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The influence of caffeinated drinks on body composition indices change, measured with bioelectric impedance

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Abstract: Bioelectric impedance is often used for body composition analysis. General restriction for such analysis is abstinence from caffeine and caffeinated drinks 12 hours before testing. Nevertheless there is still no scientific concensus concerning the question of caffeine and caffeinated drinks influence on the results of body composition indices, measured with bioelectric impedance. The aim of the research was to define, if coffee and black tea with sugar influence the received parameters of body composition, measured with bioelectric impedance. ***Material.*** Defining the changes in body composition indices with the help of bioimpedance analysis after caffeinated drinks taking. ***Research methods.*** Scientific sources analysis and summarizing, bioimpedance measurement, methods of mathematical statistics. ***Results.*** The results of the research work show that in the sampling of young healthy people without obesity standardization violation of bioimpedance analysis (BIA) before testing (drinking 200 ml of water and 1 teaspoon of "Nescafe gold" coffee) doesn't have significant influence on the received % fat body mass (FBM), % skeletal muscle mass (SMM), active cell mass (ACM) values, phase angle and general water of an organism. However, drinking the same amount of "Curtis. Elegant earl grey" black tea, with two lumps of sugar, changed ACM indices and phase angle statistically validly during 135 minutes of measurements. It is interesting that in the group with % FBM 9,0 [8,7-9,05] in case of black tea with sugar drinking we didn't reveal statistically significant changes among the indices. In the group with % FBM 23,4 [22,6-27,1] standardization violation led to statistically significant changes according to ACM indices, phase angle and % FBM. We broadened the previous observations, showing that body composition indices don't differ considerably during BIA "hand-leg" apparatus use after 200 ml of coffee. In general it proves that 200 ml of coffee don't have significant influence on fat composition in a body and muscle mass, measured with BIA among healthy active people without obesity. However, 200 ml of tea with sugar distorts the markers of body composition during 135 minutes. ***Conclusion.*** We need additional research works concerning this protocol of hydration for BIA measurements standardization among people with obesity.

Keywords: body composition, bioelectric impedance, bioimpedance measurement, anthropometry, caffeine, functional diagnostics.

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Introduction

Bioimpedance analysis (BIA) is the method, which is widely used for body composition estimation [1]. In order to provide reliability of BIA measurements we offered several recommendations. One of the recommendations is abstinence from caffeine 4-24 hours before the test [2,3]. Caffeine, which can be taken in several forms (for example, coffee, tea, energy drinks and etc.) is one of the most widely used additives in the world [4]. As caffeine is a diuretic there is a high probability that drinking coffee and tea would change general liquid in an organism and would distort body composition indices, measured with BIA [5,6]. Moreover, people, who estimate body composition in clinical or field conditions, may have no notion of the existing standardization before BIA or potential importance of such measures. At the same time the absence of standardization is often considered an insignificant problem. It leads to real, but not great mistakes in body composition estimation. The last results show that such concern can be justified. Kerr and other authors [7] carried out the research. It revealed significant consequences for mistakes interpretation

in body composition estimation, caused by non-standard conditions of measuring. During 6 months of independently chosen trainings and a diet body composition of the respondents is estimated both in standardized and non-standardized conditions – using BIA. The authors mention that the absence of standardization led to changes in body composition indices. Though some indices were more resistant to the absence of standardization, the observation concerning "real" changes of body composition, which can be completely leveled by its absence, shows the necessity to define the consequences of not optimal procedures of body composition measurement. On the basis of a problem situation, requests of sports doctors and nutritionists we formulated the aim of the research.

The aim of the research: to define the changes in body composition indices with the help of bioimpedance analysis after having caffeinated drinks.

Materials and methods

The research was organized on the basis of sports medicine department of the Russian University of sport "SCOLIPC". 9 people took part in the research (7 men and 2 women) concerning the influence of coffee, the age range - 23±2,7 years-old, weight-70,5±15,1 kg. 8 people (7 men and 1 woman) took part in the test concerning the influence of tea with sugar, age range- 21,9±1,5 years-old, weight – 73,3±14,1 kg. All respondents gave voluntary informed consent to take part in the research in accordance with Declaration of Helsinki. In order to achieve the set aim we used the following research methods: 1) scientific sources analysis and summarizing; 2) bioimpedance measurement; 3) methods of mathematical statistics. Bioimpedance analysis of body composition was realized with the help of "Medass" ABC-01 (Russia) apparatus. The first test was held in the morning on an empty stomach. After that the respondents were offered the drinks: 1) the 1st day– 200 ml of clean water ("Kalinov rodnik") + black tea "Curtis. Elegant earl grey", was made 5 min, + 2 lumps of sugar; 2) the 2nd day – 200 ml of clean water ("Kalinov rodnik") + "Nescafe gold" coffee (1 teaspoon). In 30, 60, 90, 120 and 135 minutes additional measurements were held. We registered the following parameters: 1) % of fat body mass (FBM); 2) % of skeletal muscle mass (SMM); 3) % of active cell mass (ACM); 4) general liquid; 5) phase angle. Statistical analysis was realized in SPSS program using ANOVA with the repeated measurements, non-parametric Friedman test, cluster analysis and with the help of non-parametric Mann–Whitney test.

Results and discussion

According to the results of the held analysis, after coffee drinking there were no statistically significant changes in any index (table 1). The same results were received by Williamson and other authors [5] in case of drinking 200 ml of caffeine (in capsules) by regular users of caffeinated drinks (≥ one dose 95 mg caffeine a day). Mota and other authors [6] underline that the changes in body composition, were caused by coffee drinking in 70 minutes, however, the authors of the research consider, that it was connected not with caffeine, but probably with water drinking.

Table 1

The dynamics of bioimpedance measurement indices estimation among the respondents during coffee drinking

Stages of observation	Indices					
	FBM, %		SMM, %	ACM, %	General liquid, kg	Phase angle, degree
	Me	Q1-Q3	M±SD	M±SD	M±SD	M±SD
On an empty stomach	22,1	11,6-24,1	53,4 ± 2,56	61,59 ± 3,91	41,22 ± 7,02	7,86 ± 0,98
30 min	22,5	13,6-25,7	52,96 ± 2,4	62,96 ± 4,06	40,5 ± 6,98	8,22 ± 1,08
60 min	23,3	12,4-26,2	53,06 ± 2,65	61,44 ± 3,38	40,77 ± 7,29	7,79 ± 0,83
90 min	23,4	12,9-27,0	53,1 ± 3,27	62,31 ± 2,89	40,61 ± 7,3	8,02 ± 0,76
120 min	21,8	12,7-25,2	53,14 ± 2,58	61,95 ± 3,47	41,0 ± 7,52	7,94 ± 0,9
135 min	22,1	11,5-24,0	53,31 ± 2,62	61,69 ± 3,48	41,11 ± 7,16	7,87 ± 0,9
p-value	0,194		0,343	0,235	0,223	0,165

After estimating the dynamics of bioimpedance measurement indices among the respondents during tea with sugar drinking we received the following results (table 2).

Table 2

The dynamics of bioimpedance measurement indices estimation among the respondents during tea with sugar drinking

Stages of observation	Indices									
	FBM, %		SMM, %		ACM, %		General liquid, kg		Phase angle, degree	
	Me	IQR	Me	IQR	Me	IQR	Me	IQR	Me	IQR
On an empty stomach	21,2	9,05-25,25	53,1	52,75-55,2	60,5	59,0-61,7	45,5	38,55-46,95	7,5	7,15-7,85
30 min	21,3	9,15-25,45	53,8	52,45-56,8	61,2	59,3-61,8	45,4	38,5-46,9	7,7	7,25-7,85
60 min	21,4	9,1-25,15	53,8	52,7-56,85	61,1	59,55-61,55	45,6	38,5-46,85	7,6	7,3-7,8
90 min	21,7	9,1-24,95	53,7	52,35-56,8	61,0	59,2-61,9	45,6	38,45-46,65	7,7	7,2-7,85
120 min	21,0	9,3-24,5	53,9	52,65-56,75	61,2	59,6-62,2	45,5	38,45-47,05	7,7	7,25-7,95
135 min	21,4	9,2-24,55	53,8	52,65-56,75	61,5	59,6-62,55	45,7	38,45-46,9	7,8	7,25-8,0
p-value	0,300		0,312		0,006* p_{1-4} = 0,023* p_{1-5} = 0,004* p_{1-6} < 0,001* p_{3-6} = 0,038*		0,544		0,016* p_{1-5} = 0,013* p_{1-6} = 0,002*	

Note: – indices changes are statistically significant (p<0,05)

According to the results of the held analysis we revealed statistically valid changes of ACM indices (p=0,006) (Table 2). A posteriori comparison showed statistically significant dynamics during the following data confrontation: the initial stage (on an empty stomach) and 90 min after tea drinking (p=0,023), the initial stage (on an empty stomach) and in 120 min (p=0,004), the initial stage (on an empty stomach) and in 135 min (p<0,001), and also 60 and 135 min (p=0,038) after the drink use. 87,5% of the respondents after tea with sugar drinking had statistically significant ACM increase in 120 min and 135 minutes later all respondents had this increase (picture 1).

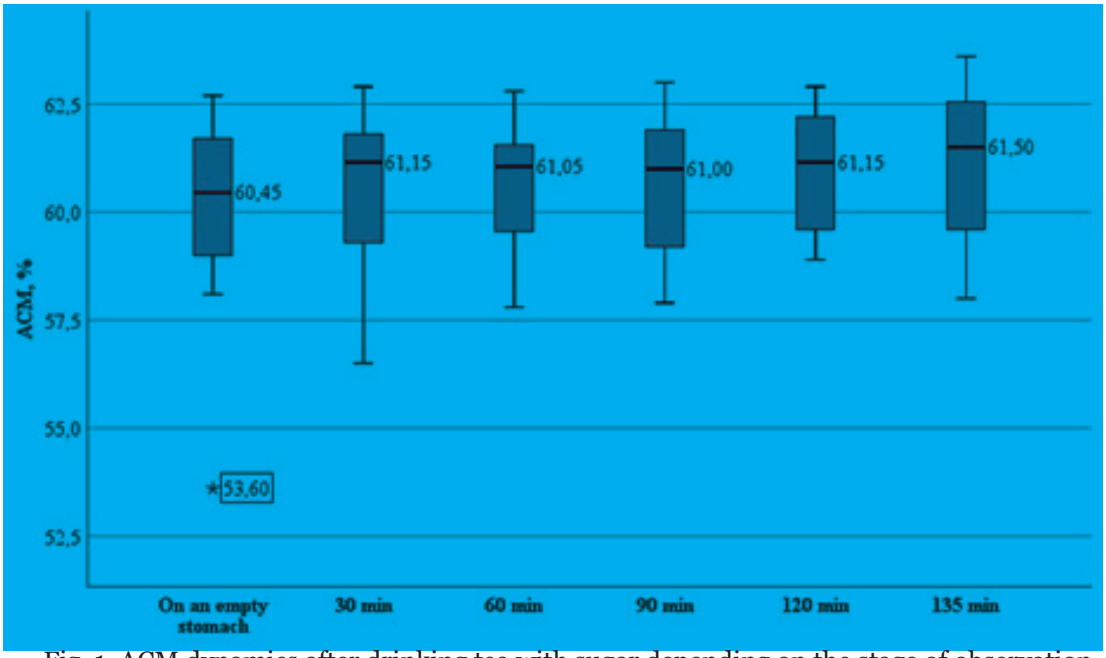

Fig. 1. ACM dynamics after drinking tea with sugar depending on the stage of observation

Moreover, as a result of the held analysis we revealed statistically significant increase of phase angle (p=0,016) (table 2). A posteriori comparison showed statistically significant dynamics during the following results comparison: the initial stage (on an empty stomach) and 120 min after drinking (p=0,013), the initial stage (on an empty stomach) and in 135 min (p=0,002). 120 minutes after tea with sugar drinking phase angle values increased statistically significantly among 62,5% of respondents, and in 135 minutes among 87,5% of respondents (picture 2). It is a well-known fact that the phase angle is directly connected with muscle power and aerobic working capacity of people of different age groups (children, teen-agers, adults and elderly people), people with different health state [8,9] and athletes [10]. The changes in phase angle indices in terms of standardization can distort results interpretation in the held clinical research works.

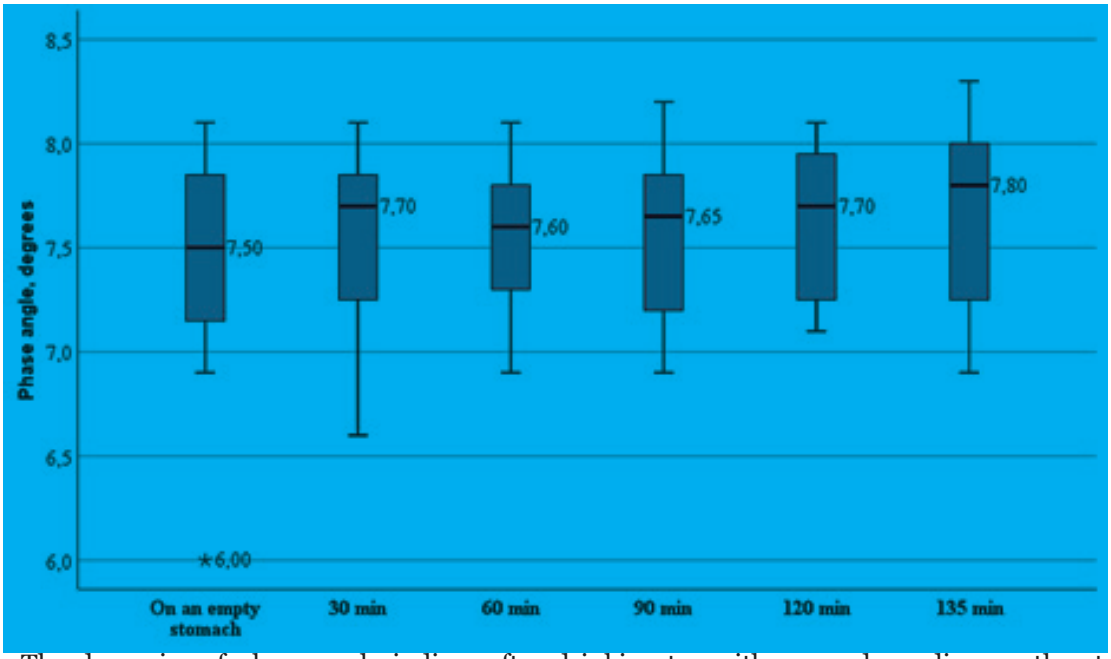

Fig. 2. The dynamics of phase angle indices after drinking tea with sugar depending on the stage of observation

Randhawa and other authors [11] had the hypothesis that the changes in body composition as a result of manipulation with the liquid can differ among people, who initially have different fat component or body mass index. We also analyzed the changes in body composition after tea with sugar drinking, dividing the group of the respondents into the corresponding clusters. As a result of a two-stage cluster analysis in the structure of the studied group we defined two clusters: the part of the 1st cluster in the general structure was 37,5%, the second – 62,5%. Silhouette measure of connection and separation was 0,8, which corresponds with good quality of clusters. Table 3 and picture 3 present the results of comparison of the received clusters according to the studied features.

Table 3

Comparison of the received clusters according to the studied features

Indices	Studied clusters		p
	The 1st (n=3)	The 2nd (n=5)	
FBM on an empty stomach, %, Me [IQR]	9,0 [8,7-9,05]	23,4 [22,6-27,1]	0,036*
FBM 30 min, %, Me [IQR]	9,1 [8,8-9,15]	23,5 [22,8-27,4]	0,036*
FBM 60 min, %, Me [IQR]	9,0 [8,85-9,1]	23,6 [22,5-26,7]	0,036*
FBM 90 min, %, Me [IQR]	9,0 [8,9-9,1]	23,3 [22,5-26,6]	0,036*
FBM 120 min, %, Me [IQR]	9,0 [8,9-9,3]	22,4 [22,4-26,6]	0,036*
FBM 135 min, %, Me [IQR]	9,0 [8,85-9,2]	22,9 [22,4-26,2]	0,036*
SMM on an empty stomach, %, Me [IQR]	56,5 [54,81-57,9]	53,1 [52,4-53,12]	0,143

Note: – changes of the indices are statistically significant (p<0,05)

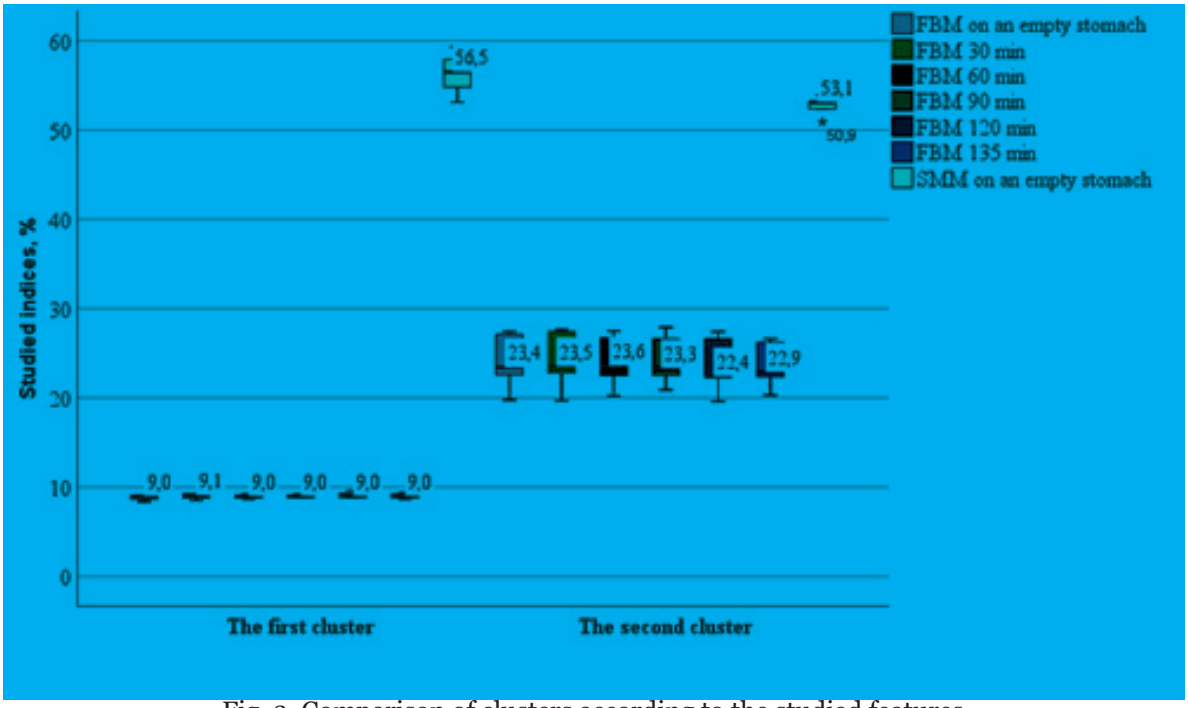

Fig. 3. Comparison of clusters according to the studied features

During the received clusters comparison (according to Mann–Whitney test) we set statistically significant differences according to FBM indices. The respondents from the 2nd cluster had the initial percentage of FBM statistically higher at the initial stage (p=0,036), 30 minutes, 60 min (p=0,036), 90 min (p=0,036), 120 min (p=0,036) and 135 min (p=0,036) after drinking. According to the results of the initial SMM indices estimation we didn't reveal statistically significant differences between the clusters (table 3). These FBM changes in terms of BIA standardization violation can have different consequences for athletes and people, who have metabolic diseases. It is a well-known fact that many football clubs, for example, introduce the limit for the percentage of FBM concentration among their athletes and this limit violation leads to different sanctions, including suspending from the games. The changed indices as a result of BIA standardization violation can also lead to incorrect diagnosis and therapy among people, for example, with metabolic syndrome. In science distorted data can throw doubt on the results of the research or lead to non-relevant results interpretation. In accordance with the held analysis we revealed no statistically significant changes in any index in the 1st cluster (table 4).

Table 4

Estimation of the indices dynamics among the respondents of the 1st cluster after tea with sugar drinking

Stages of the observation	Indices									
	FBM, %		SMM, %		ACM, %		General liquid, kg		Phase angle, degree	
	Me	IQR	Me	IQR	Me	IQR	Me	IQR	Me	IQR
on an empty stomach	9,0	8,7-9,05	56,5	54,81-57,9	61,6	61,0-62,15	39,5	38,55-42,4	7,8	7,65-7,95
30 min	9,1	8,8-9,15	57,2	56,8-58,35	61,2	61,15-62,05	39,4	38,5-42,35	7,7	7,7-7,9
60 min	9,0	8,85-9,1	57,4	56,85-58,45	61,3	61,2-62,05	39,4	38,5-42,35	7,7	7,65-7,9
90 min	9,0	8,9-9,1	57,4	56,8-58,5	61,6	61,25-62,3	39,3	38,45-42,3	7,8	7,7-8,0
120 min	9,0	8,9-9,3	57,3	56,75-58,95	61,5	61,15-62,2	39,3	38,45-42,2	7,8	7,7-7,95
135 min	9,0	8,85-9,2	57,4	56,85-58,75	62,2	62,05-62,9	39,3	38,45-42,25	7,9	7,9-8,1
p-value	0,281		0,891		0,132		0,142		0,086	

Note: * – indices changes are statistically significant (p<0,05)

As a result of the data of the 2nd cluster analysis we defined statistically significant changes according to FBM indices (p=0,035), ACM (p=0,024) and general liquid (p=0,033) (table 5). A posteriori comparison showed that FBM percentage decreased statistically significantly during the following data comparison: 90 min and 120 min (p=0,035), 60 min and 120 min (p=0,028), 30 min and 120 min (p=0,009), and also 30 min and 135 min (p=0,022) after tea with sugar drinking. Among 80% of respondents FBM percentage decreased statistically significantly 135 minutes after tea drinking.

Table 5

Estimation of the indices dynamics among the respondents of the 2nd cluster after tea with sugar drinking

Stages of the observation	Indices									
	FBM, %		SMM, %		ACM, %		General liquid, kg		Phase angle, degree	
	Me	IQR	Me	IQR	Me	IQR	Me	IQR	Me	IQR
on an empty stomach	23,4	22,6-27,1	53,1	52,4-53,12	59,9	58,1-60,5	46,9	45,6-47,0	7,4	6,9-7,5
30 min	23,5	22,8-27,4	52,6	52,3-53,6	60,0	58,6-61,3	46,8	45,5-47,0	7,4	7,1-7,7
60 min	23,6	22,5-26,7	52,9	52,5-53,7	60,4	58,7-61,0	46,7	45,8-47,0	7,5	7,1-7,6
90 min	23,3	22,5-26,6	52,5	52,2-53,7	60,3	58,1-61,1	46,3	45,9-47,0	7,5	6,9-7,7
120 min	22,4	22,4-26,6	52,8	52,5-53,7	60,2	59,0-61,7	47,0	45,9-47,1	7,4	7,1-7,8
135 min	22,9	22,4-26,2	52,7	52,6-53,7	60,2	59,0-61,1	46,7	46,2-47,1	7,4	7,1-7,7
p-value	0,035 P_{4-5} = 0,035 P_{3-5} = 0,028 P_{2-5} = 0,009 P_{2-6} = 0,022		0,283		0,024 P_{1-5} = 0,001 P_{1-6} = 0,007		0,033 P_{2-5} = 0,014 P_{2-6} = 0,011 P_{3-6} = 0,043		0,059	

Note: * – indices changes are statistically significant (p<0,05)

A posteriori comparison showed statistically significant changes of ACM index during the following data comparison: the initial level and in 120 min (p=0,001), the initial level and in 135 min (p=0,007). 135 minutes after tea with sugar drinking the percentage of ACM increased among all respondents of the 2nd cluster. Moreover, a posteriori comparison revealed statistically significant changes of general liquid level during the results comparison 30 and 120 min (p=0,014), 30

and 135 min (p=0,011), 60 and 135 min (p=0,043) after tea with sugar drinking. In this case the mass of general liquid increased among 80% of respondents 135 min after drinking.

Conclusion

National Institute of Health recommends not measuring BIA during 4 hours after eating and drinking liquid [11], and also many organizations recommend to reject caffeine and caffeinated drinks 4-24 hours before the test [2,3]. Contrary to these recommendations the results of our research work show that in the sampling of young healthy people without obesity BIA standardization violation before the test (200ml of water + one teaspoon of "Nescafe gold" coffee) doesn't have considerable influence on the received % FBM, %SMM, ACM values, phase angle and general water in an organism. However, the same amount of "Curtis. Elegant earl grey" black tea drinking with two lumps of sugar statistically significantly changed ACM and phase angle indices during 135 minutes of measurement. It is interesting that in the group with % FBM 9,0 [8,7-9,05] during black tea drinking with sugar we reveled no statistically significant changes in any indices. At the same time in the group with % FBM 23,4 [22,6-27,1] standardization violation led to statistically significant changes according to ACM, phase angle indices and % FBM. We broadened the previous observations, showing that body composition indices don't differ considerably during BIA "hand-leg" apparatus use after 200 ml of coffee. In general it proves that 200 ml of coffee don't have significant influence on fat composition in a body and muscle mass, measured with BIA among healthy active people without obesity. However, 200 ml of tea with sugar distorts the markers of body composition during 135 minutes. We need additional research works concerning this protocol of hydration for BIA measurements standardization among people with obesity.

References

1. Campa F, Gobbo LA, Stagi S, Cyrino LT, Toselli S, Marini E, Coratella G. Bioelectrical impedance analysis versus reference methods in the assessment of body composition in athletes. *Eur J Appl Physiol*. 2022 Mar;122(3):561-589. doi: 10.1007/s00421-021-04879-y.

2. Bera TK. Bioelectrical Impedance Methods for Noninvasive Health Monitoring: A Review. *J Med Eng*. 2014; 2014:381251. doi: 10.1155/2014/381251.

3. Tinsley GM, Harty PS, Stratton MT, Smith RW, Rodriguez C, Siedler MR. Tracking changes in body composition: comparison of methods and influence of pre-assessment standardisation. *Br J Nutr*. 2021 Jul 30:1-19. doi: 10.1017/S0007114521002579.

4. Contreras-Barraza N, Madrid-Casaca H, Salazar-Sepúlveda G, Garcia-Gordillo MÁ, Adsuar JC, Vega-Muñoz A. *Bibliometric Analysis of Studies on Coffee/Caffeine and Sport*. *Nutrients*. 2021 Sep 17;13(9):3234. doi: 10.3390/nu13093234.

5. Williamson CM, Nickerson BS, Bechke EE, McLester CN, Kliszczewicz BM. Influence of acute consumption of caffeine vs. placebo over Bia-derived measurements of body composition: a randomized, double-blind, crossover design. *J Int Soc Sports Nutr*. 2018 Feb 13; 15:7. doi: 10.1186/s12970-018-0211-5.

6. Mota JF, Gonzalez MC, Lukaski H, Oto GL, Trottier CF, Tibaes JRB, Prado CM. The influence of coffee consumption on bioelectrical impedance parameters: a randomized, double-blind, cross-over trial. *Eur J Clin Nutr*. 2022 Feb;76(2):212-219. doi: 10.1038/s41430-021-00932-3.

7. Kerr AD, Slater GJ, Byrne NM. Influence of subject presentation on interpretation of body composition change after 6 months of self-selected training and diet in athletic males. *Eur J Appl Physiol*. 2018 Jun;118(6):1273-1286. doi: 10.1007/s00421-018-3861-8.

8. Custódio Martins P, de Lima TR, Silva AM, Santos Silva DA. Association of phase angle with muscle strength and aerobic fitness in different populations: A systematic review. *Nutrition*. 2022 Jan; 93:111489. doi: 10.1016/j.nut.2021.111489.

9. Custódio Martins P, de Lima TR, Silva AM, Santos Silva DA. Association of phase angle with muscle strength and aerobic fitness in different populations: A systematic review. *Nutrition*. 2022 Jan; 93:111489. doi: 10.1016/j.nut.2021.111489.

10. Marra M, Di Vincenzo O, Sammarco R, Morlino D, Scalfi L. Bioimpedance phase angle in elite male athletes: a segmental approach. *Physiol Meas*. 2021 Jan 1;41(12):125007. doi: 10.1088/1361-6579/abcb5c.

11. Randhawa AK, Jamnik V, Fung MDT, Fogel AS, Kuk JL. No differences in the body fat after violating core bioelectrical impedance measurement assumptions. *BMC Public Health*. 2021 Mar 12;21(1):495. doi: 10.1186/s12889-021-10552-y.

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