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Original Research

Examining the Hydration Status and Pulse/Oxygen Saturation of Underwater Hockey Players

Nesli Ersoy[1], Aylin Açıkgöz Pınar[2], Taner Özgürtaş[3]

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Abstract

Objectives: This study was planned to determine the hydration status and tissue oxygen saturation of underwater hockey players during exercise.
Materials and Methods: Hydration status (fluid intake/loss amounts, repeatedly weight measurements) and tissue oxygen saturation measurements of 14 underwater hockey players were performed before and after the land/water training, separately. Hydration status was assessed by monitoring weight and urine specific gravity (USG) measurements, whereas tissue oxygen saturation was measured by using finger-type pulse oximeter.
Results: The study was completed with14 elite players (age=19.4±6.2 years, female=4(29%), and male=10(71%)). The body fat percentage was calculated to be male:14.2±9.4%; female: 18.8±4.0%. The mean USG of athletes was determined to be 1020.1±5.6 g/cm^3. During the water training, only 5 athletes consumed water (680±383.4 mL). All the athletes (except for 1 athlete [7.1%]) completed the training with loss of body fluid. Mean loss of water was 310±213.2 mL after land training and 723.1±501.9 mL after water training. Dehydration ratio was measured 0.97±0.64% after trainings. The first oxygen saturation was measured 96.1±1.6, that was decreased after water training (94.6±2.2; p=0.044, p=0.049). Pulse increased after water training in reverse proportion to oxygen saturation (p=0.004), but there was no difference between before and after land training (p=0.132).
Conclusion: It was found that several Underwater hockey players began training dehydrated and loss of water continued since they didn't consume enough water during training. Oxygen saturation significantly decreased after water training. Fluid consumption of underwater hockey players, especially during water training, should be monitored and adequate fluid consumption should be ensured.

Keywords: *athletic performance, anthropometry, water sports, underwater hockey players*

[1]**Nesli Ersoy (Corresponding Author). (**Hacettepe University, Faculty of Health Sciences, Department of Nutrition and Dietetics, Ankara, 06100, Turkey**,** P: +90-31-2305-1096, e-mail: nesli.arpaci@hacettepe.edu.tr, ORCID: 0000-0003-0391-8848)
[2]**Aylin Açıkgöz Pınar.** (Hacettepe University, Faculty of Health Sciences, Department of Nutrition and Dietetics, Ankara, 06100, Turkey, e-mail: aylinn@hacettepe.edu.tr, ORCID: 0000-0002-8847-9305)
[3]**Taner Özgürtaş. (**University of Health Sciences, Faculty of Medicine, Department of Medical Biochemistry, Ankara, 06018, Turkey, e-mail: taner.ozgurtas@sbu.edu.tr, ORCID: 0000-0003-1110-6671)

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Introduction

The underwater hockey has been introduced by Alan Blake, a British diver, in 1954 and started being played internationally first in Canada, South Africa, Australia, Holland, and New Zealand. The national team of our country has gone out for their first international game in 2000 (Turkish Underwater Sports Federation, 2023). Because of underwater hockey is played at the bottom surface of the pool, athletes have to spent more time under the water than other water sports and exert much more effort. Compared to other water sports, it can be considered that they are much riskier in providing adequate hydration and oxygenation. The literature on assessing the hydration levels of underwater hockey players (UHP) is very limited. Given the fact that underwater hockey is an endurance sport, it is expected that the loss of electrolyte and water through sweating would be very high during the training and game (Maughan & Shirreffs, 2007). Since most of the trainings are performed under the water, it is thought that it is not possible to consume enough water. If the athletes are not appropriately replaced their fluid losses, water and electrolytes imbalances (dehydration and hyponatremia) can develop and adversely impact on the individuals exercise performance and perhaps health. Dehydration (>2% body weight loss from water deficit) and excessive changes in electrolyte balance might be prevented by drinking water and/or consuming beverages containing electrolytes and carbohydrates during exercise (Sawka et al., 2007).

Another important point about underwater hockey is whether the increased oxygen demand of the athlete is met. In literature was reported that, breath holding sports; such as scuba-diving or swimming, have a risk for hemoptysis (Adir et al., 2004; Pons et al., 1995; Boussuges et al., 1999; Koehle et al., 2005). It has been reported that prolonged breath holding effect to the cerebrovascular and cardiopulmonary systems that may have serious acute effects in divers (Dujic & Breskovic, 2012, Lindholm & Nyren, 2005). Holding breath for a long time and with short intervals might have an effect on the cardiorespiratory system on UHP (Davis et al., 1987; Lemaître et al., 2007). Aversa & Lapinsky (2014) found that hemoptysis develops in 4 different periods after the training among the UHP, there is no case study or observational data. There are three periods; exertion of exercise, submersion and diaphragmatic contraction; which have an effect on exercise –induced hemoptysis. Underwater hockey is unique sport that has these three periods (Aversa & Lapinsky, 2014). The literature about UHP is very limited and outdated (Davis et al., 1987; Lemaître et al., 2007). The propose of study was the hydration and tissue oxygen saturation parameters, which are thought to have an effect on performance and health in underwater hockey, were measured and analyzed. The results of study are

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important to explain the possible mechanism of pulmonary capillary insufficiency on UHP by creating new study question.

Material and Methods

The number of samples required for the study was calculated and it was found that at least 28 athletes should participate in the study, with 80% power and a significance of 0.05. However, since there were 14 underwater hockey players registered in the sports club, the study was terminated with 14 athletes (age= 19.4±6.2 years; male:10; female:4). The involuntary athletes were excluded from the study. A single interview was conducted with each athlete and the data collection was performed in one session. Ethical approval was accepted by the local administration. The study was carried out in accordance with the Helsinki Declaration. In the pre-game training period of athletes, there are two subsequent training programs. These training programs are named land training and water training. The training program was planned as 60-min land training (aerobic exercise), then 30-min swimming and 30-min game. The measurements were performed before training, between two training sessions, and after training. The training program of athletes and the measurement interval are presented in Figure 1. Athletes were not restricted in terms of food and/or fluid intake before and during exercise.

Anthropometric Measurements

In anthropometric measurements, the measurements of height (0.1 cm sensitivity; Seca, Germany), weight (0.1 kg sensitive; Tanita, Japan) and skinfold thickness by caliper were performed. Based on the skinfold thickness measurements, the body fat percentage was calculated using the Jackson and Pollock calculation formula (Lohman & Roche, 1988).

Body fat percentage: [(4.95/body density-4.5)×100]

Determining the Hydration Status

Two different test methods were used in determining the hydration status of athletes: urine specific gravity (USG) measurement and weight monitoring. For USG test; urine specimens of athletes were collected using 50 mL containers before the training and the density values were determined using urine strips (Roche, Combur10 Test® M) by the authors (Ersoy et al., 2016).

In order to calculate the athletes’ water loss and dehydration percentage during the training, the weights before and after the training were measured. Moreover, also the amount of liquid that the athletes consumed (ad libitum) during training and the volume of excreted urine were measured and recorded. The dehydration percentages were calculated (Sawka et al.,

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2007).

Dehydration Percentage: [(Pre-training weight (kg) – Post-training weight)/ Pre-training weight] *100

Measurement of Pulse and Oxygen Saturation

In 5 minutes, before starting the land training, after the land training, and after the water training, the athletes' pulse and oxygen saturation were measured using a finger-type pulse-oximeter device (G Life, Germany). Since the measurements were performed during the training, the finger-type pulse-oximeter that is easy-to-use and practical was preferred. The measurement was completed within 10 seconds after placing a finger into the sensor of device.

Statistical Analyses

The descriptive statistics of data are expressed as mean values, standard deviations, numbers, and percentages. In evaluating the relationship between pre- and post-training oxygen saturation and pulse variables, the Wilcoxon test was used. The data analysis was performed using SPSS 15 statistical software. The statistical significance was set at $p<0.05$.

Ethical Statement

Ethical approval for the study was obtained from the Hacettepe University Non-Interventional Clinical Research Ethics Committee (Decision No: 2019/15), and all participants gave written, informed consent. Since voluntariness was taken as a basis for participation, all the participants signed the volunteer consent form.

Results

The mean ages of participating athletes were calculated to be 19.1±3.5 years for males and 16.5±2.4 years for females. All athletes completed the study (n=14). The mean weight of male athletes was determined to be 75.8±17 kg and height to be 170.2±6.5 cm. The triceps skinfold thickness was found to be 11.3±4.7 mm, whereas Total Skinfold Thickness (TST) was found to be 104.1±48.9 mm. The body fat percentage was calculated to be 14.2±9.4% for males. For female athletes, the mean weight was found to be 57.4±3.9 kg and height to be 162 ±3.7 cm. Moreover, the triceps skinfold thickness of female athletes was found to be 18.9±4.4 mm and TST to be 128.9±20.8 mm. The body fat percentage of female players was calculated to be 18.8±4.0% (Table 1).

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Table 1. Age and Anthropometric Measurements of Athletes

Age and anthropometric measurements	Male $\bar{x}$ ±SD	Female $\bar{x}$ ±SD
Age (years)	19.1±3.5	16.5±2.4
Weight (kg)	75.8±17.0	57.4±3.9
Height (cm)	170.2±6.5	162±3.7
Triceps skinfold thickness (mm)	11.3±4.7	18.9±4.4
Total skinfold thickness (mm)	104.1±48.9	128.9±20.8
Body fat percentage (%)	14.2±9.4	18.8±4.0

Determining the Hydration Status

The USG of athletes was determined to be 1020.1±5.6 g/cm^3. During water training, only 5 athletes consumed 680.0±383.4 mL water, and no athlete consumed any sports drink. As a result of following the weights of athletes, it was found that, except for 1 athlete (7.1%), all the athletes completed the training with water loss. The mean water loss was found to be 310.0±213.2 mL after land training and 723.1±501.9 mL after water training. The dehydration percentage was calculated to be 0.97±0.64%.

Table 2. Hydration Measurements of Athletes

Hydration measurements	$\bar{x}$ ±SD
Urine specific gravity (g/cm^3)	1020.1 ± 5.6
Water consumption (mL)*	680.0 ± 383.4
Body fluid losses after land exercise (mL)	310.0 ± 213.2
Total body fluid losses (mL)$^{\gamma}$	723.1 ± 501.9
Dehydration percentage (%)$^{\gamma}$	0.97 ± 0.64

Note: *This values calculated for only 5 athletes who consumed the water.
$^{\gamma}$This value calculated for only 13 athletes who lost the weight.

Measurement of Pulse and Oxygen Saturation

Examining the finger oxygen saturation measured before the land training and the saturation measured between two training sessions, it was determined that there was no statistically significant difference (p=0.228). However, it was determined that the finger oxygen saturation value, which was measured before and after the land training, showed a statistically significant decrease (p=0.044, p=0.049). However, the pulse showed reverse proportion to the oxygen saturation and increased after the water training (p=0.004), and there was no statistically significant difference between value measured before land training and value measured between water training (p=0.132).

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Table 3. Pulse/oxygen Saturation Measurement of Athletes

Pulse/oxygen saturation measurement	**Before training**	**Between two training session**	**After training**
	x̄± SD	**x̄± SD**	**x̄± SD**
Oxygen saturation (%)	96.1^{a}±1.6	96.5^{a}±1.9	94.6^{b}±2.2
Pulse (b/min)	94.6^{a}±20.6	102.1^{a}±19.3	121.7^{b}±14.5

^{a,b} Values within a row with different superscripts are significantly different based on Wilcoxon signed ranks test.

Discussion and Conclusion

Underwater hockey is played on the pool ground using equipment such as racket, flipper, snorkel, and gloves. There are six players in the game and four players at the reserve (Turkish Underwater Sports Federation, 2020). Because of the time spent under the water and the intensity of this sports branch, it is thought that the athletes may have a problem because of deficient hydration and oxygen use, but there are few studies on this subject in the literature. For this purpose, in this study, 14 UHPs were evaluated in terms of hydration status and oxygen saturation.

A high level of body fat mass is considered to be among the factors reducing the performance especially in endurance sports. Most of the athletes pay attention to decreasing the body fat percentage since it has a braking effect (Thomas et al., 2016). In the present study, the triceps skinfold thickness value, which shows direct proportion to the body fat percentage, was compared to the Turkish reference values calculated for age and gender (Baysal, 2013), it was determined that only 3 players (21.4%) were in 50th percentile level, whereas 5 athletes (35.7%) were below the reference values and 6 athletes (42.9%) were above the reference values. Similarly, players also have high body fat percentages. Fat mass might increase the efforts of exercise and cardiovascular systems and effect to sports performance. For this reason, this group of athletes should receive guidance and counselling from an athlete dietician about the healthy diet and ideal body composition.

The hydration status of athletes is one of the factors most rapidly influencing their sports performance. Loss of fluid negatively affects the performance since it causes the loss of 1-2% of weight before the exercise, and it is very important to drink a sufficient amount of water in order to compensate for this loss (Maughan & Shirreffs, 2007). Thus, having a well-planned hydration strategy would offer a great advantage for the athletes. There is no literature data on the hydration status of UHPs. However, since the water consumption opportunity is very limited during training and game, this sports branch requires careful observation. The mean USG of athletes was found to be 1020.1±5.6 g/cm^{3}. The American College of Sports Medicine (ACSM)

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defines dehydration as USG of 1020 g/cm^3 or lower (Sawka et al., 2007). Accordingly, it can be seen that 6 players (42.9%) have been dehydrated even before the training. The USG values of only 5 athletes (35.7%) were below 1020, and it was observed that only 5 players drank water during the training. In the present study, none of the athletes consumed sports drink. Examining the weight changes, it was determined that, except for 1 athlete (7.1%), all the athletes completed the training with loss of body fluid. The mean dehydration was calculated to be 0.97±0.64% and, in literature, this value is not considered to negatively affect the performance. However, given the fact that athletes began the training while dehydrated, it can be thought that their loss of water in the course of time might have negatively affected their sports performance. Underwater hockey necessitates liquid consumption plans, as well as follow-up and education of players on a regular basis. Given the fact that UHPs are endurance athletes, the sports drinks containing 4-8% carbohydrates and electrolytes would be useful in replacing the liquid they lost. Thus, a hydration protocol to be prepared individually for each athlete is very important. However, in the present study, it was determined that the athletes are not aware enough of and have knowledge of the effects of ensuring liquid balance and sports drink consumption on athletic performance.

It was reported that holding one's breath for a long time and with short intervals in underwater hockey might have effects on the cardiorespiratory system (Davis et al., 1987; Lemaître et al., 2007). In literature, it was reported that an UHP has hemoptysis at 4 different periods after the training. This case was reported to be related with breath held for a long time, effort made, and water depth (Aversa & Lapinsky, 2014). Moreover, holding the breath for a long time was reported to cause morphological changes in the brain among the divers (Dujic & Breskovic, 2012). In another study, in which the UHPs were compared to a control group, it was determined that the UHPs had significant bradycardia and lower oxygen saturation (Lemaître et al., 2007). Similar to this study, it was determined in the present study that the finger oxygen saturation measured before the land training decreased after it (p=0.044, p=0.049). Pulse, on the other hand, showed reverse proportion to the oxygen saturation and the pulse increased after the water training (p=0.004). Although it was expected that the pulse change would show an increase as the intensity of exercise increases, it is controversial if a low level of oxygen saturation would cause any cardio-metabolic problem. Even though it is statistically significant, if this result is clinically relevant would be determined in further detailed studies to be carried out on this subject. Underwater hockey is unique sport that is similar both of diving and swimming. Underwater hockey strains the cardiovascular capacity

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as much as swimming, and as well affects the cardiopulmonary system as in diving. Prolonged breath-holding under water may have caused a decrease in oxygen saturation in the athletes. Cardiopulmonary parameters of UHP should be evaluated at regular intervals.

According to the Turkish Underwater Sports Federation rules in underwater hockey (2023), there is no limit for player substitution and one may very frequently substitute the players. Since this sports branch has a very high intensity, both players and referees should be sensitive and the players should be provided with option to rest and to consume liquid on a regular basis. One of the limitations of the present study is the low number of samples. Besides that, since it is a cross-sectional study and there aren't enough publications in the literature, the results couldn't be discussed in terms of a cause-effect relationship. However, it is very important to inform the trainers and athletes about the importance of hydration support and the prevention of holding the breath for a long time and with a short interval. In the present study, it was observed that the athletes' awareness of this subject. For these reasons, it is thought that making the training and game environment more suitable for both hydration and resting would be appropriate.

There is a need more studies about UHP's cardiopulmonary systems examined. Relatively small number of athletes studied in this study. More number UHPs should be studied for a long time and according to sports performance.

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Conflict of Interest

Author Nesli Ersoy, Author Aylin Acikgoz and Author Taner Ozgurtas declare that they have no conflict of interest.

Author Contributions

Plan, design: NE, AAP, TÖ; Material, methods and data collection: NE, AAP; Data analysis and comments: NE, AAP; Writing and corrections: NE.

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