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Original Article

The effects of the intake of an isotonic sports drink before orienteering competitions on skeletal muscle damage

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Abstract. [Purpose] The purpose of this study was to investigate the effects of the intake of an isotonic sports drink (500 ml water, 32 gr carbonhydrate, 120 mg calcium, 248 mg chloride, 230 mg sodium) the level of the skeletal muscle damage of orienteering athletes. [Subjects and Methods] The study was carried out on 21 male elite orienteering athletes. The athletes were divided into two groups by randomized double-blind selection. The experimental group (n=11) was given the isotonic sports drink, while the placebo group (n=10) was given 500 ml pure water. Blood samples were taken pre-competition, post-competition, 2 hours post-competition and 24 hours post-competition. [Results] The pre-c troponin, myoglobin and creatinine kinase serum levels of the placebo group were significantly lower than the post-competition and 2 hours post-competition values. The 24 hours post-competition levels of the same analyses were also significantly lower than the post-c and 2 hours post-competition. The pre-competition troponin, myoglobin and creatinine kinase levels of the experimental group were found to be significantly lower than the post-competition, 2 hours post-competition 24 hours post-competition values. In conclusion, the present results suggest that the intake of supportive sports drinks before exercising significantly prevents the observed muscle damage. The study showed that serum myoglobin levels between the experimental and the placebo group is significantly different during the 2 hours post-competition period. [Conclusion] The level of serum creatinine kinase and myoglobin accurately shows the extent of the muscle damage. However, further studies on the effect of isotonic sports drink in different training programs on the cell membrane and the muscle damage are needed.
Key words: Orienteering athletes, Muscular damage, Sports drinks

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INTRODUCTION

The muscular damage is described as a condition which results in exhaustion, fatigue, loss of power and pain after heavy exercises[1)]. The cellular damage occurs depending on the intensity and the type of the exercise. This is termed as micro trauma, micro injury or muscular damage in the literature[2)]. Different type of exercises cause pain in different degree and they have different effects on the muscular damage[3)]. Strenuous and unaccustomed exercise can induce skeletal muscle damage and this is particularly true of exercise including eccentric contraction[4)]. Although muscular damage is closely related to the intensity of the exercise, unfamiliar exercises can cause muscular damage frequently[5–7)].

Increased activity of CK and LDH may occur in serum in healthy subjects after exercising and serves as a marker of injury to skeletal muscle, where the degree of biochemical abnormality reflects the extent of tissue injury. Due to the nature of the orienteering competitions which take place on both flat and rough surfaces (downwards and uphill) the muscles are subjected

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to both eccentric and concentric contractions. During the runs downwards the muscles are mainly subjected to eccentric contraction which cause more muscular damage compared with the runs on flat surfaces where the muscles are subjected to both eccentric and concentric contractions[8].

Athletes loose water and electrolyte by sweat and consume a lot of energy during training and competition periods. The loss of even 2% of liquid as a result of training or a mild dehydration may cause a significant decrease in their performance. As the body is dehydrated, the blood volume and the amount of sweat formation decrease and body temperature increases. In order to compensate this excessive temperature, the body needs to work much harder to support the blood circulation and produce more sweat. The loss of essential electrolytes of sodium and potassium salts causes complications such as muscle cramps, fatigue and exhaustion and headaches. By the help of appropriate drink, the depleted levels of water, carbohydrates and electrolytes can be replaced. The sports drinks were developed to replace the liquid, electrolyte and energy lost during the training period. The isotonic drink quickly replaces the liquid lost by sweat and provides carbohydrate needed[9]. Based on all this information, the aim of the study is to determine the effects of the intake of the isotonic sports drink on the level of the skeletal muscle damage of orienteering athletes.

SUBJECTS AND METHODS

The study was practiced on 21 male elite orienteering athletes who had at least two years of sporting life. The participants are divided into two groups as the experimental (n=11) and placebo group (n=10) (Table 1). Four different 15 cc venous blood samples were taken from the athletes' pre-competition (pre-c), post-competition (post-c), 2 hours post-competition (2 hr post-c) and 24 hours post-competition (24 hr post-c). The blood samples were first centrifuged at a rate of 5,000 revolution/minute and the upper phases were transferred to eppendorf tubes and kept at −80 °C until the use. The serum levels of troponin, myoglobin were determined by immunoassay method using original Beckman Coulter kits in an AU2700 auto analyzer, CK and LDH enzyme levels were assayed by calorimetric method using Beckman Coulter kits in an AU2700 auto analyzer.

After taking their first blood samples during the resting period the athletes were divided into two groups by randomized double-blind selection. The first group was given the isotonic drink (in 500 ml water 137 kcal, 32 gr carbohydrate (isomoltulose), 120 mg calcium, 248 mg chloride, 230 mg sodium). The second group chosen as the placebo group was given 500 ml pure water in dark colored bottles. Since the participants were in the same camp they were subjected to the same diet. The competition was carried out an advanced 7–12 km long blue tract with a target number of 20 and an estimated completion time of 60–80 minutes[10, 11]. The participants were given detailed information about the objectives of the study in accordance to the Helsinki Medical Declaration and they gave their full content. This study was carried out according to the approval of Non Enterprising Ethical Committee (decision number of 2015/3).

Because the volume of the samples was less than n=30 the non-parametric test was employed. The measurement carried out unrelated to the non-parametric test for comparisons between the groups were made by using Mann Whitney U-Test (Mann Whitney U-test for Independent Samples). The comparisons between the groups were made by using Wilcoxon Signed Rank Test for paired samples. The significant level was determined to be $p<0.05,<0.01$.

RESULTS

All of variable levels were similar for both groups ($p>0.05$) expect that it was founded significantly different for 2 hr post-c myoglobin values ($p<0.05$) (Table 2).

Pre-c serum troponin level significantly different from post-c and 2 hr post-c values for the placebo group ($p<0.05$). 2 hr troponin level significantly different from post-c and 24 hr post-c values ($p<0.05$). Post-c and 2 hr post-c myoglobin values were higher than pre-c serum level for the placebo group ($p<0.05$). 24 hr myoglobin level was found significantly lower than post-c and 2 hr post-c values ($p<0.05$). Pre-c serum ck level significantly different from post-c and 2 hr post-c values for the placebo group ($p<0.05$). 24 hr ck level was found significantly lower than post-c and 2 hr post-c values. There were no differences between in other values ($p>0.05$) (Table 2).

Pre-c serum troponin level was significantly lower than post-c, 2 hr post-c and 24 hr post-c values for the experimental group ($p<0.05$). 2 hr troponin level was significantly different from post-c and 24 hr post-c values ($p<0.05$). Pre-c serum myoglobin level was significantly lower than post-c and 2 hr post-c myoglobin values for the experimental group ($p<0.05$). Pre-c serum ck level was significantly lower than post-c and 2 hr post-c ck values for the experimental group ($p<0.05$). There were no differences between other values ($p>0.05$) (Table 2).

DISCUSSION

Schwane et al. investigated the relation between the muscle damage and plasma activities of CK and LDH of seven athletes whose muscles primarily perform eccentric contractions. The athletes were asked to run first on a flat surface then on a surface with %10 inclination. Following downhill running (57% of VO2max), significant delayed-onset soreness was experienced in gluteal, quadriceps, anterior leg, and posterior leg muscles, and plasma CPK (but not LDH) activity was significantly increased (351% at 24 h). In contrast, following a 78% of VO2max running, no statistically significant soreness

Table 1. The physical properties of placebo and experimental groups

Groups	Age (years)	Body height (cm)	Body weight (kg)	BMI (kg/m^2)	Body fat Percentage (%)
Placebo	15.7 ± 2.2	161.8 ± 8.0	50.0 ± 6.7	19.0 ± 1.5	16.6 ± 7.1
Experimental	15.4 ± 2.2	160.1 ± 9.6	48.4 ± 7.1	18.8 ± 1.6	15.5 ± 7.7

Table 2. Comparison of the serum troponin (ng/ml), myoglobin (ng/ml), CK (U/l) and LDH (U/l) concentrations levels at time durations

Variable	Groups	Pre	Post	2 hr	24 hr
		Competition	Competition	Post-competition	Post-competition
Troponin (ng/ml)	Placebo	0.005 ± 0.001	0.008 ± 0.003*	0.040 ± 0.055*	0.007 ± 0.006
	Experimental	0.005 ± 0.002	0.007 ± 0.002*	0.038 ± 0.034*	0.010 ± 0.008*
Myoglobin (ng/ml)	Placebo	30.2 ± 13.4	86.9 ± 44.9*	73.7 ± 20.8*	21.99 ± 2.3
	Experimental †	24.9 ± 5.5	61.0 ± 34.6*	50.2 ± 29.7*	51.58 ± 19.3
CK (u/l)	Placebo	259.1 ± 83.6	348.9 ± 155.9*	368.3 ± 132.5*	285.0 ± 89.5
	Experimental	213.1 ± 104.5	267.9 ± 127.4*	273.1 ± 136.5*	233.3 ± 101.1
LDH (u/l)	Placebo	222.5 ± 27.5	233.5 ± 19.1	217.2 ± 33.3	215.5 ± 23.2
	Experimental	224.9 ± 40.7	234.2 ± 31.5	229.0 ± 23.5	218.7 ± 23.8

Mean ± SD. *Significant difference compared with Pre ($p<0.05$). †Significant difference compared with placebo ($p<0.05$).

occurred in any muscle group, and plasma CPK and LDH activities were not elevated[12].

Another important factor regarding athletes' health and performance is the liquid and electrolyte balance. This balance is very important to maintain the optimum performance during the exercise. The increased need of liquid and decrease in sodium intake and the marginal insufficiency of the calcium, potassium and magnesium may result in a decline in the performance. It is stated that the intake of drinks before, during and after the competition within appropriate protocols would obviate the decrease in the performance of athletes[13, 14]. The main functions of water in relation to physical activity are to carry oxygen to tissues, hormones and nutrients as well as carbon dioxide and other metabolic wastes; to help regulate the level of blood pH, and to help dissipate heat[14]. The water needs depend on the intensity of the activity and thermal stress and 0.7–1 l/h of isotonic drink during activity should be taken[15]. The drink should contain 0.5–0.7 g Na/l for sports of 2–3 hours, while Na 0.7–1.2 g/l for ultra-endurance[16]. Sports drinks should hydrate and prevent dehydration during sports activity, provide mineral salts (mainly Na and Cl and P); provide carbohydrates (HC) increase the absorption of water by the combination of mineral salts and sugars (fast and slow absorption in a ratio of 3/1)[14].

Amelink et al. tested the hypothesis that calcium from the sarcoplasmic reticulum contributes to exercise-induced muscle damage. Dantrolene sodium (Dantrium) is a muscle relaxant that affects the flux of calcium over the sarcoplasmic membrane. Rats were treated with dantrolene sodium for a week before a 2 h run on a treadmill. The total creatine kinase activity and isoenzyme composition in plasma were measured before and after the exercise. The treated rats showed a marked decrease (34%) in exercise-induced enzyme efflux, caused by a decrease in the muscle specific isoenzyme. While a 13-fold increase found in control rats, only a 6.5-fold increase in treated animals was observed. It is concluded that dantrolene sodium protects the muscle against exercise-induced damage[17].

Brink et al., studied the effect of the sports drink on the sustainability of the performance in a tennis match on 8 tennis players. Their hypothesis was that drinking sports beverages before, during and after each tennis match would limit the decrease in physical performance compared to conditions where the only fluid intake was water. The physical test results for the lower limbs showed no significant differences between the groups. Conversely, on the upper limbs the EMG data showed greater fatigue of the triceps brachii in the placebo condition compared to resting, while the ingestion of sports drinks attenuated this fatigue[18]. In another study, six male volunteers exercised to exhaustion on a cycle ergometer at a workload which required approximately 70% of Vo2max. After one preliminary trial, subjects performed this exercise test on six occasions a week. Immediately before the exercise, and at 10-min intervals throughout, subjects ingested 100 ml of one of the following: control (no drink), water, glucose syrup, fructose syrup, glucose-fructose syrup or a dilute glucose-electrolyte solution. Each of the syrup solutions contained approximately 36 g CHO per 100 ml; the isotonic glucose-electrolyte solution contained 4 g glucose per 100 ml. Expired air samples for determination of Vo2, respiratory exchange ratio and the rate of CHO oxidation were collected at 15-min intervals. Venous blood samples were obtained before and after exercise. Subjects drinking the isotonic glucose-electrolyte solution exercised longer (90.8 (12.4) min, mean (SEM) than on the control test (70.2 (8.3) min; p less than 0.05)[19].

Also in another study, Lukaski HC emphasizes the importance of magnesium for the work performance. Acute, intense

activity results in short-term increases in both urine and sweat losses of minerals that apparently diminish during recovery in the days after exercise. Supplemental magnesium and zinc apparently improve strength and muscle metabolism[20]. Ivy et al. states that in the athletes given the carbon hydride and protein drink has 22% of their muscle glycogen refreshed after 40 minutes following a strenuous exercise and the replacement of the muscle glycogen after two hours takes place 4 times faster than the athletes who take carbohydrate support only[21]. Saunders et al., reported that the athletes given a supplement CHO-P (carbohydrate and protein) mixture throughout the an exhaustive cycling exercise had 83% lower CK enzyme levels at the15th hour after the exercise compared with those who took carbon hydride only[22].

Some results obtained in literature also support the hypothesis of this research. For example; Isomaltulose, for its slow rate of hydrolysis and low glycogenic index[23], and for the characteristics of fructose, its component, with increased fluid and solute absorption in the small intestine and increased exogenous oxidation[24], could improve the duration of exercise. Sports drinks should: hydrate and prevent dehydration during sports activity, provide mineral salts (mainly Na and Cl and P); provide carbohydrates (HC) increase the absorption of water by the combination of mineral salts and sugars (fast and slow absorption in a ratio of 3/1). For hydration to be adequate, drinks during the competition must be isotonic (200–320 mOsm/kg water). During physical activity, in sports with a duration of less than 1 hour, international institutions recommend not exceeding 6–9% in the concentration of HC[14].

It is clear that the isotonic drink acutely taken before the competition has protective effect and decreases the muscle damage incurred during competitions. Although the muscle damage of experimental group was lesser than the placebo group during the competition and recovery period, it was not found to be significant. It is possible that the isotonic drinks could be useful for athletes since they prevent the muscle from being damaged and increase the stability of muscle cells by establishing the liquid and electrolyte balance of the body. Further research is needed to clarify the effect of the isotonic drinks on the cell membrane. Sports drinks should moisturize by providing minerals and carbohydrates and increase the absorption of water with an ideal combination of salts and sugars. Therefore, it is important to provide correct hydration-protocols before, during and after physical activity, as well as know possible limitations of the sport.

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