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Application of Different Methods for Body Composition Determination among Female Elite Level Rhythmic Gymnasts in Germany

Nutzung unterschiedlicher Messmethoden zur Körperkompositionsbestimmung bei Spitzenathletinnen der Rhythmischen Sportgymnastik in Deutschland

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Summary

- **Problem:** Female athletes of rhythmic gymnastics (ARGs) are often associated with underweight and malnutrition. Body composition (BC) determinations can help to make statements about nutritional status and health. However, there is no BC database among ARGs in Germany.
- **Method:** BC determinations were performed among German ARGs using calipometry and different bioelectrical impedance analysis (BIA). All devices were compared in terms of percentual fat mass (FM%) using ANOVA. Additional parameters for the BIA devices were tested for differences using t-tests. Bland-Altman plot was created to compare the BIA devices in terms of FM%.
- **Results:** Twenty-five ARGs (M=15.2 years, SD±2.11) were measured. FM% was determined by calipometry (M=7.51, SD±1.35), InBody (M=11.87, SD±5.1), and BIVA 101 devices (M=16.2, SD±4.26). ANOVA showed significant differences for FM% ($F[2, 48]=64.46$, $p<0.001$; partial $\eta^2=0.729$). For Bonferroni-corrected post-hoc tests, significant differences ($p < 0.001$) between the three measurement methods were determined. The t-tests in BC parameters also showed significant differences ($p<0.001$) between the two BIA devices.
- **Discussion:** Compared to calipometry, BIA provides additional BC parameters. Nevertheless, the use of different measurement methods and devices in the comparison of BC parameters is not recommended. Reference values must be adapted to the respective devices.
- **Conclusion:** Uniform measurements in larger samples and generation of reference values are necessary to explore the prediction in BC on health status among ARG.

KEY WORDS:
Athletes, Body Fat, Calipometry, Bioelectrical Impedance Analysis

Zusammenfassung

- **Problem:** Athletinnen der Rhythmischen Sportgymnastik (RSG) werden häufig mit Untergewicht und Mangelernährung assoziiert. Körperkompositionsbestimmungen können dabei helfen, Aussagen über den Ernährungszustand oder die Gesundheit zu treffen. In Deutschland liegen bei Athletinnen der RSG dazu bislang keine Daten vor.
- **Methode:** Bei Spitzenathletinnen der RSG in Deutschland wurden mit Calipometrie und unterschiedlichen Bioimpedanz-Analyse (BIA)-Geräten Körperkompositionsbestimmungen durchgeführt. Alle Geräte wurden in Bezug auf die prozentuale Fettmasse (FM%) mit einer ANOVA mit Messwiederholung verglichen. Zudem wurden weitere Parameter beider BIA-Geräte mit t-Tests auf Unterschiede geprüft. Für den Vergleich der BIA-Geräte hinsichtlich FM% wurde ein Bland-Altman Plot erstellt.
- **Ergebnisse:** 25 RSG-Athletinnen (M=15.2 Jahre, SD±2.11) wurden untersucht. Die FM% wurde für die Caliper-Messung (M=7.51, SD±1.35), InBody-Messung (M=11.87, SD±5.1) und BIVA 101-Messung (M=16.2, SD±4.26) bestimmt. Die ANOVA zeigte, dass sich die durchschnittliche FM% signifikant voneinander unterscheidet ($F[2, 48]=64.46$, $p<0.001$; partielles $\eta^2=0.729$). Signifikante Unterschiede ($p<0.001$) zwischen den drei Messmethoden wurden durch einen Bonferroni-korrigierten post-hoc-Test ermittelt. Die durchgeführten t-Tests zeigten zwischen den BIA-Geräten bei mehreren Körperkompositionsparameter ebenfalls signifikante Unterschiede ($p<0.001$).
- **Diskussion:** Gegenüber der Calipometrie liefert die BIA zusätzliche Parameter zur Körperkomposition. Dennoch gestaltet sich die Nutzung verschiedener Messmethoden und Geräte im Vergleich von Körperpositionsparametern als schwierig. Referenzwerte müssen an die jeweiligen Geräte angepasst werden.
- **Schlussfolgerung:** Einheitliche Messungen bei größeren Stichproben sind nötig, um Zusammenhänge zwischen Körperkomposition und Gesundheitszustand bei RSG-Athletinnen sowie Referenzwerte zu generieren.

SCHLÜSSELWÖRTER:
Athleten, Körperfett, Calipometrie, Bioelektrische Impedanzanalyse

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Introduction, Problems and Objectives

Female athletes in rhythmic gymnastics (ARGs) are often associated with underweight and malnutrition (15). Further problems, e.g. menstrual disorder, stress fractures and high training volume are described in this context. Therefore, the determination of body composition (BC) plays an important role. The quantification of different components of the human body, e.g. body fat mass in percent (FM%) is a common procedure among patients and athletes. These values can be used to evaluate the health and nutrition status (11). For example, an increased FM% is associated with higher mortality risk (17). Some values can be evaluated to assess medical issues. In this case, BC can be used to diagnose malnutrition (7). Consequently, BC determinations for different groups, including athletes,

Table 1

BC parameter by calipometry, InBody and BIVA 101. FM%=percentual body fat mass; TBW=total body water; ECW=extracellular water; FFM=fat-free mass; FM=fat mass; BCM=body cell mass.

PARAMETER	MEAN	MINIMUM	MAXIMUM	SD
Calipometry FM [%]	7.51	5.1	10.0	±1.35
InBody FM [%]	11.87	4.1	21.8	±5.10
BIA 101 FM [%]	16.20	6.0	22.7	±4.27
InBody TBW [l]	31.16	24.4	42.8	±4.00
BIA 101 TBW [l]	31.58	25.4	40.8	±3.28
InBody ECW [l]	10.45	8.4	14.5	±1.35
BIA 101 ECW [l]	13.56	10.8	17.2	±1.51
InBody FFM [kg]	42.49	32.9	58.3	±5.45
BIA 101 FFM [kg]	40.71	31.3	55.5	±5.53
InBody FM [kg]	6.06	1.7	12.2	±3.20
BIA 101 FM [kg]	8.11	2.4	14.1	±3.02
InBody BCM [kg]	22.68	16.3	32.0	±3.79
BIA 101 BCM [kg]	29.03	22.4	39.7	±3.73

have the need for further research. One way in which BC determinations are performed among elite athletes is through annual sports medical health examinations, so-called "Jahreshauptuntersuchungen" (JHU). Top athletes must undergo such examinations in order to determine athletic resilience and to prevent health damage through sports (4). Therefore, in addition to various internal and orthopedic examinations, anthropometric characteristics, such as height, weight, and Body-Mass-Index (BMI) are collected. Moreover, a determination of body fat is recommended in health examinations in different sports, including rhythmic gymnastics (19). This value can be used in the evaluation of athletes and their performance to classify training, health or nutritional status (9). Various methods and devices can be used to determine FM%. In the sports medicine, such measurements are mainly performed with calipometry or bioelectrical impedance analysis (BIA). To best of our knowledge, no research has investigated BC among German ARGs yet.

For this study, BIA measurements were performed with ARGs from the German national team with three different BC measurement methods. The questions arise I) to what extent different methods for determining FM% differ among ARGs? Furthermore, this study will investigate II) to what extent both BIA devices differ in the determination of BC parameters?

Material and Methods

Recruitment and Anthropometric Measurements

All examinations and measurements were conducted as a part of the JHU among ARGs in the Eberhard Karls University Tübingen, Faculty of Medicine, Department of Sports Medicine from January-March 2022. All measurements took place in the morning, and after the general internal and orthopedic examination. Anthropometric characteristics were collected. For the standardized measurement, ARGs should be fasted and were informed by termination. Body height, weight, and BMI were measured. Subsequently, BC measurements with calipometry (GPM), BIA 101 BIVA (Akern), and BIA InBody 4.0 (Biospace) were performed in this order. Two trained examiners were involved in the survey.

Instruments

For the calipometry, FM% is estimated on the basis of skin fold thickness or layer thickness of the subcutaneous fat tissue (1). For the determination, the skinfold thickness is measured at three body points (triceps, subscapula, and abdomen). Therefore, the athlete stands in an upright position. The FM% was calculated with the formula according to Lohmann (13).

To measure bioelectrical impedance, a small alternating current is passed through the body to determine resistance (in ohms). Based on the directly measured parameters of capacitive resistance (Xc) and the resistive resistance (Rz), further BC parameters can be calculated using various equations and population-specific reference values (12).

The InBody 4.0 by Biospace is a multi-frequency BIA with eight electrodes. The measurements were performed in a standing position. Heels and bales were in contact with the electrode surfaces. The athlete takes one handle of the device in each hand so that the thumbs touch the electrodes on the surfaces. The arms remain extended and slightly abducted about 15° during the measurement (10).

The BIA 101 BIVA by Akern is a single-frequency BIA with 50 kHz ±1% measuring frequency. The measurements were performed in spine position (3). Here, the arms and legs are abducted about 30° and 45°, respectively. For measurement, four electrodes were placed on the extremities of the right half of the body in predetermined positions. Measurements were started only after a 5-minute rest period in supine position. BC parameters were analyzed afterwards with the corresponding software (BodygramPlus Enterprise Software, version 1.2.2.9, Akern s.r.l., Pontassieve, Italy).

In this study, the body composition parameters FM%, total body water (TBW), extracellular water (ECW), fat-free mass (FFM), fat mass (FM) and body cell mass (BCM) were calculated with both devices. The muscle mass (MM) could not be determined with both devices and was therefore not included.

Data Analysis

Data analysis was performed with the statistical program SPSS (IBM SPSS, version 28.0.1.0). For descriptive analysis mean values (M) with range (minimum-maximum) and percentages were determined. A group comparison of the ARGs was made by ANOVA with repeated measures using each of the three methods for FM% determination. The partial Eta squared (η^2) was calculated and pairwise comparison with post-hoc test was performed. To compare the parameters of both BIA devices, a t-test was performed for each measured parameter. Additionally, effect sizes by Cohen's d were calculated. Furthermore, for the comparison of the individual deviations between the two BIA devices in terms of FM%, Bland-Altman plot was created (8). For all tests, the significance level was set at $p<0.05$ in this study.

Results

A total of 25 ARGs with a mean age of M=15.2 years (13.0–21.0; SD±2.11) were included in the study. The anthropometric characteristics for weight, height and BMI were M=48.8 kg (35.6–69.1; SD±7.86), M=163.1 cm (152.7–178.5; SD±6.14), M=18.3 kg/m^2 (15.2–22.3; SD±1.96), respectively. A weekly training duration of M=32.8 hours/week (12.0-48.0; SD±7.95) was recorded.

As a part of the JHU, the ARGs received both an internal and orthopedic evaluation regarding sports suitability. In the orthopedic examination, limited sports clearance was present among four (16%) ARGs (labrum injury (n=1); bone marrow edema (n=1); condition after Achilles tendon surgery (n=1); severe hip pain (n=1)). From the internal examination, sports clearance was granted only temporarily or conditionally for n=12 (48%) athletes (positive weight trend (n=5); gynecological examination (n=4); examination of proteinuria (n=1); control of the hemoglobin level (n=1); inadequate carbohydrate intake/ elevated urea levels (n=1)). Other common diagnosis included hip issues (n=5; 20.0%), back pain (n=3; 12.0%), underweight (n=7; 28.0%), and menstrual irregularities (n=5; 20.0%).

According to the Shapiro-Wilk-Test, FM% was normally distributed for all groups ($p\geq0.05$). Mauchly-Test showed no violation of sphericity (p=0.605). A repeated measures ANOVA with the assumption of sphericity showed a statistically significant difference between the mean FM% ($F(2, 48)=64.46$, $p<0.001$, partial $\eta^2=0.729$) with a large effect according to Cohen. Bonferroni-corrected post-hoc-Test presented significant higher FM% for InBody measurement than for calipometry (MDiff=4.36, 95%CI[2.19, 6.52]; p<0.001). Moreover, Bonferroni-corrected post-hoc-Test showed a significant higher FM% for BIVA 101 measurement than for calipometry (MDiff=8.66, 95%CI[6.84, 10.52; p<0.001]) and a significant higher FM% for BIVA 101 measurement than for InBody measurement (MDiff=4.32, 95%CI[2.43, 6.22]; p<0.001). Figure 1 shows the comparison of FM% for all devices. The exact values of FM% of each measurement method are presented in table 1.

According to the Shapiro-Wilk-Test, BC parameters measured by InBody and BIVA 101 were normally distributed for all groups ($p\geq0.05$). The t-Test showed no significant differences between the BIA devices for TBW (t=-1.90, p=0.07). For the other BC parameters, t-Tests showed significant ($p<0.05$) differences. ECW was significant lower for InBody measurement than for BIVA 101 measurement (t=-29.28, p<0.001). The values for FFM measured by InBody were significantly higher than for BIVA 101 measurement (t=4.95, p <0.001). Similar to the comparison for the FM%, differences were also significant when comparing the absolute values of FM. The FM for InBody measurement was significantly lower than for BIVA 101 measurement (t=-6.23, p<0.001). The BMC for InBody measurement was significantly higher than for BIVA 101 measurement (t=20.44, p<0.001). The individual BC parameters of both BIA devices are shown in table 1 and the effect sizes for each parameter are presented in table 2. According to Cohen, there were large effects for ECW, FFM, FM and BCM.

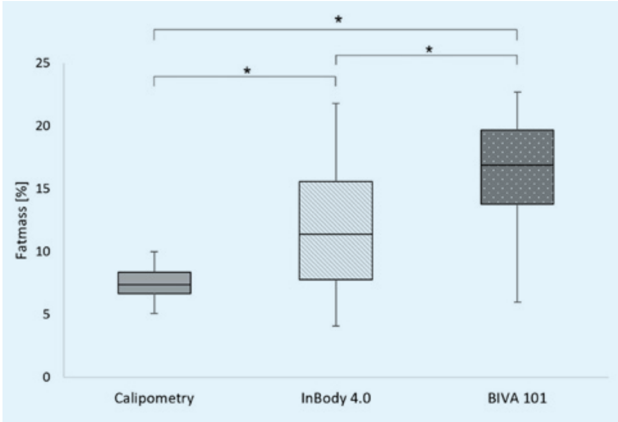

Figure 1

Fatmass (FM) % by calipometry, InBody 4.0 and BIVA 101. *significant result with p<0.05.

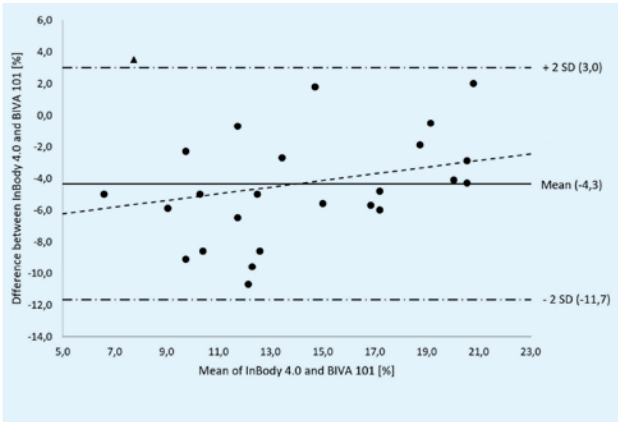

Figure 2

Bland-Altman Plot for fatmass (FM) % by InBody 4.0 and BIVA 101. Linear rgression equation y=-7.272+0.210*x. Arrow=values outside the interval mean +2SD.

With Bland-Altman Plot, the individual deviations between both BIA devices regarding FM% were considered (figure 2). Only one athlete represents an outlier. The average individual deviation (InBody 4.0 - BIVA 101) was -4.3% (95%CI[3.0, -11.7]). Furthermore, linear regression shows a decrease in the difference between InBody 4.0 and BIVA 101 with increasing mean values from both devices.

Discussion

The aim of this study was to examine the FM% and BC among ARGs with different measurement instruments and methods. To the best of our knowledge, no studies have been conducted on this topic in Germany to date. Such values could allow the classification of measured FM% values and ensure comparability. However, the results of this work have shown that the values of FM% differ greatly with various measurement methods. Significant differences were found between the two BIA devices and the caliper measurement. There were strong effects in each case, which indicates that the choice of measurement method or instrument has a decisive influence on the measured FM%. Regardless of the measurement method used, a relatively low FM% was observed in the ARGs studied.

Consideration of other studies investigating FM% in ARGs of similar age showed higher values. Examination of elite ›

Table 2

Mean differences and effect sizes for the comparison of InBody and BIVA 101. TBW=total body water; ECW=extracellular water; FFM=fat-free mass; FM=fat mass; BCM=body cell mass. *significant result with p<0.05 (two-sided test).

PARAMETER	MDIFF	SD	T	P-VALUE	D
TBW	-.424 l	±1.12	-1.90	.070	0.379
ECW	-3.116 l	±.53	-29.28	<.001	5.857*
FFM	1.780 kg	±1.80	Apr 95	<.001	0.989*
FM	-2.052 kg	±1.65	-6.23	<.001	1.246*
BCM	6.352 kg	±1.55	20.44	<.001	4.087*

ARGs using 9-point calipometry yielded values for FM% with 18.9% (16). Similarly, in sub-elite ARGs, FM% values by 16.5% were shown when measured by BIA/STA (Akern) (2). Further studies on ARGs of different performance levels and ages provided values for FM% between 13.8% and 20.7% measured by various InBody devices and calipometry (5,14,15).

When comparing the measurement methods used in this survey, it is noticeable that the measurement of FM% with the caliper, in contrast to a BIA measurement, is strongly dependent on the examiner. Caliper measurements are non-invasive and can be performed quickly, but they only provide information on FM%. With BIA measurements, additional BC parameters can also be determined. Depending on the BIA device, the time required is similar to a caliper measurement. BIA measurements provide various information about BC parameters. These values can be used, for example, to make statements about a person's state of health or nutrition. In the case of the ARGs studied, such parameters were determined using both the InBody 4.0 and the BIVA 101. When comparing both devices, it could be shown that all parameters (ECW, FFM, FM, and BCM) differ significantly from each other except for TBW. Similar to the FM%, this also changes the view when looking at BIA data. With different devices, various statements can be made about the BC. This confirms the fact that the comparison of BIA data and reference values is only possible on a device-specific basis. Accordingly, the classification of BC parameters can only be made against the background of the device used.

The differences between the two BIA devices in the comparisons of the BC parameter means were also evident when looking at the individual differences in terms of FM% by Bland-Altman plot for both BIA devices. Moreover, the linear regression indicated that athletes with higher values of FM% or with increasing mean values from both instruments, the differences between the instruments become smaller. Consequently, in addition to the general differences between various devices, individual BC or FM% may also have an impact on the variation between different methods.

However, intra-individual monitoring and comparisons over time can be performed and evaluated for athletes using one device. Here, athletes could be examined regularly in addition to JHUs, e.g., in their training groups. Especially in sports where athletes are at increased risk for underweight or low FM%, BIA measurements could be used preventively in addition to diagnosis. Furthermore, PhA can be determined during measurement with BIVA, which is one of the most important BIA parameters in the scientific and clinical context today. In athletes, such values could be used, for example, to assess muscle quality (6).

In the context of this work, BC surveys of ARGs were conducted for the first time in Germany. A strength of this work is the use of three different measurement methods. Furthermore, the high-performance level of the sample can be emphasized. All the athletes studied belong to the German national team of the rhythmic gymnastics. Due to the extensive investigation in the context of the JHU including complete surveys with the measurement methods, all relevant data were completely available without missing values.

A total of only 25 female athletes were examined. For more meaningful results, larger surveys are necessary here. Another limiting factor was that the measurements were performed by two examiners. Particularly in the case of the caliper measurement, this can play a role in the measurement results due to the examiner dependency. In the BIA measurements, not all possible disturbance variables could be excluded despite the standardized procedure. The temperature in the examination room was not measured. In addition, it could not be guaranteed that the ARGs were actually fasting at the time of measurement. Information on the menstrual cycle at the time of measurement was not available. These factors can influence the results of the BIA measurements (18).

Conclusion

The choice of method or instrument for the determination of BC in ARGs strongly influences the results. Therefore, parameters of BC can only be compared device-specifically and reference values have to be adjusted. The large differences in the measured BC parameters between the measurement methods indicate a need for further research in this regard. In order to obtain meaningful results on the BC of ARGs in Germany, further measurements with larger samples must follow. Nevertheless, such measurements can be used for the evaluation of intra-individual BC changes in athletes. Here, BIA measurements provide additional parameters compared to calipometry. Finally, the use of uniform BIA devices as well as recommendations for performing BC determinations in the context of JHU could provide further information on BC of athletes.

Conflict of Interest

The authors have no conflict of interest.

Summary Box

Different measurement methods for determining the percentage fat mass differ significantly from each other in their results. Reference values must be adapted accordingly to the respective devices.

There are significant differences in the determination of various body composition parameters between different BIA devices. A comparison across devices is not recommended.

References

(1) **BÖS K, SCHLENKER L, TITTLBACH S, KRELL-RÖSCH J, SCHMIDT S.** Testaufgaben zur Erfassung von Komponenten der motorischen Leistungsfähigkeit [Test items for the assessment of components of motor performance], in: Bös K. (Hrsg.): Handbuch Motorische Tests: sportmotorische Tests, motorische Funktionstests, Fragebögen zur körperlich-sportlichen Aktivität und sportpsychologische Diagnoseverfahren (3., überarbeitete und erweiterte Auflage). Hogrefe, Göttingen. 2017: 1-112.

(2) **D'ALESSANDRO C, MORELLI E, EVANGELISTI I, GALETTA F, FRANZONI F, LAZZERI D, PIAZZA M, CUPISTI A.** Profiling the diet and body composition of subelite adolescent rhythmic gymnasts. Pediatr Exerc Sci. 2007; 19: 215-227. doi:10.1123/pes.19.2.215

(3) **DE RUI M, VERONESE N, BOLZETTA F, BERTON L, CARRARO S, BANO G, TREVISAN C, PIZZATO S, COIN A, PERISSINOTTO E, MANZATO E, SERGI G.** Validation of bioelectrical impedance analysis for estimating limb lean mass in free-living Caucasian elderly people. Clin Nutr. 2017; 36: 577-584. doi:10.1016/j.clnu.2016.04.011

(4) **DEUTSCHER OLYMPISCHER SPORTBUND (DOSB).** Sportmedizinisches Untersuchungs- und Betreuungssystem im deutschen Leistungssport [Sports medicine examination and care system in German competitive sports]. DOSB 2014; https://cdn.dosb.de/user_upload/Leistungssport/Dokumente/sportmedizin_konzept_2019_30.07.2020.pdf [11 July 2023].

(5) **DIMITROVA A, IVANOVA-PANDOURSKA IY.** Body Composition Characteristics in Bulgarian Rhythmic Gymnasts. Acta morphologica et anthropologica. 2019; 26: 88-93.

(6) **DI VINCENZO O, MARRA M, SCALFI L.** Bioelectrical impedance phase angle in sport: a systematic review. J Int Soc Sports Nutr. 2019; 16: 49. doi:10.1186/s12970-019-0319-2

(7) **DI VINCENZO O, MARRA M, DI GREGORIO A, PASANISI F, SCALFI L.** Bioelectrical impedance analysis (BIA) -derived phase angle in sarcopenia: A systematic review. Clin Nutr. 2021; 40: 3052-3061. doi:10.1016/j.clnu.2020.10.048

(8) **GROUVEN U, BENDER R, ZIEGLER A, LANGE S.** Vergleich von Messmethoden [Comparison of measurement methods]. Dtsch Med Wochenschr. 2007; 132: e69-e73. doi:10.1055/s-2007-959047

(9) **HERM KP.** Methoden der Körperfettbestimmung [Methods of body fat determination]. Dtsch Z Sportmed. 2003; 54: 153-154.

(10) **JEON KC, KIM SY, JIANG FL, CHUNG S, AMBEGAONKAR JP, PARK JH, KIM YJ, KIM CH.** Prediction Equations of the Multifrequency Standing and Supine Bioimpedance for Appendicular Skeletal Muscle Mass in Korean Older People. Int J Environ Res Public Health. 2020; 17: 5847. doi:10.3390/ijerph17165847

(11) **KOBEL S, KIRSTEN J, KELSO A.** Anthropometry – assessment of body composition. Dtsch Z Sportmed. 2022; 73: 106-111. doi:10.5960/dzsm.2022.527

(12) **KYLE UG, BOSAEUS I, DE LORENZO AD, DEURENBERG P, ELIA M, GÓMEZ JM, HEITMANN BL, KENT-SMITH L, MELCHIOR JC, PIRLICH M, SCHARFETTER H, SCHOLS AM, PICHARD C; COMPOSITION OF THE ESPEN WORKING GROUP.** Bioelectrical impedance analysis--part I: review of principles and methods. Clin Nutr. 2004; 23: 1226-43. doi:10.1016/j.clnu.2004.06.004

(13) **LOHMAN TG.** Skinfolds and Body Density and Their Relation to Body Fatness: A Review. Hum Biol. 1981; 53: 181-225. http://www.jstor.org/stable/41464609 [11 July 2023].

(14) **MATSUSHITA S, HASHIZUME M, KISARA K, YOKOYAMA Y, KOTEMORI A, TADA Y, HIDA A, YOSHIMURA Y, ISHIZAKI S, KAWANO Y.** Time-of-Day of Energy Intake is associated with body fat percentage in Japanese female university rhythmic gymnasts and non-athlete students. J Nutr Sci Vitaminol (Tokyo). 2019; 65: 233-241. doi:10.3177/jnsv.65.233

(15) **MITEVA S, YANEV I, KOLIMECHKOV S, PETROV L, MLADENOV L, GEORGIEVA V, SOMLEV P.** Nutrition and body composition of elite rhythmic gymnasts from Bulgaria. Int J Sports Sci Coaching. 2020; 15: 108-116. doi:10.1177/1747954119892803

(16) **OLIVEIRA GL, GONÇALVES PSP, OLIVEIRA TAP, SILVA JRV, FERNANDES PR, FERNANDES FILHO J.** Assessment of body composition, somatotype and eating disorders in rhythmic gymnasts. Journal of Exercise Physiology. 2017; 20: 125-139.

(17) **PADWAL R, LESLIE WD, LIX LM, MAJUMDAR SR.** Relationship Among Body Fat Percentage, Body Mass Index, and All-Cause Mortality: A Cohort Study. Ann Intern Med. 2016; 164: 532-541. doi:10.7326/M15-1181

(18) **REIMERS C, MERSCH S, MÜLLER-NOTHMANN SD.** Die Bioelektrische Impedanzanalyse (BIA). Methoden zur Messung der Körperkompartimente in der Ernährungsmedizin [Bioelectrical Impedance Analysis (BIA). Methods for measuring the body compartments in nutritional medicine]. Schweiz. Zschr. GanzheitsMedizin. 2005; 17: 355-361. doi:10.1159/000281984

(19) **DICKHUT HH.** Sportmedizinische Untersuchungsverfahren - Körperkomposition, in: Dickhut HH, Röcker K, Gollhofer A, König D, Mayer F (Hrsg): Einführung in die Sport- und Leistungsmedizin. Hofmann Verlag, Schorndorf, 2011, 220-221.