Dynamic MLSI	PLA	1.33	0.35	-0.29	0.74	0.33
	BRJ	1.11	0.79			

OSI= Overall Stability Index; APSI= Anterior–Posterior Stability Index; MLSI= Medial-Lateral Stability Index. *Significant differences (P <0.05).

Table 2. Comparison of Balance Performances of PLA and BRJ Supplementation at Fatigue

Parameters	Supplementations	Mean (score)	Std. Deviation	Confidence Interval Lower	Upper	p
Static OSI	PLA	2.77	0.68	0.34	1.53	0.00*
	BRJ	1.83	0.34			
Static APSI	PLA	2.02	0.52	0.20	1.12	0.01*
	BRJ	1.36	0.24			
Static MLSI	PLA	1.40	0.66	-0.13	0.90	0.12
	BRJ	1.01	0.33			
Dynamic OSI	PLA	2.43	0.67	0.16	1.16	0,01*
	BRJ	1.77	0.55			
Dynamic APSI	PLA	1.91	0.65	0.11	1.10	0,02*
	BRJ	1.30	0.61			
Dynamic MLSI	PLA	1.15	0.20	0.04	0.40	0.02*
	BRJ	0.92	0.15			

OSI= Overall Stability Index; APSI= Anterior–Posterior Stability Index; MLSI= Medial-Lateral Stability Index. *Significant differences (P <0.05).

Balance parameters of PLA and BRJ supplementation at rest were shown in table 1. While Static OSI and APSI were the same in both trials, Static MLSI significantly improved (ES=1.29) in favor of BRJ. Dynamic OSI and APSI (respectively ES=0.95, ES=1.22) were improved by BRJ whereas there was no significant change in terms of Dynamic MLSI

. Balance parameters of PLA and BRJ supplementation at fatigue were shown in table 2. There were significant improvements in Static OSI (ES=1.3), APSI (ES=1.2), Dynamic OSI (ES=1.1), APSI (ES=1.0), and MLSI (ES=1.0) in favor of BRJ. Static MLSI scores did not change in both trials.

DISCUSSION

According to our knowledge, this is the first study examining the effect of a single dose of BRJ on the balance performance after FSE. The main results of this study were that *i)* balance performance after FSE was better in the BRJ group compared to the placebo group; *ii)* some balance parameter at rest was better in the BRJ group compared to the placebo group.

It is known that muscle fatigue has a negative effect on proprioception acuity (21, 22). It can cause a motor deficit by decreasing muscle stimulation and a gradual decrease in the force capacity of muscle (23). Muscle fatigue does not only affect the motor unit but also affects afferent types III-IV (24). Therefore, fatigue causes a decrease in afferent input which has an important contributor in maintaining balance (25). Also, central fatigue may also increase balance impairment (26). Considering that nitrate-rich BRJ can lead to fatigue resistance, in our study, we suggested that delay in the occurrence of fatigue after FSE in the nitrate-rich BRJ group compared to the placebo group is the main reason for maintaining the balance (27). The decrease in proprioceptive acuity with muscle fatigue may play a role in decreasing athletic performance and cause sports injuries, therefore, nitrate-rich BRJ intake may be useful the prevent the negative effects caused by fatigue (28).

Muscle fatigue is complex, involving multiple factors acting at numerous cellular sites (29). It causes increased lactate, H+, K+, and P, decreased ATP, and disturbed intracellular Ca++, therefore decreased PH and O2 pressure (29). These substances not only affect the metabolic process but also affect the neurological pathways by increasing the threshold of muscle spindle discharge and impair the kinesthetic properties of joints (30). Also, some substances (e.g serotonin) are released with fatigue and can cause central nerve inhibition (31). NO plays a key role in several physiological, hemodynamic, and metabolic events in the body (32, 33). Probably the most important in terms of exercise physiology is reduced ATP cost of muscle force production and enhances tolerance to high-intensity exercise (12, 34). Also, NO enhanced mitochondrial efficiency (35). Moreover, it facilitates calcium handling, typically has lower mitochondrial and capillary density, especially type 2 fibers (36, 37). Importantly for maintenance of NO bioavailability, NO3− reduction to NO is stimulated by low PO2 and low pH (38). Therefore, NO activity may increase in hypoxia (39). Additionally, NO causes blood vessel dilation and increased blood flow to the muscles (40, 41). When we considered that type 2 fibrils dominantly participate in both short duration FSE and balance measurement and the required energy is presented by non-oxidative pathways, it can be said that NO may have affected maintain balance performance positively by delaying the depletion of ATP reserves, facilitating greater muscle glucose and creatine uptake. Therefore, maintaining better muscle excitability, affecting afferent and efferent pathways, and decreasing of occurrence of substances that can inhibit muscle stimulation (12, 36, 42). Also, nitrate-rich BRJ may reduce muscle metabolic perturbation by expanding the antioxidant pool, therefore, may allow high-intensity exercise to be tolerated for a greater period of time (43-45). Lastly, in animal studies, it was reported that NO modulates synaptic AChE activity (46). NO may facilitate muscle stimulation by modulating synaptic AChE activity as a similar effect in humans, therefore, may contribute to maintaining balance performance.

Reaction time is an important factor for balance performance. It is known that as mentioned above, muscle fatigue delays the reaction time by affecting the afferent and efferent pathways, therefore, reduces muscle stimulation (47, 48). We thought that nitrate-rich BRJ may have reduced the delay in reaction time by delaying fatigue. On the other hand, it was reported that two weeks of nitrate-rich BRJ caused a significant improvement in reaction time in patients with diabetes mellitus (49). Although there is no study examining the effect of a single-dose nitrate-rich BRJ intake on reaction time, a single dose of BRJ may have also decreased reaction time directly. Also, co-activation of the antagonist's muscles is necessary to help the ligaments in maintaining joint stability (50). Although studies are showing that muscle fatigue increases muscle co-activation (51, 52), it was also reported that muscle fatigue induces a reduction and delay in the activation of both the quadriceps and hamstring muscles in response to rapid destabilizing perturbations (53). The slight improvement in co-activation may also have positively affected balance performance.

The visual system is an important component of the somatosensory system (54). It contributes to maintaining balance by providing afferent input continuously (55). Moreover, the visual system does not only provide information on daily activities or rest but also contributes to immediately coping with the destabilizing effect induced by muscular fatigue (56). Considering that NO has positive effects on vision in both the retina and visual cortex, nitrate-rich BRJ may have reduced the impairment in balance by providing the visual system to perform more precisely (57, 58).

The main effect of NO on the cardiovascular system is vasodilation (32). Also, NO protects the heart against myocardial ischemia and improves perfusion (59). Thereby, sympathetic response to exercise may be reduced slightly due to NO effects. In addition to this, it was reported that muscle metaboreflex and cardiopulmonary baroreflex have an interactive influence on the neural control of cardiovascular function (60). Since it is known that increased heart rate affects balance performance negatively, we thought that nitrate-rich beet juice might have reduced the impairment in balance performance by reducing the heart rate and sympathetic response after FSE (61-63). It was also reported that hyperventilation has a negative effect on postural control (64). In addition to the NO effects mentioned above, it is known that NO facilitates lung gas exchange, especially in hypoxia (12, 38). In light of this information, nitrate-rich BRJ may have also reduced the impairment in balance performance by reducing the hyperventilation response to FSE.

As mentioned above, interestingly, in our study, some balance parameters were better in the BRJ group compared to the placebo group in rest despite NO efficiency improves in hypoxia. We thought that nitrate-rich BRJ may have affected even at rest in wrestlers who generally have high anaerobic power, high anaerobic capacity, and a somatotype that emphasizes mesomorphy (dominantly type II fibers) (3, 65).

Our study had some limitations. First, we induced fatigue in the thigh muscles, however, other muscles, e.g., hip and leg muscles also contribute to balance performance. Second, there was no data on plasma nitrate and lactate levels. The third point is the number of subjects was relatively small. Lastly, we only included Greco-Roman wrestlers in this study. It would be appropriate to research athletes with different percentages of muscle types.

CONCLUSION

Nitrate-rich BRJ has a positive effect on balance performance after FSE by affecting several mechanisms. Using BRJ can be useful to maintain balance performance and prevent sports injuries.

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