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The Impact of Acute Hydration on Body Composition Assessment Using the Bioelectrical Impedance Method in Female Pilates Novices

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Abstract

The aim of this study was to examine the impact of acute hydration on body composition assessment using the bioelectrical impedance (BIA) method. Given the sensitivity of BIA measurements to changes in hydration status, it was examined how the intake of 0.5 l of water affects body mass and body fat percentage and how quickly the values stabilize after hydration. The study was conducted on 28 female subjects who are recreationally involved in Pilates, and measurements were performed in the morning on an empty stomach, using a multi-purpose BIA device. Body mass and fat percentage were assessed four times: twice before hydration and five and fifteen minutes after hydration. The results showed a statistically significant increase in body mass immediately after water intake ($p < 0.001$), while body fat percentage also increased, contrary to expectations. The values stabilized within 15 minutes after hydration. These changes can be explained by the redistribution of fluid in the body and the algorithms that BIA devices use to assess body composition. It is concluded that fluid intake immediately before BIA analysis may temporarily affect the results, which may lead to misinterpretations of body composition. It is recommended to standardize the measurement conditions and conduct testing under the same hydration conditions to ensure greater reliability of body composition assessment.

Keywords: *body composition analysis, body composition, hydration status, body weight, body fat, measurement reliability*

Introduction

Body composition assessment is one of the key elements in the analysis of an individual's health and fitness. This is particularly important in the context of preventing and monitoring various health conditions, including obesity, diabetes, cardiovascular disease and osteoporosis. In clinical and sports settings, accurate determination of the ratio of fat to lean tissue allows for informed decisions about nutrition, training and health interventions.

One of the most used methods for assessing body composition is bioelectrical impedance analysis (BIA). It is a non-invasive method based on measuring the resistance to electrical current as it passes through the body. Lean body mass, rich in water and electrolytes, conducts electricity well, while adipose tissue, with a lower water content, provides greater resistance. In this way, BIA allows for the assessment of body fat percentage and other body composition parameters (Ling et al., 2011). However, the results obtained with the BIA method can be influenced by various factors, among which hydration of the organism is of particular importance.

The degree of hydration can significantly affect the measurement, since changes in body water change the electrical resistance. For example, dehydration reduces total body water, increasing drag and potentially overestimating body fat percentage (Algül & Özçelik, 2022). On the other hand, hyperhydration can lead to an underestimation of body fat percentage. A study by Dixon et al. (2009) showed that fluid intake can affect body composition estimates using BIA, especially the estimation of visceral fat and total body water. In addition to hydration, other factors such as physical activity prior to measurement, food and beverage intake, skin temperature, and individual characteristics such as gender, age, and

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fitness level can also affect BIA measurement results. For example, physical activity immediately prior to measurement can change the distribution of body water, which can affect the results (Ekingen et al., 2022). Also, food and beverage intake can increase the water content of the digestive tract, which can lead to an underestimation of body fat percentage. Therefore, it is advisable to conduct measurements under standardized conditions, such as measurements in the morning after waking up, before food and fluid intake, and after bladder emptying, in order to minimize the influence of these variables on the results (Mišigoj-Duraković, 2008).

Previous research suggests that different BIA models and frequencies may exhibit different sensitivity to changes in hydration status. Anusitviwat et al. (2023) found that dual-frequency bioelectrical impedance (DF-BIA) can provide more accurate estimates of muscle mass compared to single-frequency models but is still sensitive to fluctuations in hydration. Furthermore, Jeong et al. (2023) found that acute hydration can affect estimates of body mass, body fat percentage, and total body water, with multi-frequency BIA devices showing greater stability compared to single-frequency ones.

In addition, recommendations from manufacturers of BIA scales also emphasize the importance of standardizing measurement conditions to reduce variations caused by changes in hydration. TANITA and other leading BIA manufacturers recommend performing measurements in the morning on an empty stomach, after emptying the bladder, and before fluid intake, as even small changes in hydration status can affect the accuracy of the results. Vasold et al. (2019) further point out that cheaper BIA models may exhibit greater variability and less reliability than more expensive, professional models.

Multifrequency bioelectrical impedance (MF-BIA) provides an estimate of total body water. However, it is not known whether MF-BIA detects increases in body water due to acute hydration, thereby affecting the validity of MF-BIA body composition measurements. Single-frequency bioelectrical impedance (SF-BIA), looking at the results of studies conducted only in women, reveals significant increases in fat percentage, fat-free mass, and fat mass, while total body water significantly decreased with acute hydration (Jeong et al., 2023).

The issue investigated in this paper relates to the impact of acute hydration on the results obtained by the bioelectrical impedance method. Although BIA is widely used in research and clinical settings, there is a need to better understand its sensitivity to fluctuations in hydration. Different levels of hydration can lead to underestimation or overestimation of body fat percentage, which can lead to misinterpretations of body composition.

Therefore, the main aim of this study is to examine how acute hydration affects the assessment of body composition using the bioelectrical impedance method. Specifically, changes in body mass and body fat percentage will be investigated before and after the consumption of 0.5 l of water, and to determine how quickly the results stabilize after fluid intake.

It is predicted that the intake of 0.5 l of water will result in a statistically significant increase in body mass immediately after hydration. Furthermore, it is expected that increased hydration will affect the assessment of body fat percentage, whereby a decrease in electrical resistance could temporarily lead to its lower value. It is assumed that body mass and body fat percentage parameters will stabilize within 15 minutes after fluid intake.

Methods

Subjects

A priori power analysis was performed using the G*Power program (version 3.1.9.7, Germany, Düsseldorf), based on a univariate analysis of variance for repeated measures. The following assumptions were used in the calculation: a minimum practically significant standardized effect size of 0.20, a significance level of 0.05, a statistical power of 0.80, and a correlation between repeated measures of 0.7. The results of the analysis showed that the minimum required sample size was 26 subjects.

Accordingly, 28 women who practice Pilates recreationally were included in the study. The mean age of the subjects was 42.6 ± 9.9 years, height 169.5 ± 5.6 cm, body weight 66.5 ± 11.3 kg, body mass index (BMI) 23.1 ± 3.7, and body fat percentage 28.3 ± 7.7%.

All subjects were informed in detail about the aim and conditions of the study before participating and provided written informed consent. The study was conducted in accordance with the principles of the Declaration of Helsinki, and subjects were assured anonymity and the possibility of withdrawing from the study at any time without consequences. Ethical approval was granted by the Ethics Committee of the Faculty of Kinesiology, University of Zagreb (approval number: 48/2025).

Research design

The study was conducted using a cross-sectional design, as the effect of acute hydration on the subjects' body mass and fat percentage was analysed through short-term measurements within a single session, without the need for long-term monitoring of changes over time. All measurements were performed in a single morning visit to the fitness center, and the measurements were performed by experienced assessors. The subjects were advised to come rested, without jewellery, and were measured in their underwear. In order to ensure the greatest possible control of the initial hydration status, the subjects were recommended to consume enough fluids the day before the test and to avoid diuretics such as caffeine and alcohol. In addition, to minimize the influence of previous food and drink intake, all subjects had to come in a fasting state, with the last meal allowed no later than 10 hours before the test. The subjects were also advised not to participate in intense physical activities that could affect hydration and body fluid balance the day before the study. Before the start of the measurements, they were familiarized with the protocol and methods of using the measuring instruments. All measurements were conducted under controlled conditions at a room temperature of 22°C.

As part of the anthropometric measurements, the subjects' height was measured with an anthropometer, and their body mass and body fat percentage were measured with a diagnostic scale. Body mass and body fat percentage were measured four times: twice before and twice after consuming half a litre of water. The first two measurements were performed consecutively to analyse the reliability of the measuring instrument, while the third measurement was performed five minutes after, and the fourth measurement fifteen minutes after hydration. The first, third, and fourth measurements were included in the further analysis, while the second measurement was used solely for assessing the instrument's reliability. After each measurement, the data were stored in a single database for further analysis.

Measuring tools

A digital scale with body composition analysis (TANITA RD-545HR, InnerScan PRO Body Fat & Segmental Composition Scale) was used to measure body mass, while height was measured using an anthropometer (Gneupel, Prazisionsmechanik, Bachenbulach, Switzerland). Based on the measured values of body mass and height, the body mass index (BMI) was calculated according to the formula: BMI = mass (kg) / height (m)^2.

The reliability of the scale was assessed by internal consistency analysis (ICC) and coefficient of variation (CV), with high reliability values obtained for the measurement of body mass (ICC = 0.999, CV = 0.09%) and body fat percentage (ICC = 0.987, CV = 1.27%).

Statistical analysis

Basic descriptive statistics were calculated for age, height, body mass, body fat percentage, and body mass index. Statistical analysis of data was performed using the Statistica software packages (TIBCO Software Inc. (2020). Data Science Workbench, version 14. http://tibco.com) and Excel 365 (Microsoft® Excel® for Microsoft 365 MSO, version 2412, 64-bit version 16.0.18324.20092).

The statistical significance of differences in body mass and body fat percentage was tested by univariate analysis of variance for repeated measures. In the case of a statistically significant difference between measurement points, a post hoc analysis with Bonferroni correction was performed to identify specific differences between individual measurement time points, while controlling for type I error. The statistical significance level was set at $p < 0.05$.

Effect sizes were calculated as Cohen's d and percentage change between measurement points (1, 2 and 3) for body mass and fat percentage. Cohen's d for paired measurements was calculated using the formula: $d = (M_2 - M_1) / SD_{(shared)}$; and Percentage change (%) between measurements: $\%\Delta = ((M_2 - M_1) / M_1) \times 100$. A Cohen's d value of 0.2 is considered a small effect, 0.5 a moderate effect, and 0.8 a large effect (Faul et al., 2007).

Results

A repeated measures analysis of variance showed a statistically significant difference in body mass between different time points ($F = 179.86$, $p < 0.001$). Post-hoc analysis with Bonferroni correction revealed that body mass increased significantly after water consumption compared to the initial measurement ($p < 0.001$), while there was no significant difference between measurements taken five and fifteen minutes after hydration ($p = 1.000$).

Similarly, analysis of variance for body fat percentage showed a statistically significant difference between time points ($F = 18.76$, $p < 0.001$). Post hoc analysis showed a significant increase in body fat percentage between the first and second measurements ($p < 0.001$), while the difference between the second and third measurements was not statistically significant ($p = 0.261$).

The results indicate that the consumption of half a liter of water leads to an acute increase in body mass and estimated body fat percentage, with values stabilizing after hydration.

Table 1. Results of ANOVA and Post Hoc Analysis for Body Mass and Fat Percentage

Measure	Measurement time	M ± SD	ANOVA F	p	Post hoc (p)
Body weight (kg)	1.	66.46 ± 11.30	179.86	<0.001	1. vs. 2. (<0.001)
	2.	67.01 ± 11.23			2. vs. 3. (1.000)
	3.	67.00 ± 11.27			1. vs. 3. (<0.001)
Fat percentage (%)	1.	28.30 ± 7.68	18.76	<0.001	1. vs. 2. (<0.001)
	2.	29.59 ± 7.58			2. vs. 3. (0.261)
	3.	29.21 ± 7.41			1. vs. 3. (<0.001)

Note. M: mean; SD: standard deviation.

Table 2. Cohen's d and Percentage Change for Body Mass and Body Fat Percentage

Measure	Measurement time	Cohen's d	Percentage change (%)
Body weight (kg)	1 → 2	0.05	0.84
	2 → 3	-0.00	-0.01
	1 → 3	0.05	0.83
Fat percentage (%)	1 → 2	0.17	4.53
	2 → 3	-0.05	-1.27
	1 → 3	0.12	3.21

Cohen's d shows a very small effect size across all body mass measurements, indicating minimal differences between time points. On the other hand, the effects for body fat percentage are somewhat more pronounced, especially between the first and second measurements ($d = 0.17$). The percentage change also suggests that the largest difference between the first and second measurements was for body fat percentage (4.53%), while there was a slight decrease between the second and third measurements (-1.27%).

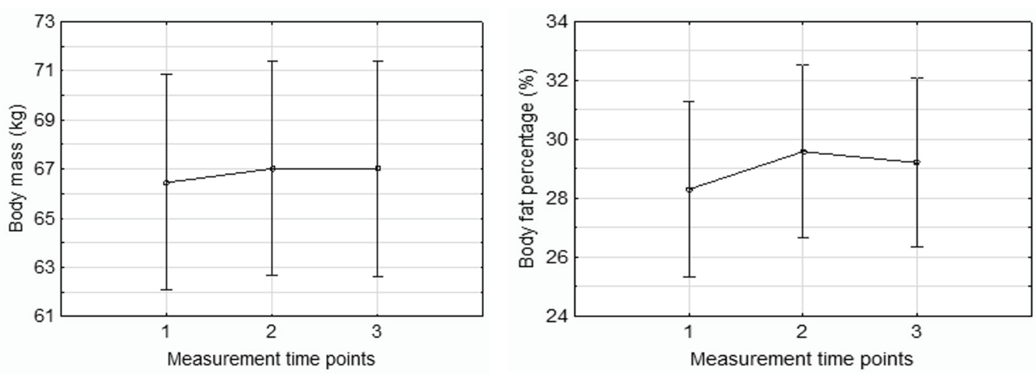

FIGURE 1. Graphs depicting the effects of consuming half a liter of water on body mass and fat percentage at three measurement points: before hydration (point 1) and after hydration (points 2 and 3).

The results suggest that water consumption causes slight but statistically significant changes in body mass and fat percentage, which gradually stabilize after 15 minutes (Figure 1).

Discussion

The results of this study showed that drinking 0.5 l of water caused a statistically significant increase in body mass and body fat percentage immediately after hydration. Body fat percentage recorded the largest change between the first and second measurements (4.53%), while body mass and body composition values stabilized after 15 minutes. Cohen's d showed small effects between time points, suggesting that differences are present but not very pronounced. These findings support the hypothesis that acute hydration can temporarily alter the results of body composition measurements. As expected, body mass increased by approximately half a kilogram, which is consistent with the amount of water consumed. However, a surprising finding was the increase in body fat percentage, which is contrary to expectations. This phenomenon can be explained by changes in the electrical conductivity of the body, since bioelectrical impedance uses the resistance of different tissues to estimate body composition (Algűl & Özcelik, 2022). Fat tissue has higher resistance than muscle tissue, and increased hydration usually reduces the total body resistance, which should result in a decrease in the estimated fat percentage (Algűl & Özcelik, 2022). However, it is possible that the temporary fluid redistribution affected the body composition estimation algorithms, causing a temporary increase in the measured body fat percentage.

Our results are in line with previous research that has shown that fluid consumption immediately before measurement can affect bioelectrical impedance (BIA) and other methods of body composition analysis (Barreira et al., 2020). Namely, the BIA method is based on the passage of an electrical current through the body and measuring the resistance, where increased hydration can reduce the overall resistance, resulting in erroneous estimates of body mass and composition. This phenomenon is particularly pronounced in individuals with different degrees of hydration, where even small variations in fluid intake can significantly affect the results.

Studies such as that of Brtkova et al. (2014) have shown differences in body composition depending on the measurement methods, where it was found that anthropometric methods and BIA often provide different estimates of body fat percentage. This suggests the need to standardize measurement conditions to ensure greater reliability of the results. Furthermore, the study by Vasolda et al. (2019) highlighted the low reliability of cheaper BIA devices when it comes to analyzing hydration status, with more expensive, professional devices being more accurate but still subject to variations caused by acute changes in hydration. This research confirms the need for further research to improve the methodology of body composition assessment and reduce the sensitivity of measuring devices to changes in hydration status.

In addition, Dahlmann and Demond (2022) proposed new anthropometric models that more accurately predict body composition, regardless of current hydration. Our findings support the claim that short-term changes in hydration can cause bias in measurements, which is important for understanding variability in body composition analysis.

Hydration plays a key role in the accuracy of body composition analysis, especially in methods such as bioelectrical impedance analysis (BIA), which are sensitive to changes in body fluids. Previous studies (Anusitviwat et al., 2023) have shown that dual-frequency BIA has better accuracy in determining muscle mass, but it remains susceptible to fluctuations in the hydration status of the subjects.

The practical aspect of these findings is not only important for athletes and people monitoring their fat loss progress, but also for the general population who use various inexpensive digital scales at home that can estimate body fat percentage. Many users are not aware of the potential errors in measurement, especially with fat percentage, which is susceptible to fluctuations caused by hydration. Water consumption can cause a relatively large increase in fat percentage, which can lead users to make incorrect conclusions about their progress in controlling body weight and body composition.

To minimize misassessment of body composition, it is important to standardize measurement conditions and ensure that subjects are in the same hydration status during all measurements. It is desirable to avoid fluid intake for at least two hours before the measurement, and it would be optimal to perform measurements in the morning on an empty stomach to reduce the influence of daily fluctuations in hydration. It is also recommended to perform multiple measurements over different days and analyze trends instead of relying on individual values, which can achieve greater accuracy and reliability of results.

Our study showed that drinking water immediately before body composition analysis causes temporary changes in body mass and body fat percentage. These findings highlight the importance of standardizing measurement conditions to ensure accuracy and reliability of results. Furthermore, research on hydration and its impact on body composition analysis should continue to improve methodology and reduce potential errors in assessing health and body composition.

Conclusion

Based on the research conducted, it can be concluded that drinking water immediately before measuring body composition can temporarily affect the results, increasing body mass and fat percentage. These results emphasize the importance of standardizing measurement conditions, especially in the context of using bioelectrical impedance to assess body composition. Individuals who monitor their progress in body composition, whether they are athletes, recreational athletes or the general population using home digital scales, should be aware that fluid intake can temporarily alter the results and lead to misinterpretations.

Limitations and future research

This study has several limitations that should be considered when interpreting the results. The research was conducted using a short-term, cross-sectional design, which limits the ability to draw conclusions about the long-term effects of hydration on body composition assessment. Furthermore, the sample included only female participants with recreational experience in Pilates, which restricts the generalizability of the findings to other populations, such as men, athletes, or individuals with different physical characteristics. Another limitation is the use of a single bioelectrical impedance device model (TANITA RD-545HR), which may not reflect results obtained with other devices that use different measurement technologies or algorithms.

Future studies should consider employing longitudinal designs to explore how hydration status influences body composition assessment over extended periods. It would also be beneficial to include a more diverse sample concerning sex, age, physical activity level, and body composition. In addition, comparing different BIA devices, including those based on single- and multi-frequency technologies, could provide deeper insight into their sensitivity to acute hydration changes and help establish more robust measurement protocols, as well as contribute to the development of standardized guidelines that would allow for more accurate assessment of body composition independent of acute changes in hydration status.

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