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Differences of 2.2% and 2.8% Dehydration Effects on 400 Meter Running Performance

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Abstract

Dehydration is a case that will happen when exercising. The allowed dehydration level for a single exercise for health is still uncertain. Based on a review of research, dehydration up to 2% can lower mood but has not decreased aerobic performance. Information on the allowed level of dehydration to maintain exercise and performance still needs to be done. The research method used was an experimental pre-test post-test method. This study compared 2.2% and 2.8% dehydration levels on 400 meters running performance. The population of this study was all Sports Coaching Education students class of 2017 and 2018. The sample grouping was administered randomly into two groups. The first group was the 2.2% dehydration group consisted of 16 students. The second group was the 2.8% dehydration group consisted of 25 students. The dehydration process was conducted passively by doing sunbathing while using a raincoat. Bodyweight was measured before dehydration up to several times to reach the desired level of dehydration. The measurement of the 400-meter run was carried out before weight measurement and after dehydration. The data were analyzed by Mann-Whitney U test. The results of the data analysis concluded that there was no difference in the 400-meter run performance at the two levels of dehydration. Dehydration between 2.2% level and 2.8% level equally lowered the 400-meter running performance. This study suggests that the athlete's hydration level when exercising should be kept below 2.2% to achieve optimal performance. During training, athletes should be provided with drinks to maintain hydration levels.

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INTRODUCTION

Sports activities will coexist with an increase in metabolic rate, causing the body temperature to increase. As the body temperature increases, the heat dissipation mechanism is activated. Therefore, in most sports situations, there will be an increase in body temperature. When vigorous exercise is performed along with a high ambient temperature, the core temperature will rise substantially by about 2–3 °C. An increase in body temperature during activity can be debilitating and have a fatal impact. It happens due to the fluid expenditure in the body as an effort to cool down the temperature. Thus, the effort to cool down the body temperature has a possibility to decrease the fluid in the body. This lack of fluids in the body is known as dehydration.

Dehydration symptoms include daily weight loss ranging from 0.5 to 1.0 kg (1 to 2 lbs), small amounts of dark urine (the urine color is apple juice or darker), and a thirst sensation (Casa et al., 2019). When two or more of these dehydration symptoms are detected, dehydration has likely occurred. If more than three symptoms appear, the athlete has experienced dehydration. While it is vital to consider hydration status, the three main symptoms should be assessed upon awakening each morning.

Water can be considered an essential nutrient in food. The importance of this component in the daily human diet is since the human body consists mainly of water (about 70% in adults and 80% in children) (Davis et al., 2016). In endurance training, fluid depletion will occur during or during competition if the fluid intake is less than the expended sweat, even if the athlete starts exercising with good fluids. Previous hypohydration will amplify the fluid deficit effect occurring during exercise. Incorporating the right amount of fluid will help keep the fluid balance and temperature in optimal condition.

Proper hydration is good for a healthy life. Research evidence states that lack of fluid intake will result in the risk of chronic body system damage. Evidence shows that dehydration has a negative impact on physical performance for activities lasting more than 30 seconds, but dehydration does not have significant impacts on physical performance for activities lasting less than 15 seconds (Carlton & Orr, 2015). Research in 13 countries in Europe states that water intake varies between 720 to 2621 mL/day (Gandy, 2015).

Another study show that hypohydration decreased cycling performance and interfered independently with the thirst thermoregulation, while subjects were unaware of their hydration status (Adams et al., 2018). Based on a meta-analysis, dehydration interferes with cognition, attention, task completion, and movement coordination if dehydration occurs to level 2% (Wittbrodt & Millard-Stafford, 2018). This opinion becomes a concern as a reference for doing exercises in sports. Another research supporting this study states that giving fluids had a positive influence on decision-making cases compared to the group that was not given drinking (Patsalos & Thoma, 2019). Both of these are evidence that dehydration affects performance. Another research evidence states that 0.6% fluid loss is sufficient to reduce working memory efficiency (Young & Benton, 2017). Changes in hydration status will affect the learning process in the classroom (Perry et al., 2015). Further evidence shows that the dehydration incidence will cause an increase in body temperature and impaired memory and perceptual abilities (van den Heuvel et al., 2017).

The research findings above are fairly convincing that dehydration will be detrimental to athlete activities, learning activities, and working memory. According to (M. B. Fortes et al., 2015), when an individual experiences dehydration, the body will have (1) increasing heart rate in normal conditions of inactivity (> 100 bpm), (2) low/decreasing systolic blood pressure (<100mm Hg), (3) dry mucous membranes, (4) dry underarms, (5) dry skin, (6) sunken eyes, (7) a long time for blood to fill in the capillaries (> 2 seconds), (8) colored urine, (9) heavy urination, and (10) changes in salivary gland fluid. These are some of the signs that a person is dehydrated. Other studies support that fluid loss will affect endurance and physiological function, increase body temperature, decrease fusion in blood and muscles, disrupt aerobics, and affect muscle dependence on glycogen reserves (Trangmar & González-Alonso, 2019).

There are different research results about the effect of dehydration. First, dehydration in the elderly dramatically contributes to the death of hospitalized patients. It is emphasized that dehydration of more than 2% will consistently affect mood, increased fatigue, and low alertness (Benton & Young, 2015). The second study specifically explains that dehydration of more than 2%

would not interfere with cognitive performance (Young & Benton, 2017) and aerobics in a cold environment. Starting from a skin temperature of 27 °C, every 1-degree increase would increase impaired performance by 1.5%. Dehydration will have a negative effect on aerobic performance in highland, warm, and hot environments (Sawka et al., 2015). The third study states that dehydration affects aerobic performance. Another research proves that dehydration does not affect power and aerobic performance (Hosick et al., 2020). These studies illustrate different effects of dehydration, such as 1.5% level of dehydration has a negative effect, 2% level of dehydration affects mood and fatigue, while some state that dehydration does not affect aerobic performance.

Another research study states that 2% fluid loss will interfere with the athlete's physiological function performance; the results also show that dehydration could lower mood for some people (David Benton, Alecia Cousins, 2019). Research has provided evidence that dehydration is detrimental. It should be a concern that many people want to lose weight fast, and martial arts athletes only have a limited amount of time to lose weight for a class adjustment. Research evidence shows that losing weight by reducing energy and fluid intake has a negative impact on strength, heart and lung work, and an increase in fatigue (Cengiz, 2015). It should be noted that the negative effects of a fast weight loss will disappear after 12 hours of recovery, and strength will increase after weight loss (Cengiz, 2015). Dehydration can impair the body's ability to maintain thermoregulation and water balance during exercise, especially in hot conditions, and has been shown to inhibit cognitive function and motor skill performance (Hillyer et al., 2015). However, in reality, many people are still determined to carry out weight loss procedures in instant ways. Moreover, athletes also do sports in hot temperature conditions. Findings of studies show that hot situations will have a negative effect on endurance; thus, it is recommended to take an acclimatization process at least 1-2 weeks before competing in hotter areas (Racinais et al., 2015);(Neal, Corbett, Massey, & Tipton, 2016).

The concern of this study is the dehydration level of 2.2% and 2.8% on the 400-meter running performance. The previous research still revolved around the effect of dehydration in the 1.5%-2% dehydration level. The conclusion from the results of the reviewed study shows that, in that dehydration level, there was a disturbance in cognitive function (Young & Benton, 2017), class (Perry et al., 2015), and mood (Benton & Young, 2015); (David Benton, Alecia Cousins, 2019); (Hosick et al., 2020), but not in aerobic capacity (Hosick et al., 2020). Dehydration level 2-3% will certainly affect anaerobic performance. Therefore, studying the effects of 2.2% and 2.8% dehydration levels on the 400-meter running performance will provide the right feedback regarding setting interval training for athletes. Besides, the results of relevant studies are still around its effect on cognition, mood, and aerobic endurance. Specifically, the 400-meter run can be classified as short-distance running so that the predominant energy is no longer aerobic.

METHODS

The method used in this research was the experimental research with a pre-test post-test design.

Participants

he population of this study was students in a Sports Study Program at a University in Indonesia aged 19-21 years. The entire population was involved as the study sample. This study provided the treatment to two groups. The first group was the dehydration level 2.2% group (16 people), while the second group was the dehydration level 2.8% group (25 people).

Materials and Apparatus

Dehydration research was carried out passively by sunbathing while wearing a raincoat. The dehydration procedure was carried out in several steps, including (1) weighing, (2) a 400-meter running test, (3) dehydration process to the target levels (2.2 and 2.8%), (4) 400-meter running test after the targeted dehydration level had been reached.

Data Analysis

The data were analyzed by SPSS 20. The normality analysis concluded that the data were not normal; hence the data were analyzed using non-parametric statistics. In addition, the Wilcoxon test and Mann-Witney U test were performed.

RESULT

Based on the descriptive statistics, the results of the mean, median, and mode are as follows:

Table 1. Descriptive statistics results of 400 meter running performance before and after dehydration

	Group 2.2%		Group 2.8%	
	Before dehydration	After dehydration	Before dehydration	After dehydration
Mean	103.4375	168.8125	109.2400	150.3200
Median	102.5000	164.0000	104.0000	151.0000
Mode	83.00	101.00	82.00	178.00

Table 1 provides information that the mean running performance for the 2.2% dehydration group was 103.43 seconds. Cumulatively, after the participants were dehydrated through a passive procedure, their performance decreased sharply to 168.81. The 2.8% dehydrated group also experienced the same thing. The initial achievement was 109.24, which was not much different from the 2.2% dehydrated group. However, after performing the dehydrated process to the 2.8% level, the performance decreased considerably to 150.32 seconds to complete the running distance. This finding describes that the dehydration level of 2.2% could reduce achievements, while the higher dehydration level (2.8%) also lowered performance. The mean values before dehydration were in the same area, which was below 100 for both groups. However, in the next stage, both groups gained an increase in the mean after dehydration.

Based on the test, the results of a 400-meter run were found. The first group consisted of 16 people, and the second group consisted of 25 people. According to the normality test, if statistical significance is greater than 0.05, the data is declared normal. The test found that only the pre-test value of the 2.2% group had a significance value of more than 0.05, while the other three statistical significances were below 0.05, so the data were not normal. Furthermore, the test was continued using the non-parametric Wilcoxon test and the Mann-Whitney U test.

Furthermore, non-parametric analysis was also administered from these two sample groups by examining the difference between the pre-test and post-test of the two experimental groups (table 2). Based on the difference between the two experimental groups, a difference test was performed using the Mann-Whitney U test. The significance result of the Mann-Whitney U test was 0.059, which is greater than sig. 0.05. It concludes tha the two levels of dehydration are not different in the 400-meter running performance. Therefore, it can be said that the two dehydration levels will have the same impact on the 400-meter running performance.

Table 2. Non-parametric test results

	Pre-test & Post-test 2.2% Result	Pre-test & Post-test 2.8% Result	Gain
Z	-3.519[b]	-4.374[b]	-1.886
Asymp. Sig.(2-tailed)	.000	.000	.059
Mann-Whitney U			129.500

The non-parametric statistical test found that the significance values of the group receiving dehydration treatment (2.2% and 2.8% groups) were less than 0.05. It inferred that the pre-test and post-test scores were different. This difference can be interpreted as dehydration, either 2.2% or 2.8%, affecting the 400-meter running time. The effect shows the difference between the initial score and the final score. This difference can be seen from the difference in the initial mean score (pre-test) and the final mean score (post-test) of the two groups. As a result, there was an increase in the amount of time to complete the 400-meter run. Furthermore, non-parametric analysis was also administered from these two sample groups by examining the difference between the pre-test and post-test of the two experimental groups. Based on the difference between the two experimental groups, a difference test was performed using the Mann-Whitney U test. The significance result of the Mann-Whitney U test was 0.059, which is greater than sig. 0.05. It concludes that both dehydration levels are not different related to 400-meter running performance; both levels will have the same impact on the 400-meter running performance.

DISCUSSION

Regarding the study's findings, doing exercise for a long time will have physiological responses, such as dehydration, decreased blood sugar, increased pulse rate, and electrolyte loss. Some of these responses will result in decreased performance during exercise. For example, dehydration will accelerate the decrease in blood flow to the brain during exercise (Trangmar et al., 2015). A study shows that high-intensity exercise has a higher dehydration percentage (Morales-Palomo et al., 2017). Athletes do exercise and recovery. Exercise will cause changes in the total water in the body through sweating, depletion of glycogen in the muscles and liver, and loss of water for metabolism. This fluid loss will cause increased heart performance as the blood volume decreases, and the blood viscosity becomes more concentrated. The more concentrated the blood, the harder the heart work will be, spurring the heart to work extra.

The results of this study provide a new contribution to the limit of allowable dehydration. Dehydration can lead to impaired tissue fusion. The metabolic system is affected by cardiovascular demands during exercise (Trangmar & González-Alonso, 2017). A dehydration level of 0.6% reduces working memory efficiency (Young & Benton, 2017). Some individuals who are dehydrated experience mood loss (David Benton, Alecia Cousins, 2019).

Dehydration associated with a high-temperature increase will result in a decreased simple motor task performance by four ± 1%, math task performance by four ± 1%, math and pinch performance by 9 ± 3%, and visuomotor tracking performance by 16 ± 4% (Piil et al., 2018). Another research also provides the same information that dehydration has a less beneficial effect. The study conducted on teenage wrestlers who lost weight one week before the match showed a negative relationship between weight loss and mood levels (Karninčič et al., 2016). In martial arts, dehydration is sometimes carried out three weeks before the match, where even one week will be detrimental to the athlete's performance, including physiology, psychology, and brain performance. If these three performances have been disrupted, the expected performance will not appear optimally.

For martial arts athletes, they are closely related to the losing weight process. The effects of dehydration will not fully recover within 13-18 hours after dehydration. There will be a decrease in neuromuscular performance at the beginning of the match (Pallarés et al., 2016). MMA athletes lose and gain weight for competing purposes. The weight loss is at least 1.4-5.6 kg (8-1.8%), while the body weight gain is adjusted between 7.4 ± 2.8 kg (11.7 ± 4.7%) with 3176 ± 482 kcal. day-1 and 471 ± 124 g. per day mean intake. For the athletes taking the weight loss process, 57% of them are dehydrated (1033 ± 19 mOsmol.kg-1), and 43% are severely dehydrated (1267 ± 47 mOsmol.kg-1). The dehydration process is carried out in a dangerous way (saunas and plastic clothes 43%:43%) (Matthews & Nicholas, 2017).

In the first phase, a study conducted a 7-week plan to reduce calorie intake from 1300 to 1900 calories per day. For five days, fluid intake was 8 liters per day. As a result, the body weight was from 80.2 to 65.7, with a decrease of 4.4, 2.8, and 7.3 kg in each phase and dehydration to 9.3% in 24, which causes hyperthermia and kidney damage. The study data were obtained from martial arts that usually compete in a certain weight requirement (Kasper et al., 2019). The 400-meter run is assumed as an anaerobic exercise, the same as the martial arts sport, which is also considered an anaerobic sport.

Here is research-based evidence arguing that dehydration condition is detrimental. It is stated that losing 2% of body weight affects physiological function; research has shown that giving water and electrolytes is better in preventing a decrease in mood (Cousins et al., 2019). Fluid loss of up to 2.5% affects decreased reaction time, but not for a long time in trained people (Irwin, Campagnolo, Iudakhina, Cox, & Desbrow, 2018).

Research conducted by Irwin et al. (2018) regarding the effect of aerobic exercise on fluid loss and cognitive performance in trained athletes, with dehydration level 2-3%, show a significant decrease in reaction time. Exercise at 70% Vo2max level, with a temperature of 30 degrees Celsius, resulted in 2.5% dehydration in a glycogen supercompensation phase with a carbohydrate diet of 8-12kg/bb consumed for 48 hours. As a result, body weight decreased by 1.93 kg, and supercompensation led to an increase in average body mass of 2.53 (Toomey et al., 2017). Furthermore, research conducted by Fortes et al. (2018) suggest that dehydra-

tion could be considered as an intermediary factor in decision-making performance in male soccer athletes based on the results of the Game Performance Assessment Instrument (GPAI), showing that an effective decrease in decision-making index occurred in dehydration conditions compared to not dehydrated conditions and control group, $F(2,38) = 31.4$, $p < 0.05$, $ES = 0.8$.

In comparison, dehydration level 2% to 3% is not beneficial in terms of fluid balance, reaction time, and psychology (mood). The results of this study imply that we must be very careful in giving exercise. It is necessary to consider the air temperature and fluid and macronutrient intake to determine the supercompensation in exercise. If dehydration is too high, the drawbacks will be more than the benefits, especially for physiological aspects.

Further research evidence provides convincing evidence that a dehydration level of more than 3% already affects performance. Dehydration levels 3% and 5% will result in decreased working memory, decreased visual perception, and difficulty performing manipulation movement tasks (van den Heuvel et al., 2017). In a dehydration experiment, Cyclists were dehydrated to 1.4% at 45 minutes, 2.3% after 90 minutes, and 3.1% after the trial time with a 65% VO2max intensity, followed by TT. The result of TT shows that they were 13% slower in 2.3% dehydration conditions (Logan-Sprenger et al., 2015) (Kasper et al., 2019). Research findings prove that dehydration up to 9.3% within 24 hours will cause kidney injury. It is clear evidence that dehydration above 3% is dangerous for health, even causes kidney damage at a 9.3% dehydration level. At a dehydration level above 3%, there are no physiological and psychological functions that run normally. At this level, there is a tendency to crash and decrease in all performance.

Suggestions from several studies on dehydration treatment do exist. Several research results have provided advice for conducting safety training and activity. Two important components must be maintained, including physiology and psychology. The physiology will ultimately affect performance in sports, while psychology will ultimately affect working memory (brain) and its relationship to motivation, mood, and stress. Fluid intake in dehydration conditions can improve performance during exercise in hot temperatures (McCartney et al., 2017). Homemade coconut water and pineapple juice have the same effect as isotonic drinks (J, Okonkwo et al., 2018). It was based on a study on 17–26-year-old girls who ran for 45 minutes, took a 10-minute break and consumed a different drink. The provision of water intake positively affects cognitive performance in children and adults (McDermott et al., 2015). Based on the results of previous dehydration management studies, the most important thing to do is give fluids. The fluid will at least replace the composition of intra and extracellular fluids in the body.

Based on research, palm and processed pineapple water can help rehydration recovery. Even neutral water can have an effect. (Hoxha et al., 2015) suggest that the characteristics of dehydrated people can be seen through several symptoms, such as sunken eyes, reduced skin turgor, weak pulse, and general appearance. Even though dehydration can increase fatigue levels, CHO intake produces an anti-fatigue effect by maintaining high levels of Glc in the blood, which supports muscle energy production during physical activity and when muscle glycogen is depleted (Orrù et al., 2018). Therefore, the CHO integration in sports drinks is important to maintain optimal sports performance (Hao et al., 2014). Besides adding calories for energy, at the same time, it could overcome dehydration.

The ability to recognize dehydration needs to be introduced to athletes early. (backes & fitzgerald, 2016) state that the performance of athletes who did exercise by drinking regularly was significantly better (longer duration and faster pace) compared to the athletes whose drinking periods were determined. However, the cognitive test results were not significantly different between the athletes with regulated water drinking conditions and those with independent water drinking conditions..

CONCLUSION

This study concludes that both dehydration levels 2.2% and 2.8% reduce the 400-meter running performance. In this study, the distance traveled as a benchmark was 400 meters. Therefore, it is necessary to consider a purely anaerobic distance of 50-100 meters with similar dehydration. For elite sports training, based on the results of this study, the hydration level must be maintained so that the athletes are always in optimal condition. Based on a research review, 3% and above

dehydration levels are not recommended and should be prohibited.

CONFLICT OF INTEREST

The authors declared no conflict of interest.

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