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PREVENTING EXCESSIVE LOSS OF WATER DURING TRAINING AT MODERATE ALTITUDE WITH PROPER HYDRATION

PREPREČEVANJE PREKOMERNE IZGUBE VODE V TELESU MED VADBO NA ZMERNI VIŠINI S PRAVILNO HIDRACIJO

ABSTRACT

The concept of altitude training is a widespread practice in swimming. The mountain conditions of most altitude venues are characterized by cold and dry air, which leads to an increased loss of water with increased pulmonary ventilation. There are indications that the body composition of athletes who are exposed to high altitudes may change significantly after exercise.

The aim of the study was to experimentally test with Bioelectrical Impedance Analysis (BIA) to find if athletes with proper hydration and dietary restrictions can prevent excessive water loss during training at moderate-altitudes. The survey included 14 women (16.6 ± 1.2 years) and 6 men (19.2 ± 3.0 years), members of the national swimming team. All BIA measurements were carried out before, and four times during the twenty-one-day swim camp at moderate altitude as well as after altitude exposure.

There were no statistically significant differences found with ANOVA between the measured or calculated body weight, the amount of body fluid, and the amount of body fluid in terms of body weight in % for men or for women.

The results of our study show that adequate water replacement (up to 3 litres per day depending on the needs) and diet can prevent dehydration during training at a moderate altitude. The BIA seems to be a useful tool for measuring the amount of body fluid in swimmers. Measurements with the help of BIA are acceptable for use, although the amounts of body fluid obtained with BIA appear to be overestimated in terms of other methods of measuring the amount of body fluid.

Key words: swimming, altitude training, dehydration, body mass, BIA

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IZVLEČEK

Koncept višinskih priprav je ustaljena praksa v plavanju. Za visokogorske pogoje na večini višinskih centrov za priprave je značilen mrzel in suh zrak, ki povzroči povečano izgubo vode s povečano pljučno ventilacijo. Obstajajo nekateri dokazi, da se lahko telesna sestava športnikov, izpostavljenih višini, po treningu značilno spremeni.

Cilj študije je bil eksperimentalno testirati z bioelektrično impedančno analizo (BIA), če je s pravilno hidracijo športnikov in navodili za prehrano mogoče preprečiti prekomerno izgubo vode med treningom na zmerni višini. V raziskavi je sodelovalo 14 žensk (16,6 ± 1,2 let) in 6 moških (19,2 ± 3,0 let), članov državne plavalne reprezentance. Vse meritve z BIA so bile izvedene pred, štirikrat med enaidvajset dnevnimi plavalnimi pripravami na zmerni višini in po izpostavljenosti višini.

Nobenih statistično značilnih razlik med izmerjenimi ali izračunanimi vrednostmi telesne mase, količini telesne tekočine in količini telesne tekočine glede na telesno maso v % nismo našli niti za moške, niti za ženske s pomočjo ANOVE.

Rezultati naše študije kažejo, da je z ustreznim zaužitjem vode (do 3 litre na dan glede na potrebe) in prehranjevanjem mogoče preprečiti dehidracijo med traningom na zmerni višini. Zdi se, da je BIA uporabno orodje za merjenje količine tlesne tekočine pri plavalcih. Meritve s pomočjo BIA so sprejemljive za uporabo, čeprav se zdi, da so pridobljene vrednosti količine telesne tekočine s pomočjo BIA očitno precenjene glede na druge metode merjenja količine telesne tekočine.

Ključne besede: plavanje, višinski trening, dehidracija, telesna masa, BIA

INTRODUCTION

The concept of altitude training is a widespread practice in swimming. Altitude training camps are typically found at elevations from 2000 to 3000 m. Altitude training results in increased demand for fluids. The mountain conditions of most altitude venues are characterized by cold and dry air that can increase loss of respiratory water (Wilber, 2007). Altitude-induced diuresis and impaired thirst are typical responses in the first hours of altitude exposure. Increased rates of ventilation and dry (low-humidity) air can worsen the loss of water from the respiratory system (Kayser, 1994). Collectively, the total water losses from the urinary and respiratory systems could be as high as 2 L/day-1, which needs to be substituted through increased hydration. Consequently, fluid intakes of as much as 4–5 L/day-1 have been recommended (Wilber, 2007) for athletes training and competing at altitude in a variety of sports (Stellingwerff T, et al., 2014). There are some evidences that the body composition of athletes exposed to altitude may be significantly changed after training (Michalczyk et al., 2016). Therefore, proper nutrition strategy is a key factor determining the effectiveness of altitude training (LH-TH). For example, Svedenhag *et al.* (1991) and Gore *et al. (1998)* reported insignificant differences in body composition in endurance athletes (runners and cyclists) after a few weeks of altitude training conducted at a moderate altitude (2000 and 2700 m). According to the authors, these athletes experienced this effect despite proper nutrition and adequate hydration.

The general scientific consensus is that starting exercise with hypohydration >2% body mass impairs endurance performance/capacity (James L, et al., 2017; Cheuvront S. N., and Kenefick R. W., 2014). Dehydration results in a reduction in plasma volume (i.e., hypovolemia) and leads to a cascade of effects that increase cardiovascular strain (Sawka et al. 2015), potentially limiting maximal oxygen uptake (Cheuvront and Kenefick 2014). Therefore, the maintenance of proper nutrition and fluid balance during swimming training is a key factor determining sport performance.

According to Stellingwerff T, et al. (2014) monitoring of fluid intakes, urine-specific gravity, and body mass changes is useful in identifying swimmers at risk for dehydration during altitude training and exposure.

Bioelectrical Impedance Analysis (BIA) measures the impedance associated with passage of an alternating current through the body which is proportional to total body water (TBW) and therefore can provide expedient estimates of body composition. Despite extensive research in the field of BIA and athletes has been conducted, there remains a large gap in the literature pertaining to a single generalised athlete equation developed using a multiple-compartment model that includes total body water (TBW). Multi-frequency BIA is described as a tool able to assess total, extracellular, and intracellular fluid in humans (Eliot DA, et al, 2002; Martionoli R. et al., 2003; Mika C. et al., 2004; Valensise H, et al. 2000) for different populations. It was also found that the higher accuracy of BIA in predicting individual TBW highlights its utility in water assessment of recreational and elite athletes (Valensise et al., 2000). However, clinically meaningful differences in the accuracy of BIA between individuals exist (Widen et al., 2014). It should be also mentioned that there are also studies suggesting that BIA appears ineffective for diagnosing water-loss, dehydration after stroke and cannot be recommended as a test for dehydration suggesting that separating assessment by sex and using TBW as a percentage of lean body weight may warrant further investigation (Kafri et al., 2013).

The aim of the study was to experimentally test with BIA if with the proper hydration of the athletes and nutrition instructions is possible to prevent excessive loss of water and body mass during training at moderate altitude.

METHODS

Subjects

The study was conducted on 14 female subjects (16.6 ± 1.2 years) and 6 male subjects (19.2 ± 3.0 years). The average body height for female subjects was 168.1 ± 5.5 cm and body weight 55.9 ± 5.2 kg, and the average body height for male subjects was 181.5 ± 2.3 cm and body weight 70.7 ± 4.9 kg. The participants were members of the national swimming team. During the measurement period, none of the participants complained of any medical conditions or was taking any medicines. They participated in the research voluntarily and were informed in advance of its procedure. All the participants or their parents, for participants under the age of 18 years, gave written informed consent to take part in the research. The research was approved by the Ethics Committee at the Faculty of Sport in Ljubljana and is in compliance with the Declaration of Helsinki.

Procedures

All measurements were performed during the twenty-one days swim camp at the High-Performance Centre CAR Sierra Nevada (Spain) which lies 2320 metres above sea level. Tests were performed in the morning on the fourth, eleventh and twenty-first day at moderate altitude and 24 hours after the altitude exposure. Measurements at the sea level were performed seven days prior and fourteen days following the altitude exposure. All the participants in the study were daily supplied with additional three litres of water and were instructed to drink it during their stay at moderate altitude according to their needs.

All the athletes performed two swimming sessions per day. One day per week was a rest day without trainings.

The participants in the measurements were informed in advance of the conditions that must be observed prior to the measurement (no alcohol 48 h before the measurement, no vigorous exercise 12 h prior to the measurement and no food or drink 4 h prior to the measurement). All the measurements took place in the morning hours (7:00 am–9:00 am). The participants were always measured before breakfast. Every participant was always measured at the same time.

The following body composition parameters were measured in the research: body mass (BM) and total body water (TBW). The device used for measurements was a tetrapolar bioelectrical impedance analyser Tanita TBF-310GS Body Fat Composition Analyser (Tanita Corporation, Japan). Tanita TBF-310GS Body Fat Composition Analyser is a mono frequency BIA analyser, which uses the frequency of 50 kHz for measurement through pressure contact stainless steel foot pads and the stepping platform for transmission of electric current into the body. For the measurements the mode Athlete was used. The analyser complies with the applicable European standards (93/42EEC, 90/384EEC) for use in the medical industry.

STATISTICAL ANALYSIS

Means and standard deviations were computed for all variables. Individual one-way repeated ANOVA measures were employed to test for any significant differences between the measured parameters. Significance was accepted when p<0.05. The statistical processing of the results was carried out by SPSS Statistic ver. 21.0 (IBM, USA)

RESULTS

Table 1.
Average values of body mass and total body water before the experiment at sea level, during altitude exposure and after altitude exposure at sea level

Measurements	Before	1.	2.	3.	4.	After
Body mass (kg)	60,98 ±8,47	60,32 ±8,59	59,56 ±8,28	59,70 ±8,36	59,87 ±8,56	60,60 ±8,33
TBW	37,98 ±7,35	37,38 ±7,29	37,39 ±7,16	37,75 ±7,22	37,43 ±7,39	37,40 ±7,34

The average values of the observed parameters of the body composition are provided in Table 1.

Average body mass values during all measurements were in the range between 59, 56 ±8,47 kg on the fourth day of altitude exposure and 60,98±8,28 kg before the altitude exposure. No statistically significant differences between the values of body mass were found.

Average total body water (TBW) values during all measurements were in the range between 37,38±7,29 kg on the second day of altitude exposure and 37,98 ±7,35 kg before the altitude exposure. No statistically significant differences between the values of body mass and total body water were found.

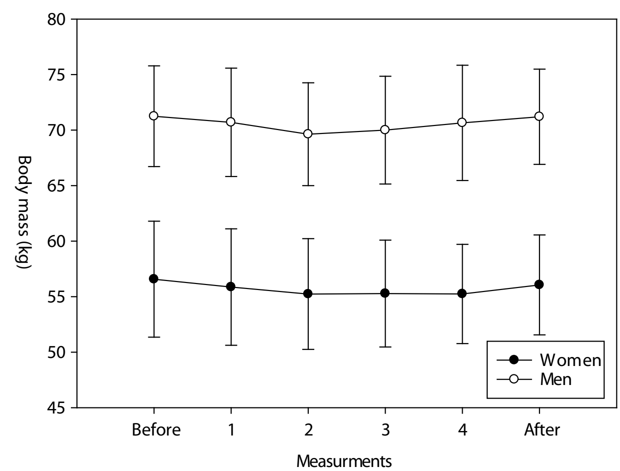

Fig.1 Average body mass for female and male subjects before the experiment at sea level, during altitude exposure and after altitude exposure at sea level

Average body mass values for male subjects during all measurements were in the range between 69,6±4,6 kg on the fourth day of altitude exposure and 71,2±4,5 kg before the altitude exposure.

Average body mass values for female subjects during all measurements were in the range between 55,2±4,9 kg on the fourth day of altitude exposure and 56,6±4,5 kg before the altitude exposure.

No statistically significant differences between the values of body mass were found neither for male neither for female subjects.

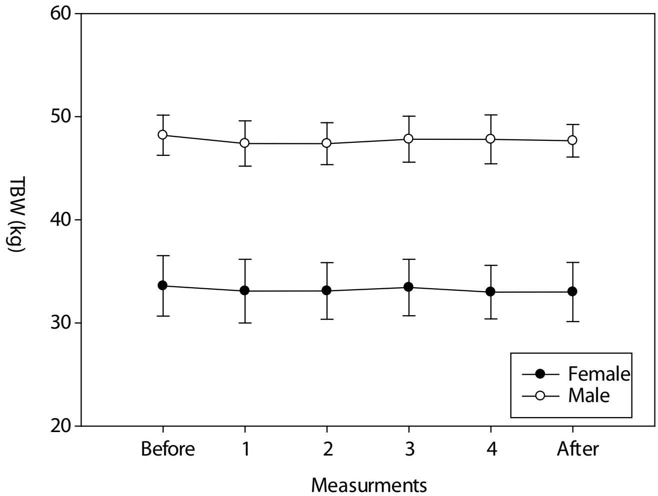

Fig.2 Average total body water for female and male subjects before the experiment at sea level, during altitude exposure and after altitude exposure at sea level

Average total body water values for male subjects during all measurements were in the range between 48,2±1,9 kg on the fourth day of altitude exposure and 48,4±2,0 kg before the altitude exposure.

Average total body water values for female during all measurements were in the range between 32,38±2,6 kg on the fourth day of altitude exposure and 33,69±2,9 kg before the altitude exposure.

No statistically significant differences between the values of total body water were found neither for men neither for women.

Average % of total body water values for male subjects during all measurements were in the range between 67±1,9 % on the measurement after altitude exposure at sea level and 68,1±1,8 % on the third measurement at altitude exposure.

Average % of total body water values for female during all measurements were in the range between 58,9±2,5 % on the measurement after altitude exposure at sea level and 60,6±2,4 % on the third measurement at altitude exposure.

No statistically significant differences between the values of total body water were found neither for men neither for women.

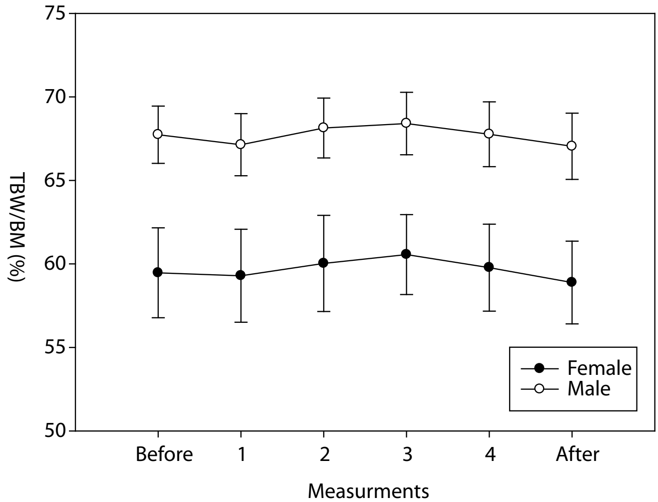

Fig.3 Average total body water for female and male subjects as a percentage of body mass before the experiment at sea level, during altitude exposure and after altitude exposure at sea level

DISCUSSION

The results of our study suggest that with the proper nutrition and hydration it is possible to prevent excessive water loss and body mass during altitude exposure. At the beginning of the altitude exposure there was a slight but not significant decrease of body mass and TBW probably due to increased rates of ventilation and dry air at altitude (Wilber, 2007). However, this decrease was less than three percent of TBW which could influence competition or training performance (James L, et al. 2017; Cheuvront S. N., and Kenefick R. W., 2014). When the losses of sweat are higher than 2% of body weight, and the amount of time in between training is less than 6-8 hours, it is necessary to set up a specific post training rehydration program (Burke LM, 2014; Hoyt, 1996). With the goal of optimising hydration, and water retention (considering that some part will be excreted via diuresis), the amount of water should be equivalent to around 150% of fluid loss during training (Burke, 2014; Hoyt, 1996). Since the instructions to the swimmers were to drink additionally 3 L of water during the day it seems that our programme of preventing dehydration during altitude exposure was successful since after four days of altitude exposure the values of body mass and TBW stabilised.

It is difficult to discuss our results of TBW during the altitude stay since we were not able to find similar research with the use of BIA. The only study we found was on 14 Polish swimmers where our results were not in accordance with the results of their study were BM and TBW were BM and TBW statistically decreased (Ciosek et al, 2015). However, it should be mentioned that Polish swimmers trained at sea level in a tapering period where slight weight loss is preferable.

TBW values as a percentage of body mass were approximately 10 % higher than in other studies where TBW volumes as a percentage of body mass for adult males and females were estimated from simple anthropometric measurements (Watson et. Al., 1980). As stated earlier, there are limited studies comparing BIA in athletes with multiple compartment models containing a criterion TBW estimation. Andreoli et al. (2004) discovered that BIA overestimated TBW % by 12.1% and produced a lower value of 0.49 in male water-polo players compared with a four-compartment (4C) model. In contrast, Clark et al. 74 revealed a total error of only 3.08 kg for minimal weight predictions in NCAA wrestlers and concluded that the BIA was an acceptable alternative to a 4C model. Discrepancies in literature could be due to several issues such as different methods and equations for the 4C models and different athletic populations (Moon, 2013).

However, BIA equations developed for specific athletes may also produce acceptable values and are still acceptable for use until more research is conducted (Moon, 2013). It is also important to address some limitations of this study. A small and gender unbalanced sample is most certainly the main limitation, as the statistical power could be small to detect true changes in hydration status. Also, there were used only body composition data to access hydration status, while urine specific gravity or haematocrit status were not followed. These are the issues that future studies should take care about in the study design.

CONCLUSIONS

The results of our study suggest that is possible to prevent dehydration during training at moderate altitude with the proper hydration and nutrition plan. The BIA seems to be a reliable tool for measurements of total body water in swimmers and measurements are acceptable for use, although it appears that the obtained values of TBW with BIA seem to be overestimated according to other methods.

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