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The Effect of Rehydration with Variation Fluid Temperature on Hydration Status Among Football Athletes

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***Abstract*—Increase body temperature during exercise especially in the hot environment can lead to dehydration, so it was needed fluid regulation. The purpose was to know the effect of rehydration with variation fluid temperature on hydration status in among athletes. Quasi experimental study in 30 male football athletes aged 14-18 years old. Subjects were divided into 3 groups based on variations of rehydration fluid temperature, ie cold (T1) 10^0-16^0C, normal (T2) 20^0-26^0C, warm (T3) 40^0-48^0C. Subjects were given 1400 ml rehydration fluids during the exercise period. The activity that was given was the football game with 90 minutes duration. Data collected were fluid intake 24 hours before exercise, body weight and urine specific gravity (USG) before and 60 minutes after exercise. Bivariate analysis used One-way ANOVA and Kruskall Wallis Test. Subjects had minimal dehydration (73,3%) before exercise based on the USG values and all subjects in all three groups were dehydrated after exercise ($p<0.05$). There were significant difference of status hydration in athletes on indicator percent body weight changes and USG after intervention ($p<0.05$). The most significant difference was in T1 Vs T3 group. Conclusion: Rehydration fluid with temperature of 10^0-16^0C proved to effect the percent body weight change and USG changes that was lower than the rehydration fluid with temperature of 20^0-26^0C and 40^0-48^0C.**

***Keywords*— temperature, fluid, hydration**

I. Introduction

The development of soccer has significant improvement in Indonesia. Not only adult, recently teenagers are involved in this sport. This phenomenon is indicated from soccer training center which start to empower and train the athlete since they are teenager. Even organization of Persatuan Sepak Bola Seluruh Indonesia (PSSI) actively develop teenager soccer tournament based on certain age group such as U15, U17, and U19 [1]. Soccer is one of endurance sport with high intensity of practice. High intensity of training in long duration can increase the risk of dehydration.

Dehydration is a problem of liquid equilibrium in the body. It is because the liquid drain out from the body in massive amount and not compensate with adequate liquid intake. Dehydration can cause negative effect toward athlete performance [3]. According to National Athletic Trainers Association (NATA), dehydration as 1-2% of body weight due to the drain out of body liquid will disturb the physiologic function of the body the decrease of body weight for more than 3% can cause physiologic function and increase the exertional heat illness risk such as heat cramps, heat exhaustion, or heat stroke [4]. Besides the decrease of 1-2% of body weight can decrease athlete performance up to 10 %. The decrease of 5% body weight can decrease 430 % of performance. Especially for high intensity sport and endurance sport such as soccer, the decrease 2.5% of body weight can decrease the performance up to 45% [5].

According to several studies adolescence athlete has higher risk than adult because there is a lot of fat in their body and contains only 20% water.[2,3,6] Besides, adolescence has high risk to have dehydration due to higher body heat generation and higher ability to absorb heat because they have higher body surface ratio compare to adult athlete so that the body liquid inside their body is utilized to decrease the heat [6]. In average soccer athlete lose 1.59% of body weigh during their practice in hot environment [7]. This study shows the prevalence of dehydration as 87.5% at te time the soccer payer doing exercise with urine density as >1.020 g/dl [8]. Study in brazil shows that adolescent soccer athlete release seat as 2-3 liters during the match meanwhile American College of Sports Medicine (ACSM), National Athletic Trainers Association (NATA) and American Dietetic Association (ADA) recommend liquid intake at the period of match as much as 2,4-3,4 liters [9,10].

The attempt to overcome dehydration on athlete is continuing to be done, especially the water intake in term of amount, frequency and the type of liquid consumed [11]. However, the problem of dehydration on athlete in not completely overcome yet. The setting of liquid temperature is one of the attempts which considered reducing dehydration level and increasing players' performance. Several studies shows that liquid temperature has positive effect in slowing the increase of body temperature [12,13]. The increase of body temperature during exercise especially in high temperature environmental causes the drain of body liquid through sweat, this factor can cause the dehydration on athlete [14]. A meta-analysis conducted in Australia in 2010 stated that rehydration water temperature affect toward athlete performance especially in low temperature (chill) intake. Four out of seven studies analyzed show that chill water intake in high temperature environment increase the performance up to 10% [13]. This finding is in accordance with the study conducted in 2013, which showed that rehydration water temperature has effect in overcoming the fatigue on athlete due to dehydration. The temperature of water consumed by athlete during the play affects respond of sweating and the decrease of body weight is an indicator of dehydration [15].

Based on those depictions, it can be conclude that water temperature has effect on hydration status of athlete, in which the hydration status affects the performance of athlete during exercising. The study related to hydration status has been conducted from various sport fields, however the most frequent studies conducted is related to amount, frequency and type of liquid. Based on that background, it is necessary to do the study regarding the effect of rehydration water intake with the temperature variation toward hydration status and weight change on soccer athlete.

II. MATERIALS AND METHOD

This research was conducted on soccer athletes at the Terang Bangsa Football School (SSB) of Semarang in August 2017. This research was a quasi-experimental study and was included in the scientific field in the field of community nutrition. The samples used in this study were 30 people, which were divided into 3 groups based on the treatment group. Each group consists of 10 people. Sampling was done by consecutive sampling method, based on inclusion criteria, namely aged 14-18 years, living in a dormitory, not sick especially fever and diarrhea, not being treated by a doctor, not consuming alcohol, cigarettes and certain supplements, and not doing heavy activities 24 hours before the study.

The independent variable in this study is the administration of rehydration water with temperature setting, with the dependent variable was hydration status. The given liquid temperature is divided into 3 based on the number of groups, namely the first group (T1) is given a rehydration liquid with a temperature of 10^0–16^0 C, the second group (T2) is given liquid with a temperature of 20^0–26^0 C, and the third group (T3) is given a liquid with temperature 40^0–48^0 C. The rehydration water provided is in the form of 1400 ml of mineral water of which 300 ml was given 10 minutes before exercise, 600 ml at resting time and 500 ml immediately after exercise.

This research has obtained the ethical clearance from Health Research Ethic Commission, Faculty of Medicine, Diponegoro University Number 544/EC/FK-RSDK/VIII/2017. The study began at 3:30 a.m. with an environment temperature of 31^0C. The exercise used was an exercise in a 2x45 minute soccer match with a 10 minute break. Data collected included subjects' characteristics, fluid intake, and hydration status. Data on subject characteristics obtained through direct interviews using identity questionnaires included names and ages. Anthropometric data including height was measured directly using microtoise with accuracy of 0.1 cm, body weight using digital scales with accuracy of 0.1 kg, and nutritional status using body mass index (BMI) based on actual height and weight. Nutritional status is categorized into three, namely thin if the BMI was <18.5 kg/m^2, normal if the BMI was 18.5-25 kg / m^2, and fat if the BMI was > 25 kg / m^2 [16].

Data on fluid intake was collected to see the total fluid entering the body from drinks and food a day (24 hours) before being given intervention. The fluid intake of the subject was obtained using a 24-hour food recall method. The level of adequacy of the subject's fluid intake was categorized into three, those are less if fluid intake was <90% of the need, adequate if fluid intake was > 90-110% of the need, and excess if the fluid intake was> 110% of the need [17].

The examination of hydration status in this study was carried out before and after the intervention by using indicators namely percent changes in body weight, urine density (UD). Percent changes in body weight were calculated using the formula = [(weight after intervention-weight before intervention): body weight before intervention x 100%] [4]. Weight measurement was carried out 10 minutes before intervention and 5 minutes after intervention. Meanwhile, urine samples were collected 10 minutes before the intervention and 60 minutes after the intervention using a closed clear bottle to check the hydration status based on UD, then the results were examined in the laboratory. The hydration status was categorized into four categories according to the National Athletic Trainers Association (NATA) of each indicator. Based on changes in body weight, it is categorized as not dehydrated if it has a value of +1 up to -1, mild dehydration -1 to -3, moderate dehydration -3 to -5, severe dehydration > 5. Whereas based on UD it is categorized as not dehydrated if it has a value of <1,010, mild dehydration 1,010-1,020, moderate dehydration 1,021-1,030, severe dehydration> 1,030.4.

Data processing and analysis is done using a computer program. Univariate analysis was used to describe the frequency distribution of data on age, height, weight, BMI, fluid intake, and initial hydration status. Normality test was conducted by using Saphiro-Wilk. Bivariate analysis used the One-way ANOVA test for normally distributed data and the Kruskal Wallis test for abnormally distributed data.

III. RESULTS AND DISCUSSION

The study was conducted on 30 male soccer athletes aged between 15-17 years divided into 3 groups, each group consisting of 10 people. During the study, no subject dropped out. Based on the results of the study, most subjects had normal nutritional status (90%). Water intake the day before the intervention showed that most subjects had adequate fluid intake (83.3%). The subject's hydration status based on urine density before being given an intervention showed that 73.3%

of subjects had mild dehydration. Subject categorical frequency distribution can be seen in table II.

TABLE I. SUBJECTS CARACTERISTICS BEFORE INTERVENTIONS

		Groups			*p*
		T1 (n=10)	**T2 (n=10)**	**T3 (n=10)**	
Age (Years)	Mean (DS)	15.8±0.6	15.9± 0.9	15.7± 0.8	0.840[b]
	Minimum	15	15	15	
	Maximum	17	17	17	
Weight (kg)	Mean (DS)	56.6±5.5	55.8±5.2	55.9±10.0	0.961[a]
	Minimum	50.60	45.10	41.60	
	Maximum	67.90	65.90	71.50	
Height (cm)	Mean (DS)	165.4±3.7	164.5±3.9	164.2±7.8	0.881[a]
	Minimum	160	159	152.2	
	Maximum	170	173	178	
Body mass index (BMI)	Mean (DS)	20.7±1.40	20.6±1.36	20.6±2.3	0.992[a]
	Minimum	18.90	17.84	17.24	
	Maximum	23.50	22.55	25.03	
Fluid intake (ml)	Mean (DS)	2996±95.6	2977 ±133.6	3044 ±104.5	0.406[a]
	Minimum	2882	2730	2890	
	Maximum	3189	3256	3210	
Urine Density (gr/ml)	Mean (DS)	1.016±0.003	1.016±0.004	1.015±0.005	0.942[b]
	Minimum	1.010	1.010	1.005	
	Maximum	1.020	1.020	1.020	

[a] One-way ANOVA; [b] Kruskal Wallis Test

TABLE II. CATEGORIES OF NUTRITIONAL STATUS, FLUID INTAKE, AND HYDRATION STATUS BEFORE INTERVENTION

Subjects characteristic	T1		T2		T3		Total (n=30)
	n	%	n	%	n	%	
Nutritional Status (BMI)							
Underweight	-	-	1	10	2	20	3 (10%)
Normal	10	100	9	90	8	80	27 (90%)
Fluid Intake everyday							
Adequate	8	80	8	80	9	90	25 (83.3%)
Inadequate	2	20	2	20	1	10	5 (16.7%)
Hydration Status (Urine Density)							
Well hydrated	2	20	3	30	3	30	8 (26.7%)
Mild dehydration	8	80	7	70	7	70	22 (73.3%)

Based on UD, it was found that most subjects experienced mild dehydration before the intervention and there was a re-change in the hydration status after being given an intervention. UD changes before and after intervention can be seen in Figure 1.

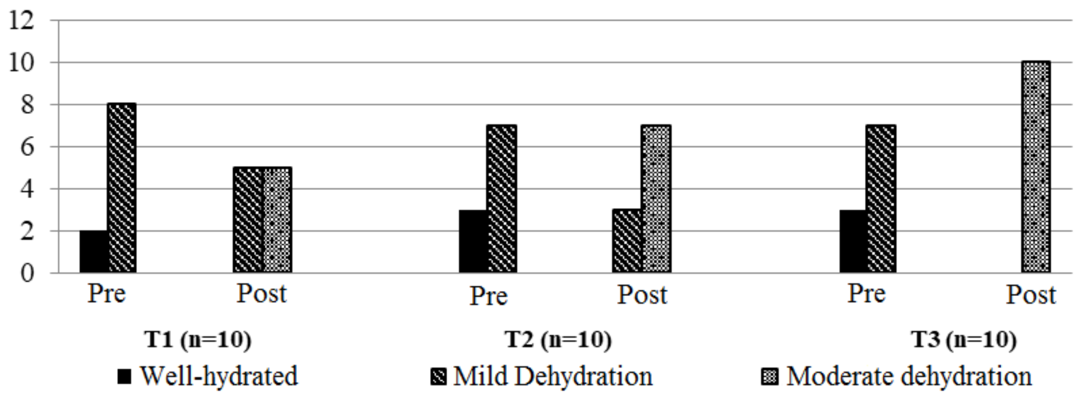

Fig.1. Description of hydration status based on urine specific gravity before and after intervention

Based on Figure 1. It is known that the highest category of dehydration after intervention is the category of moderate dehydration. The number of subjects who were moderately dehydrated after the intervention occurred most in the T3 group (100%), followed by the T2 group (70%), and the number of subjects who were moderately dehydrated after the intervention occurred at least in the T1 group (50%).

The description of the subject's hydration status based on percent changes in body weight after intervention can be seen in Figure 2.

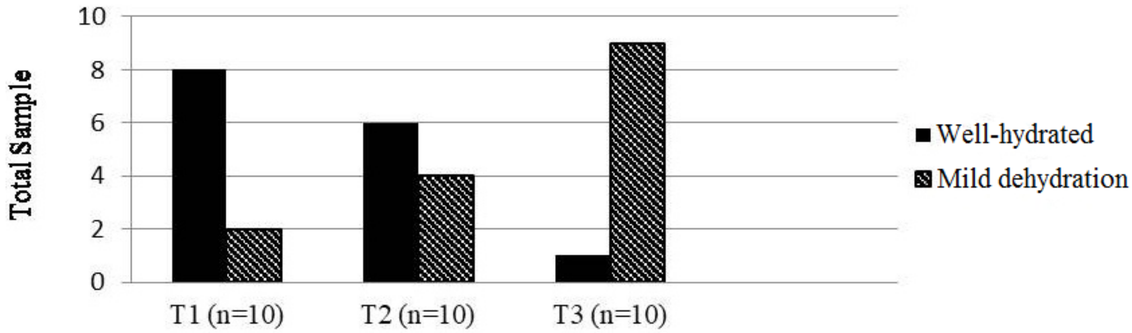

Fig.2. Description of hydration status based on percent change in weight after intervention

Based on Figure 2. it is known that the highest category of dehydration after intervention is the category of mild dehydration. The number of subjects who were mildly dehydrated after the most intervention occurred in the T3 group (90%), followed by the T2 group (40%), and the number of subjects who experienced mild dehydration after the intervention occurred at least in the T1 group (20%).

Table III. shows that the change in hydration status of the three indicators, the lowest occurred in T1 group and the highest in T3 group. There were significant differences from the percent changes in body weight and UD changes from the three intervention groups (p <0.05), therefore further testing was needed. While in the urine color there were no significant differences from the three intervention groups (p> 0.05), so it was not necessary follow-up test

TABLE III. EFFECTS OF INTERVENTION ON PERCENT CHANGES IN BODY WEIGHT, CHANGES IN UD, AND CHANGES IN URINE COLOR LEVELS IN THE THREE GROUPS

Hydration Status	T1	T2	T3	p
	Mean ±SD	Mean ±SD	Mean ±SD	
Weight change percentage (%)	0.73±0.29	1.05±0.44	1.53±0.40	0.000 a
Change of Urine Density (gr/ml)	0.007±0.002	0.012±0.007	0.013±0.006	0.002b

a One-way ANOVA; b Kruskal Wallis Test

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TABLE IV. PERCENT DIFFERENCES IN CHANGES IN BODY WEIGHT AND CHANGES IN UD IN THE THREE GROUPS

Hydration Status	T1-T2	T1-T3	T2-T3
	p	p	p
Weight change percentage (%)	0.193a	0.000a	0.024a
Change of Urine Density (gr/ml)	0.067b	0.001b	0.037b

a One-way ANOVA Benferroni; b Mann-Whithney

Table IV. shows that there is no difference in percent change in body weight between the T1-T2 group (p> 0.05). In contrast for the T1-T3 and T2-T3 groups, there were significant differences with significant values of (p <0.05). Likewise, the UD changes show that there is no difference in UD changes between the T1-T2 group (p> 0.05). Meanwhile for the T1-T3 and T2-T3 groups, there were significant differences with significant values (p <0.05). Based on the table it can be seen that the most significant difference between the two indicators is in the T1-T3 group.

This study used 30 subjects divided into 3 intervention groups namely T1 group, T2 group, and T3 group. General data on subject characteristics including daily fluid intake, UD and initial urine color level were seen before the subjects were given intervention. The results of different tests showed that there were no differences in age, weight, height, nutritional status, daily fluid intake, UD, and the initial urine color level of the subjects before intervention in each group (p> 0.05). This shows that the three groups have the same characteristics.

One day before the study was conducted, subjects were given education related to fluid intake. The results showed that the subject's water intake the day before the intervention was mostly in the adequate category (83.3%), the rest were in the low category (16.7%). The recommended fluid intake of male adolescence aged 14-18 years is 3.3 liters/day [10,18]. Consumption of fluids is needed by the body to reduce the risk of dehydration before undergoing training or exercise [19].

The subject's hydration status was determined by 3 indicators, namely percent change in body weight, UD and urine color.[4] Measurements of hydration status were conducted before and after the intervention. The subject's hydration status before the intervention was in the category of mild dehydration based on the value of UD (73.3%) and the color of urine (50%). This is similar to a study in Turkey (2013) which found that 65% of 40 research subjects experienced mild dehydration before exercise [20]. Mild dehydration is dehydration that occurs in a short period of time and is not too severe but if it is not checked it will have a negative effect on health [21]. Dehydration this is usually caused by lack of fluid intake, while a history of fluid intake a day before the study shows that most subjects have adequate fluid intake. The state of dehydration may be caused by differences in the amount of fluid released through sweat, urine, phases, and breathing caused by differences in physical activity and / or subject intake the day before intervention [22].

After the intervention was given, all subjects from the three groups were experienced dehydration which was indicated by an increase in the hydration status of each indicator. Physiologically everyone who has a strenuous activity such as exercise is at risk of dehydration, especially if the exercise is carried out in sufficiently hot environmental conditions and carried out for a long duration [23]. This study was carried out in an open field with an ambient temperature of 31^0C and 60 minutes of high intensity exercise at hot environmental temperatures which are around $31\text{-}32^0$ C can increase the discharge of fluid through sweat by 2% of body weight [23]. When the environment temperature is hot, the body will increase heat by sweating. Excessive sweating can increase the risk of dehydration [11, 14].

In addition, dehydration is also caused by a process of increasing body temperature during exercise due to the effect of the environment and the intensity of soccer games [24,25]. In this study the maximum increase in athlete's temperature reaches 37.8^0C. The higher the intensity of the body the more increasing temperature would be. In this situation, the temperature in the peripheral tissues of the body reflects the ambient temperature around it [14]. The average normal temperature of a human being ranges from $36{,}5^0$–37^0C. During exercise temperatures can rise to close to 40^0 C without any ill effects, because these changes are physiological conditions normal [14].

The results of different tests showed that there were differences in the status of hydration from the percentage indicator of changes in body weight and UD in the three groups ($p < 0.05$). However, there was no significant difference in the hydration status of the urine color indicator after intervention in all three groups ($p > 0.05$). When viewed from changes in the hydration status of the three indicators, all indicators indicate an increase in dehydration after the intervention including the urine color indicator. However, in the urine color indicator the changes that occurred could not explain the significant differences in the entire intervention group. This is because in addition to the adequacy of the exercise fluid intake, urine color is also influenced by food ingredients, drinks, or drugs that may be consumed by the subject before the study. In addition, careful observation of urine color may be one of the factors causing the problem [26].

Further tests conducted on indicators of hydration status based on percent changes in body weight and UD showed that there were significant differences between the T1-T3 group and the T2-T3 group ($p < 0.05$). However, there was no difference between the T1-T2 groups ($p > 0.05$). Whereas the group with the most significant difference occurred in the T1-T3 group in the percent weight change indicator and UD. This might be due to the temperature range of the liquid being dictated

Based on the results of different tests, it was also seen that the intervention in the T1 group was shown to increase dehydration status lower than the T2 and T3 groups based on changes in hydration status indicated by the three indicators of hydration status. This is because the consumption of chill water during exercise in a hot environment can inhibit excessive body heat [24, 25]. Some studies suggest that consumption of cold-temperature liquids can at least prevent a rise in core temperature and body surface temperature [17, 25, 26]. Body temperature humans are regulated by the thermo-regulator center of the hypothalamus known as the thermostat under the brain. The hypothalamus is divided into two based on its function, namely the anterior hypothalamus which functions to regulate heat dissipation and the posterior hypothalamus which functions to regulate heat storage. When consuming cold liquids, the hypothalamus thermostat will receive stimulation and cause blood vessels to experience vasoconstriction so that sweating becomes less in an effort to maintain body heat. Conversely, when consuming warm fluids while practicing, the hypothalamic thermostat will receive more than one heat stimulation, which comes from an increase in temperature due to activity, the environment and an increase in temperature coming from intake, this results in vasodilation in the blood vessels resulting in increased perspiration through the skin in an effort to remove body heat. [12, 24, 25]

Sweating is a factor that can affect hydration status [11]. Sweating exposes the presence of moisture lost during exercise usually seen from losing weight after a workout formulated in percent changes in body weight. The greater the weight lost, the more body fluids that come out, the higher the risk of dehydration in athletes [28].

Excessive loss of body fluids during exercise can cause an increase in osmolality in the blood as a result of which blood becomes hypertonic. This results in osmoreceptors in the hypothalamus stimulating the pituitary gland to secrete antidiuretic hormone (ADH). ADH stimulates the kidneys to increase absorption of water. This causes a decrease in the amount of urine output and an increase in urine concentration. The higher the concentration of urine, the higher the density and the thicker the color, this condition can be found in patients with fever and dehydration. Meanwhile urine density less than 1,009 can be caused by excessive fluid intake, hypothermia, alkalosis and chronic kidney failure [10, 29].

Some literature also states that the temperature of the liquid affects the speed of slow gastric emptying. Cold water is about 10^0–15^0 C better than warm water, because cold water is more easily absorbed by the intestine, so the gastric emptying time is faster. However, the level of gastric emptying due to fluid temperature only lasts about 10 minutes after consumption. This is because the stomach has the ability to balance the temperature of the drink which is swallowed to near normal core temperature. Unfortunately the literature that discusses how the process of cold water is absorbed by the body so that it affects the level of emptying in the stomach is very limited [4, 11, 13].

IV. CONCLUSION

Conclusion of this study is rehydration fluid with temperature of 10^0-16^0C proved to effect the percent body weight change and USG changes that was lower than the rehydration fluid with temperature of 20^0-26^0C and 40^0-48^0C. so that the regulation of rehydration fluids should not only regulate the amount and type of liquid, the regulation of fluid temperature should also be considered during exercise. Providing fluids with cold temperatures of about 10^0-16^0C C was appropriate during sports in a hot environment because it can help reduce dehydration problems based on the percent change in body weight and BJU.

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