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Effects of Passive Dehydration on Muscular Strength

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1. Abstract

The purpose of this study is to determine the effect of passive dehydration on the muscular strength. Ten healthy handball players [from 19 to 28 years of age] from Handball Male Team, volunteered to participate in this study. Turkish Hamam used for dehydration. Subjects rested in ambient temperature 40ºC [humidity was recorded %81-78] for 30 minutes in the upright sitting position. Heart rate, blood pressure, body temperature, body mass index [BMI], total body water [TBW] hand grip, biceps strength and leg strength were measured before and after Turkish Hamam. Significant differences between pre and post values was determined by Wilcoxon. The association between the changes was determined by Pearson Correlation. The level of significance was set at $p<0.05$. After 30 minutes Hamam, body mass, BMI and TBW was significantly decreased [$p<0.05$]. There were no significantly changes in hand grip [%1,2], biceps strength [%3,7] and leg strength [%3,31] before and after dehydration [$p>0,05$]. After Hamam, there was a significantly correlation between hand grip and biceps [$r=0,707$], leg strength and hand grip [$r=0,759$] [$p>0,05$], however, there was a lover correlation between leg strength and biceps [$r=0.548$] [$p<0,05$]. In conclusion, moderate passive dehydration can adversely affect the maximum muscular strength, but is not significantly.

2. Introduction

The effects that dehydration [hypohydration] has on increasing heat strain and cardiovascular strain and aerobic exercise performance are well documented. Less understood are the effects of dehydration on skeletal muscle performance metabolism. While two studies reported that hypohydration reduced muscle endurance another study found no difference in fatiguability during handgrip exercise. Likewise, anaerobic exercise performance has been reported to be decreased or not altered by hypohydration [1]. Dehydration is a serious and potentially life-threatening condition in which the body contains an insufficient volume of water for normal functioning. Water is the organic solvent for most biochemical processes; therefore, adequate hydration is important peak performance [2,3]. Dehydration is a frequent problem in physically active individuals exercising at high volumes in hot ambient environments, with losses of 6% to 8% of PR exercise body mass common [4]. As little as 1% to 2% body mass loss in the heat challenges cardiovascular compensatory mechanisms for increased body temperature and reduces exercise capacity [5]. Normal skeletal muscle function is affected by altered physiologic states such as dehydration [6,7]. Sweating is maintained by intracellular water shifting to the extracellular space, resulting in cell dehydration and adversely affecting skeletal muscle cell function [8]. Dehydration negatively affects muscle endurance, strength [9] and mucle performance by impeding thermal regulation, altering water movement across cell membranes [10]. Turkish Hamam: The Turkish Hamam [also known as Turkish Bath] or hamam is the Turkish variant of a steam bath. The Turkish Hamam is described as a place for body treatments, cleansing, purification and social life [11]. Available methods to induce dehydration are use of a sauna for passive dehydration, vigorous exercise for active dehydration, and /or use of diuretic pharmacologic agents. Because of diuretics are banned by most organizations governing sports, use of this agents to make weight could result in disqualification and possible suspension from the sport. Active dehydration is often avoided because the exercise that is used to promote the water loss may also lead to fatigue, depletion of energy substrate and impaired performance. Adverse effect of passive dehydration has been reported for such tasks as vertical jumping and isometric strength/endurance, and isometric / dynamic endurance [2]. The effects of dehydration on strength are conflicting [2] with reports of unaffected decreased muscular strength [2,9] and the significant increase in jump height [9]. Hedley et al. explained that to support the warm-up practice before high-velocity maximal power performance, and it seems that the methodology to increase muscle temperature is not important; however, the optimal time for the warm-up protocol is critical [9]. In general, the effects of passive dehydration [2] and acute heat exposure [30 minutes at 65-75o C, relative humidity 15%] [9] induced by sauna. Studies have suggested that long-term sauna bathing may lower blood pressure in persons with hypertension by causing a direct loss of extracellular water and plasma minerals [12]. Comparing the different physiological parameters in sauna with un air temperature of 80 to 90 C and a relative humidity of 50%, and the wet sauna with an air temperature of 45 to 50 C and a relative humidity of 100% showed that the heat strain and hence the risk in both saunas are similar and exposure in either sauna exceeding 10 minutes may be dangerous [13]. Because of the different protocols, heat and humidity the adverse effects of dehydration on muscular strength is little understood. But no studies have investigated the effects of passive dehydration on muscular strength induced by 30 minutes at 40-42o C, and relative humidity 78-81%. Therefore, the purpose of this study was to examine the effects of passive dehydration on leg strength, biceps strength and hand grip strength.

3. Methods

3.1. Research Design

Procedures for the study were explained and informed to the research group. Before the experiment, all subjects were familiarized with the Turkish Hamam environment and experimental procedures. Subjects were then tested on two occasions [before/baseline and after the dehydration]. Subjects had no alcohol or caffeine for 24 hours before the tests, which were tested at least three hours after a meal. The study was designed in one day and was conducted by the Traditional Turkish Hamam. Before participating in the study, subjects completed a health history questionnaire and an informed consent form.

The dehydration protocol consisted of participants reporting to the Turkish Hamam. Subjects were dehydrated by resting in ambient temperature 40-42C and 78-81% relative humidity for 30 minutes in the upright sitting position during dehydration. Subjects were allowed to Hamam for 10 minutes intermittent.

3.2. Subjects

Subjects were 10 healthy male handball players from university handball club aged 21,2±2,5 years [range 19 to 28 years]. Subjects were volunteered to participate in this study.

3.3. Measurement Protocols

On arrival at the Turkish Hamam hall, subjects were seated and allowed to rest for 10 minutes, then blood pressure, heart rate [HR] and body temperature [BT] was measured. Then height, bioelectric impedance analysis [BIA] and strength tests were subsequently measured. After 30 minutes of Hamam, subjects toweled off and body mass was measured than BT, blood pressure and HR was measured in 10 minutes resting position. After that, strength tests were conducted in the following order: Hand grip, leg strength, and biceps strength. The tests were measured 2 times in each test sessions.

3.4. Height and Bioelectric Impedance Analysis [BIA]: Height were recorded using a portable stadiometer [14]. Bioelectric impedance analysis [BIA] measures the opposition of bodily tissues to the flow of a mild [less than one milliamp] alternating electric current. Body mass, body mas indices [BMI], percent body fat [%], total body water [TBW] was measured for all participants using BIA [TBF-300], at baseline and after Hamam. Total, extracellular, and intracellular water compartments were calculated using BIA formulae [11]. During BIA measurement all subjects were naked.

3.5. Blood Pressure, Heart Rate and Temperature: Systolic [SBP] and diastolic [DBP] blood pressure was measured using an automatic sphygmomanometer. Hart rate [HR] was assessed using a Heart Rate Monitor [Polar Electro-F5] and was assessed with subjects resting in lying position on lounge. Body temperature was measured using a thermometer from armpit.

3.6. Muscle Strength Tests: Grip strength dynamometer, 5-100 kgf [TAKEI PHYSICAL FITNESS TEST, JAPAN]. Handgrip strength is important for any sport in which the hands are used for catching, throwing or lifting. Subject holded the dynamometer in dominant hand in line with the forearm and hanging by the thigh. Maximum grip strength is then determined without swinging the arm. The best of trial is recorded [15].

3.7. Leg Strength Test: A portable dynamometer used for leg strength. Between 0.3 and at the most 3.0 seconds using an adjustable handle cable tensiometer and a foot stand [Takei Scientific, Tokyo, Japan]. Strength is expressed in kilograms force. Measuring range is from 0 to 300kg [16].

3.8. Biceps Strength Test: Biceps curl strength was measured in seat with back rest adjusted to an angle of 30 degrees to the vertical [Baceline Digital Push-Pull Dynamometer-250lb./150 kg].

3.9. Data Analysis

Data were analyzed using the SPSS 10.0 for Windows Statistical Package. Pre and post measures were determined by Wilxoson test. The association between the change in leg, biceps and hand grip was determined by Pearson correlation test. Significance was set at P≤0.05 for all statistical analyses.

4. Results

Subjects' characteristics was recorded in (Table 1). as age = 21.2 ± 2,5 years, height = 178.8 ± 7.4 cm, and body mass = 76.2 ± 8.9 kg. Mean values for body mass, BMI, fat%, TBW, HR, SBP, DBP and BT are represented in (Table 2). The mean body mass, BMI and TBW [p<0,05] decreased significantly after dehydration, whereas there was no change in body fat % [p>0,05]. HR increased significantly [p<0,05], SBP also increased but there was no significantly [p>0,05]. DBP decreased and BT increased but changes were resulted in small. (Table 3) indicated changes in leg strength, biceps strength and hand grip strength, before and after dehydration. As shown, leg, biceps and hand grip strength were decreased after dehydration, but there were no significantly changes [p>0,05]. (Table 4) represents the correlation in leg, biceps and hand grip strength before and after dehydration. After dehydration; there was a significantly correlation between biceps and handgrip [r=,707] and between leg and hand grip strength [r=,759], but there was no significantly correlation between biceps and leg strength [r=,548].

Table 1: Subject characteristics

n=10	Mean± SD
Age (y)	21,2±2,5
Height (cm)	178,8±7,4
Mass (kg)	76,2±8,9

Table 2: Effect of Dehydration on Body Mass, BMI, Percentage of Body Fat, Total Body Water, Heart Rate, Blood Pressure, Body Temperature (Mean ± SD)

Parameters	Baseline/Before Mean± SD	After Mean± SD	P
Mass (kg)	76,2±8,9	75,7±8,9	0,00**
BMI (kg/m2)	23,8±2,1	23,5±2,1	0,00**
(%)	10,1±3,2	10,2±3,2	0,83
TBW (kg)	50,6±5,2	49,8±5,2	0,03*
HR (beats.min-1)	61,5±7,5	70,6±7,9	0,00*
SBP (mmHg)	112,5±9,8	115,7±6,3	0,44
DBP (mmHg)	67,5±3,5	66,5±11,3	0,73
BT (C°)	36,5±0,8	36,8±0,5	0,24

**P<0,001 *P<0,05; BMI= body mass indecs; TBW= total body water; HR= resting heart rate; SBP= systolic blood pressure; DBP= diastolic blood pressure; BT= body temperature (armpit); %= percentage of body fat.

Table 3: Effects of Dehydration on Muscular Strength

Parameters	Baseline/Before Mean± SD	After Mean± SD	P
Leg strength (kg)	157,3±32,9	152,1±36,8	0,23
Hand grip (kg)	52,0±8,2	51,2±7,5	0,79
Biceps strength (kg)	24,1±2,6	23,1±1,9	0,08

Table 4: Correlation of Leg Strength, Biceps Strength and Handgrip Strength Before and After Dehydration

n=10	HG-b	HG-a	B-b	B-a	LS-b
HG-a	,881**				
BS-b	,810**	,799**			
BS-a	,687*	,707*	,802**		
LS-b	,689*	,779**	,427	,429	
LS-a	,644*	,759*	,436	,548	,968**

** p< 0.01 *p< 0.05 HG=hand grip; BS=biceps strength; LS=leg strength; b=before; a=after

5. Discussion

We demonstrated that a passive dehydration induced by Turkish Hamam in 30 minutes at 40-42o C, and relative humidity 78-81%, resulted in a 1% reduction in body mass adversely affected muscle strength. Dehydration alters cardiovascular, thermoregulatory, central nervous system, and metabolic functions [17]. During dehydration, plasma hyperosmolarity is exacerbated as water is redistributed from the intracellular to the extracellular compartments of skeletal muscle in an attempt to maintain normal blood osmolarity. Muscle proteins affected most by dehydration are those involved in electrolyte distribution across the sarcolemma, calcium release and reuptake by the sarcoplasmic reticulum, and components of the mitochondrial respiratory chain [3]. Cardiovascular compensatory mechanisms for thermoregulatory blood pooling in the skin determine tolerance to dehydration and exercise in the heat. Exercise performance decreases as less blood is available for perfusion of active skeletal muscle. Blood flow to exercising muscles is significantly reduced with dehydration due to reductions in blood pressure and perfusion pressure [3] Blood flow to the exercising muscles declines significantly with dehydration, due to a lowering in perfusion pressure and systemic blood flow rather than increased vasoconstriction. Furthermore, the progressive increase in oxygen consumption during exercise is confined to the exercising skeletal muscles [18]. A similar response in blood pressure and temperature has been described by previous researchers. Hedley et al. [9] find that the HR increased significantly by 58 beats.min-1 [90,63%] from resting state during sauna. SBP also increased significantly from a presume value of 122 mm Hg to 148 mm Hg at the end of sauna exposure, in contrast DBP decreased from 78 mm Hg to 60 mm Hg. but no significantly. These findings support our results. In aur findings, before and after Hamam [first 5 minutes] HR significantly increased from 61 to 70 beats.min-1. SBP increased from 112 mm Hg to 115 mm Hg and in contrast DBP decreased from 67 mm Hg to 66 mm Hg but was not significantly. Alonso et al. [19] suggests that, lowering of stroke volume with dehydration appears largely related to increases in heart rate and reductions in blood volume. It has generally been considered that decreases in performance become apparent when dehydration exceeds 2% of body weight; that performance decrements become substantial when fluid losses exceed 5% of body weight; and that when fluid losses approach 6-10% of body weight, heat stroke and heat exhaustion become life-threatening. Dehydration also affects mental functioning. Therefore, the effect of hypohydration on real-life sport may be greater than that shown in laboratory studies of physiological performance [20]. Moderate dehydration [loss of ≤ 2% of body mass] can adversely affect the maximum muscular strength. The adverse effects of dehydration seem to be overcome by a 2-hour rest period and water consumption [2]. The results of this study were that dehydration [1% loss of body mass] reduced muscular strength by 1,2% handgrip, 3,7 %biceps and 3,3% leg strength but these results had no significantly decrement on muscle strength. Several studies have also reported decrements in strength following dehydration. Schoffstall et al. [2] reported that passive dehydration resulting in approximately 1,5% loss of body mass adversely affects bench press 1 RM performance. Hedley et al. [9] reported that hyperthermic [65-75 degrees C, 15% RH] condition for 30 minutes by sauna. Whereas 1RM leg press strength was significantly decreased [4%], leg press [29.2%] and bench press [15.8%] after the sauna exposure. In contrast, muscular power [vertical jump] increased significantly [3.1%] after acute heat exposure. Greiwe et al. [21] reported some different results to the above findings; quadriceps muscle strength and endurance are unaffected in 7 males 3.5 h after dehydration of approximately 4% loss of body mass following passive dehydration in a sauna. These results have shown that, the different reports and explanations about dehydration effects on muscle strength insufficient. Reasons for these conflicting findings are unclear, but may be related to differences in types of strength measurement, different protocols, subjects, populations, body composition status. But we need further studies with increased number of subjects and experimental studies. In summary, we found that, moderate passive dehydration is adverse effect to muscular strength, but 1% loss body mass is not detrimental for athletic performance. The effects of dehydration can be eliminated by a 1 hour- period of rest coupled with the ingestin of fluid. The information gained from this study can assist athletes and coaches to make more information about level of dehydration and it is recommended that athletic activities in hot atmosphere [nearly 40^{o}C more than 30 minutes] can be detrimental.

References

1. Montain SJ, Smith SA, Mattot RP, Zientara GP, Jolesz FA, Sawka MN. Hypohydration effects on skeletal muscle perfor-mance and metabolism: a 31 P-MRS study. J Appl Physiol. 1998; 84(6): 1889–94.
2. Schoffstall JE, Branch JD, Leutholtz BC, Swain DE. Effects of dehydration and rehydration on the one-repetition maximum bench press of weight-trained males. J Strength Cond Res. 2001; 15(1): 102-8.
3. Barr SI. Effects of dehydration on exercise performance. Can J Appl Physiol. 1999; 24(2): 164-72.
4. Sawka MN, Knowlton RG, Critz JB. Thermal and circulatory responses to repeated bouts of prolonged running. Med Sci Sports. 1979; 11: 177–80.
5. Haynes EM, Wells CL. Environment and Human Performance. Champaign, IL: Human Kinetics. 1986.
6. Alonso JG, Calbet JA, Nielsen B. Muscle blood flow is reduced with dehydration during prolonged exercise in humans. J Physiol. 1998; 513: 895–905.
7. Nielsen B, Savard G, Richter EA, Hargreaves M, Saltin B. Muscle blood flow and muscle metabolism during exercise and heat stress. J Appl Physiol. 1990; 69: 1040–1046.

8. Sawka MN. Physiological consequences of hypohydration: exercise performance and thermal regulation. Med Sci Sports Exerc. 1992; 24: 657–670.
9. Hedley AM, Climstein M, Hansen R. The effects of acute heat exposure on muscular strength, muscular endurance, and muscular power in the euhydrated athlete. J Strength Cond Res. 2002; 6(3): 353-8.
10. Hargreaves M, Febbraio M. Limits to exercise performance in the heat. Int J Sports Med. 1998; 19: S115–S116.
11. Ayçeman N. Türk Hamam kültürü, Erişim tarihi: 21.12.2018. 2014.
12. Servidio MF, Mohamed EI, Maiolo C, Hereba AT, Perrone F, Garofano P, Iacopino L.Analysis of body water compartments after a short sauna bath using bioelectric impedance analysis. Acta Diabetol. 2003; 207-9.
13. Shoenfeld Y, Sohar E, Ohry A, Shapiro Y. Heat stress: comparison of short exposure to severe dry and wet heat in saunas. Arch Phys Med Rehabil. 1975; 57(3): 126-9.
14. Rodacki CL, Fowler NE, Rodacki AL, Birch K. Technical note: repeatability of measurement in determining stature in sitting and standing postures. Ergonomics. 2001; 44(12): 1076-85.
15. Mogk JP, Keir PJ. The effects of posture on forearm muscle loading during gripping. Ergonomics. 2003; 46(9): 956-75.
16. Coldwells A, Atkinson G, Reilly T. Sources of variation in back and leg dynamometry. Ergonomics. 1994; 37(1): 79-86.
17. Cheuvront SN, Carter R, Sawka MN. Fluid balance and endurance exercise performance. Curr Sports Med Rep. 2003; 2(4): 202-8.
18. Alonso JG, José AL. Calbet and Bodil Nielsen Muscle blood flow is reduced with dehydration during prolonged exercise in humans. The Journal of Physiology. 1998; 513(3) 895-905.
19. Alonso JG, Rodríguez RM, Edward F. Coyle Stroke volume during exercise: interaction of environment and hydration. Am J Physiol Heart Circ Physiol. 2000; 278(2): 321-330.
20. Naghii MR. The significance of water in sport and weight control. Nutr Health. 2000; 14(2): 127-32.
21. Greiwe JS, Staffey KS, Melrose DR, Narve MD, Knowlton RG. Effects of dehydration on isometric muscular strength and endurance. Med Sci Sports Exerc. 1998; 30(2): 284-8.