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Effect of Watermelon Juice Compared to Carbohydrate Drinks on Rehydration and Anaerobic Performance in Active Male Adolescents

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Abstract
Background: Considering the high amount of water in watermelon, this study aimed to investigate the effect of watermelon juice compared to carbohydrate drinks and water on rehydration and anaerobic performance.
Methods: In this quasi-experimental study, twelve active adolescents experienced weight loss of about 2% in three separate sessions, one week apart, by running a treadmill exercise program including two sets of 30-minute aerobic activity separated by a 10-minute rest. Then, they consumed one of the three drinks of water, carbohydrate drink, or watermelon juice at 125% of their weight loss. Two hours after each session, they performed a 300-yard shuttle run test. Urine specific gravity (USG) and participants' weight were measured three times: before and after the dehydration protocol and before the anaerobic performance.
Results: Data analysis showed no significant difference in USG ($P=0.41$) and the 300-yard shuttle run test ($P=0.87$) after consuming the three drinks. There was a significant difference ($P=0.001$) in weight gain after consuming the three drinks, with greater mean weight gain for watermelon juice and carbohydrate drinks compared to water.
Conclusion: The results indicated the same effect in carbohydrate drinks and watermelon juice on weight return, rehydration, and subsequent anaerobic performance. However, because watermelon juice contains vitamins and minerals compared with carbohydrate drinks, it is suggested that athletes use this drink.
Keywords: Urinary specific gravity, Rehydration, Watermelon juice, 300-yard shuttle run

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Introduction

A significant decrease or increase in body water can harm health and exercise performance (1). Exercise training in different climates can increase sweating, affecting exercise performance due to increased central-peripheral body temperature (2). If fluid intake is less than its excretion, it may lead to dehydration, usually occurring at the end of exercise. More than a 2% reduction in body weight is dangerous in such cases. Research has shown that losing two percent of body weight due to dehydration in adult athletes adversely affects their performance. As an athlete has little time to replenish body water sources, more care is needed to maintain fluid balance by replacing the lost water (1). Dehydration can reduce aerobic power, strength, and capacity. It also makes the athlete susceptible to heat-related illnesses, muscle weakness, and cognitive function (3). Proper fluid intake after exercise can restore water and electrolyte balance if sufficient time is available (4). However, when the interval between physical activities (during individual competitions such as wrestling, taekwondo, etc) is short, proper rehydration strategy after physical activity is more important to avoid the harmful effects of dehydration in subsequent competitions or races (1).

Carbohydrate beverages, known as sports drinks, are among the first choices athletes turn to for rehydration (2). According to McCartney et al, carbohydrate drinks can significantly improve aerobic and anaerobic performance (5). Recently, fruit juice as a sports drink has attracted athletes' attention. Some athletes prefer these natural drinks to sports drinks, which often contain artificial sugars, flavors, and electrolytes (e.g., sodium and potassium) (6). For example, the effect of coconut water on rehydration and subsequent exercise performance has been investigated, and conflicting results have been reported (6,7). Among fruits, watermelon can help replenish water because of its abundant water.

Watermelon contains varying amounts of vitamins, minerals, carotenoids, and the non-essential amino acid L-citrulline (8), in addition to water (about 92%) (9). From the perspective of traditional medicine, watermelon is a diuretic and also effective in quenching thirst (10). Therefore, it may be possible to conceive a dual role in the body (rehydration versus dehydration) for watermelon. The results of studies have shown that watermelon's citrulline, as an effective precursor for arginine production, could lead to the dilation of the renal vessels by increasing nitric oxide and, eventually, excretion of extracellular fluids (11). On the other hand, the nitric oxide system is activated when the level of the interstitial fluid exceeds the normal level (12). According to these interpretations, watermelon is thought to have a diuretic effect when the extracellular water level is above normal. As the amount of extracellular water is decreased during dehydration, a condition that occurs during or after exercise (13), the hydrating role of watermelon is expected to be prominent.

Few studies have been conducted on the effect of watermelon on exercise performance. Cutrufello et al evaluated the effect of intake a single pre-exercise dose of L-citrulline, watermelon, and a placebo on the maximum number of repetitions completed more than five times (5-RM), fatigue time, maximal oxygen consumption, anaerobic threshold, and vascular flow. Results showed no effect for L-citrulline and watermelon juice on outcomes (14). On the other hand, Shanely et al reported that the consumption of watermelon puree by cyclists had effects similar to a carbohydrate drink (6% concentration) during endurance exercise (9). In addition, to our knowledge, no study has addressed the role of watermelon in rehydration after exercise. Accordingly, considering the adverse effects of dehydration during exercise or lost weight in weight sports (such as wrestling and judo), the present study was conducted to investigate the effect of watermelon juice intake after an endurance exercise session on rehydration and anaerobic performance in comparison with traditional drinks

Methods

Population

In this quasi-experimental study, the statistical population was 400 active high school students. After screening, 12 volunteers were selected. The inclusion criteria included an age range of 13–18 years, regular activity, such as participation in aerobic, resistance, and anaerobic exercise activities 3–5 hours per week, and being non-smoking and drug-free (thiazides, frusemide, or acetazolamide) (Table 1). Subjects had no history of cardiovascular, metabolic, neurological, or orthopedic disorders, which may affect their ability to participate in the study, and no new nutritional supplements were selected for the study. However, they were allowed to continue taking the nutritional supplements they were taking before starting the study (like multivitamins) (6). To do this research, the code of ethics IR.BUMS.REC.1397.317 was obtained from the research Ethics Committee of Birjand University of Medical Sciences. All participants filled out a written informed consent.

The sample size was calculated with G*Power software version 3.1.9.7 using information ($\alpha = 0.05$; $\beta\text{-}1 = 0.8$; the number of groups = 1; the number of dependent variables = 4; and average effect size Cramér's $V = 0.25$). According to calculations, ten people were necessary, and considering the possibility of drop-out, 12 people were selected.

Procedure

In the first session, participants' height was measured by a Stadiometer (Seca height rod, Germany), weight was measured by a digital scale (Emsig digital scale, China), and blood pressure was assessed by a digital blood pressure monitor (Model 22 B800, Germany). The participants were asked to avoid physical activity during the 24 hours prior to the intervention sessions and refer to the Faculty of Sport Sciences laboratory in three separate sessions (one week apart in fasting conditions). At the beginning of each session, they had a standard breakfast consisting of a slice of bread and a tablespoon of cream cheese with a maximum of 470 mL of water (6). After 60 minutes, their urine sample was taken, and the initial weight of participants was measured after urinary discharge. Participants then continued the next steps in the following order:

Dehydration phase

Sixty minutes after the standardized breakfast, participants performed the dehydration phase. At this phase, after a 5-minute warm-up, participants performed two 30-minute stages of walking/jogging on a treadmill (Olympia EMS 1100, Taiwan) separated by a 10-minute rest. At each stage, running began at 4.8 km/h for 10 minutes and was increased every 5 minutes to 6.4, 8, 9.6, and 11 km/h. After the end of the first phase, participants rested for 10 minutes. During the break, they were allowed to move around or remain in their chair. Then, they repeated the

Table 1. Demographic characteristics of the 12 active teens, values are shown as mean ± standard deviation

Drink type	Age (years) ± SD	Height (cm)	BMI (kg/m²)	Weight (kg)
Water			19.123 ± 1.866	58.117 ± 7.266
Carbohydrate drink	16.645 ± 0.963	174 ± 0.080	19.143 ± 1.767	58.150 ± 6.819
Watermelon juice			19.061 ± 1.733	58.933 ± 7.017

second phase, going through the same speeds as the first phase. The dehydration phase was performed in a room at 36 °C and a relative humidity of 48% (6).

Rehydration phase

The drinks used in this study included water, watermelon juice, and carbohydrate beverage (6% concentration). To make watermelon juice, the watermelon was first purchased from the vegetable market, and after removing its rind, it was processed using a blender, and the juice was separated from the pulp. In this study, we used crimson sweet watermelon with a round shape, red color, thin rind, medium size, and sweet taste (6). The carbohydrate beverage was prepared from 30 mEq/L sodium compound (chloride as an anion), 5 mEq/L potassium, and 6% carbohydrate (13). The amount of each drink was determined based on the weight lost during the dehydration phase in each session. In the research literature, higher amounts than the amount of water lost are used for rehydration, up to 150% of the lost body weight (i.e., 150% of the amount of dehydration) (15). Participants drank one of the three drinks at about 125% of the weight they lost to dehydration within 60 minutes. The same program was repeated in the second and third sessions one and two weeks later, respectively, except that the type of drink consumed was changed (6).

Anaerobic performance test

Three hours after the dehydration phase, the anaerobic performance test, a 300-yard shuttle run, was performed. The shuttle run test was used as an anaerobic tolerance test. Two cones were set 25 yards apart, and participants ran back and forth between them, running six round trips. Two investigators timed each participant, and the average time of the two stopwatches was recorded as the subject's record (16).

Measurement of body weight changes

The simplest and most accurate method to assess whole-body sweating rate is via changes in body mass during exercise (17). In this study, body weight (BW) measurement was carried out with minimal clothing and after urination in three stages: before and after dehydration and rehydration, (6). BW (kg) changes were calculated as the difference between the BW measured before dehydration and after dehydration. The percentage of BW lost or gained was calculated as the difference between the initial and final BW divided by the initial BW and expressed as a percentage (18).

Measurement of urine specific gravity (USG)

Three urine samples were taken in each session: before and after dehydration and before the anaerobic test. The samples were immediately used to determine the USG using a urine strip (Combe Screen, made in Germany). The rate of perceived exertion (RPE) caused by physical activity in each of the above steps was also measured using the Borg scale (19). At different stages of the intervention, the participant's blood pressure and heart rate were controlled and recorded to monitor their physiological condition. Table 2 shows the timing of the measurement of the study variables.

Statistical analysis

All clinical and physiological parameters were presented as mean ± SD. Mixed between-within subjects ANOVA was utilized for data analysis, and the Bonferroni test was used for pairwise comparisons. The statistical analyses were conducted using SPSS version 22 software. The significance level was set at $P < 0.05$.

Results

Regarding the weight changes at different times, the repeated analysis of variance and Bonferroni post hoc test results showed that time was an effective factor in weight outcome. There was a significant difference between participants' weight measured three times before and after dehydration and after rehydration. According to the mean data, dehydration caused weight loss, and rehydration resulted in weight gain (Table 3). According to Figure 1, none of the beverages was able to rehydrate as much as the weight lost. The rate of dehydration-induced weight loss did not show a significant difference in the three separate sessions ($P = 0.84$). The three beverages significantly differed in rehydration-induced weight gain ($P = 0.001$). Tukey's test results showed a significant difference

Table 2. Timing of the measurement of the study variables

Variable	Time				
	before dehydration	Immediately after dehydration	One hour after dehydration	Three hours after dehydration *	Immediately after the anaerobic performance
Weight measurement	×	×		×	
Blood pressure	×			×	×
Urine specific gravity	×	×		×	
Heart rate		×			×
Borg scale		×			×

* After this time, the anaerobic performance test (300-yard shuttle run) was done, and the records were recorded.

between watermelon juice and carbohydrate beverages. After consuming the drinks, the weight regained after consuming carbohydrate drinks and watermelon juice was significantly higher than the weight regained after drinking water.

The main effect of time ($P<0.001$) and group × time interaction effect ($P=0.001$) were significant for the USG. On the other hand, the groups' differences in USG were insignificant; in other words, the consumption of none of the beverages had a significant effect on USG ($P=0.41$, Table 4). According to the results, there was no significant difference in the USG before and after dehydration, while the USG after rehydration was significantly different compared to before and after dehydration.

Concerning the effect of the beverage type on anaerobic performance, the findings indicated no significant difference between the three beverages ($P=0.87$). In other words, watermelon juice consumption had no significant effect on anaerobic performance compared to carbohydrate and water drinks. According to the results of the Borg scale, the level of pressure perceived by participants when performing the 300-yard test after consuming each of the three beverages indicated a significant difference ($P=0.02$). Based on the results, carbohydrate beverages significantly affected RPE compared to water and watermelon juice. On the other hand, in the water drink, participants had a higher RPE score despite a weaker record (62.55 seconds) in anaerobic performance compared to the watermelon juice (62.36 seconds). At the dehydration stage, however, RPE scores demonstrated no difference between the three beverages ($P=0.33$).

Discussion

The present study investigated the effect of water, watermelon juice, and carbohydrate drinks on rehydration and anaerobic performance after dehydration by physical activity. The findings of this study showed that the consumption of watermelon juice and

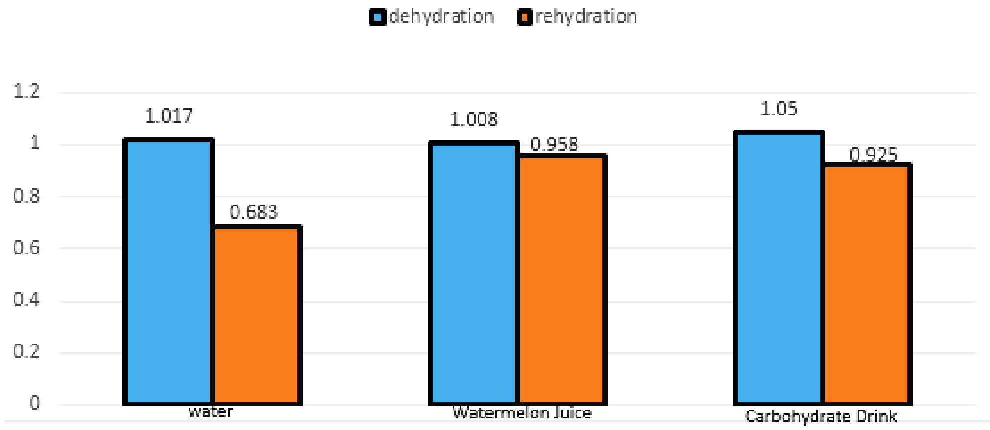

Figure 1. Comparison of dehydration (weight loss) and rehydration (weight gain)

Table 3. Results of statistical tests for the measured variables

Variables	Time	Water (n = 12) (Mean ± SD)	Carbohydrate drink (n = 12) (Mean ± SD)	Watermelon juice (n = 12) (Mean ± SD)	*P* value
Weight (kg)	Before dehydration	58.11 ± 7.26	58.15 ± 6.81	57.93 ± 7.01	0.001*
	After dehydration	57.11 ± 7.16	57.14 ± 6.73	56.83 ± 6.90	
	After rehydration	57.80 ± 7.17	58.10 ± 6.73	57.80 ± 6.97	
Anaerobic performance (s)	After rehydration	62.55 ± 2.31	62.87 ± 1.87	62.36 ± 3.01	0.87
Weight Loss (kg)	After dehydration	1.01 ± 0.19	1.008 ± 0.19	1.05 ± 0.17	0.84
Weight gain (kg)	After rehydration	0.68 ± 0.17	0.95 ± 0.19	0.92 ± 0.17	0.001*
Borg Scale	300-yard shuttle run	16.58 ± 1.62	14.67 ± 1.82	15.17 ± 1.58	0.02*
	Dehydration phase activity	13.42 ± 2.50	13.42 ± 1.88	14.58 ± 2.15	0.33

*$P<0.05$.

Table 4. Results of statistical tests for urine specific gravity

	Time	Water (n = 12) (Mean ± SD)	Carbohydrate drink (n = 12) (Mean ± SD)	Watermelon juice (n = 12) (Mean ± SD)	*P* value (time effect)	Partial η2
Urine specific gravity	Before dehydration	1.023 ± 0.011	1.025 ± 0.007	1.024 ± 0.007	0.001	0.535
	After dehydration	1.027 ± 0.007	1.022 ± 0.008	1.026 ± 0.006	0.41	0.051
	After rehydration	1.008 ± 0.009	1.011 ± 0.009	1.019 ± 0.007	0.001	0.268

carbohydrate beverages led to more weight gain than water. Carbohydrate beverages can help rehydration due to their high sodium compared to water (1). In this regard, Ostojic and Mazic concluded that the amount of urine excreted when drinking water was higher than after carbohydrate drink consumption. Therefore, weight gain after consuming a carbohydrate beverage was greater than after drinking water (20). Machado-Moreira et al stated that the sodium in carbohydrate beverages could preserve body water (13). Evans et al also found that high-volume water consumption increased blood volume and decreased plasma osmolality and arginine vasopressin release, thereby increasing urine production (1). The results of the present study indicated that average weight gain after water and carbohydrate beverage consumption was 0.68 and 0.95 kg, respectively. Therefore, these findings are in line with the findings of previous investigations (1,13,20).

Every 100 g of watermelon juice contains 1 mg of sodium, 112 mg of potassium, and 7.5 g of carbohydrates (21). The reason for watermelon juice-induced rehydration through water retention and prevention of urination in the present study cannot be attributed solely to the presence of sodium (small amount, about 1 mg/100 cc) in this beverage. On the other hand, watermelon juice has the unnecessary amino acid L-citrulline. The results of studies have demonstrated that L-citrulline, available in watermelon juice, could lead to the dilation of renal vessels by producing nitric oxide and, eventually, cause the excretion of extracellular fluids (14,22). The nitric oxide system is activated when the interstitial fluid exceeds the normal level (12), so watermelon juice has a diuretic effect when extracellular water is higher than normal. Considering the 1.8% weight loss of the participants due to dehydration in the present study and that the rate of extracellular water decreases during dehydration (a condition that occurs during or after exercise) (13), watermelon juice cannot have a diuretic effect and its use after the dehydration period in the present study was probably accompanied by a rehydration effect. Therefore, considering the average weight gain after rehydration with watermelon juice (approximately 0.92 kg), it can be concluded that watermelon juice consumption in this study preserved body fluid.

Based on the findings, there was no significant difference between the three drinks in the USG amount. However, the urine concentration was reduced after consuming the three beverages. In other words, in decreasing order, the highest rate of USG loss was observed after water, watermelon juice, and carbohydrate beverages. In line with our results, some researchers have demonstrated no significant differences in the mean USG after water and carbohydrate beverage consumption for rehydration (6,23,24). However, Castillo indicated that the amount of USG after drinking water was less than after drinking carbohydrate beverage (25). A probable reason for the present study's disagreement with Castillo's study is related to the time and period of rest after rehydration. A comparison of USG changes after consuming watermelon juice and carbohydrate beverages has not been done so far, and this study showed no significant difference between the two drinks. Zubac et al concluded that USG assessment was unsuitable for detecting body hydration status (26). When diet and training are not controlled, and body fluids are in balance, using the USG method to measure rehydration is difficult due to different sampling methods, delay in reading the results, and the kidney's unknown ability to adapt to dehydration conditions in physical activities (26). Therefore, according to the recent findings and Zubac's theory, the ability of the kidneys to adapt to dehydration and hyperhydration conditions could be a possible reason for the lack of significant difference in the mean USG in rehydration with the three beverages.

This study showed no significant difference in participants' anaerobic performance after rehydration with three beverages. These findings are in line with previous studies. Figueroa et al stated that L-citrulline could improve exercise performance by increasing muscle oxygen consumption or decreasing lactic acid production. Thus, the high concentration of L-citrulline in watermelon juice can be helpful to athletes (22). However, little research has been done on the effect of watermelon juice on sports performance. Cutrufello et al examined the effects of a single pre-exercise dose of L-citrulline and watermelon juice on anaerobic and aerobic exercise performance (14). Results showed that the supplements did not significantly affect the total number of repetitions, fatigue time, VO2 max, and anaerobic threshold. In the present study, the anaerobic performance after rehydration with the three beverages had no significant difference. Shanely et al also reported that watermelon juice was as effective as carbohydrate beverages in impacting endurance performance (9).

Conclusion

The consumption of carbohydrate beverages and watermelon juice could lead to weight gain and rehydration after dehydration. However, because watermelon juice contains vitamins and minerals compared with carbohydrate drinks, it is suggested that athletes use this drink.

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Authors' Contribution

Conceptualization: Mohsen Mohammadnia Ahmadi, Mohammad Reza Gheybizadeh.

Data curation: Mohammad Reza Gheybizadeh.
Formal analysis: Mohammad Reza Gheybizadeh, Mohammad Yousefi, Mohsen Mohammadnia Ahmadi.
Investigation: Mohsen Mohammadnia Ahmadi, Mohammad Reza Gheybizadeh, Mohammad Yousefi.
Methodology: Mohsen Mohammadnia Ahmadi, Mohammad Reza Gheybizadeh.
Project administration: Mohammad Reza Gheybizadeh.
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Software: Mohammad Yousefi, Mohammad Reza Gheybizadeh.
Supervision: Mohsen Mohammadnia Ahmadi.
Validation: Mohsen Mohammadnia Ahmadi.
Visualization: Mohsen Mohammadnia Ahmadi.
Writing–original draft: Aliyeh Daryabor.

Competing Interests

The authors declare that they have no competing interests.

Ethical Approval

All ethical principles such as obtaining informed consent from participants, confidentiality of their information, and allowing them to leave the study at any time were considered in this study. Ethical approval was obtained from the research Ethics Committee of Birjand University of Medical Sciences (code: IR.BMSU. REC.1397.317).

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