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Comparison of Bioelectrical Impedance Parameters and Body Composition Among Street Workout Athletes According to Training Experience

Comparación de Parámetros de Impedancia Bioeléctrica y Composición Corporal entre Atletas de Street Workout Según Experiencia de Entrenamiento

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SUMMARY: Bioelectrical impedance analysis (BIA) is useful for determining bioelectrical parameters and body composition. In turn, differences have been reported when comparing these variables in athletes by training status. Nevertheless, there is no evidence of bioelectrical impedance parameters in Street Workout (SW) athletes. Thus, this study aimed to compare bioelectrical parameters and body composition through BIA between trained and untrained SW athletes. Twenty-two male SW athletes were classified as trained (n=6; 26.3 y [21.0–28.9]) and untrained (n=16; 21.8 y [20.5–24.7]) based on their SW experience. A bioelectrical impedanciometer was used to estimate bioelectrical parameters and body composition. There was no difference in body composition between trained and untrained SW athletes. Regarding impedance, trained athletes had lower values in the upper limbs (right arm: p=0.049; left arm: p=0.027) and trunk (p=0.004), while phase angle values were higher in the upper limbs (right arm: p=0.004; left arm: p=0.001), and trunk (p=0.006), as well as the mean phase angle (p=0.007), than untrained athletes. Bioelectrical impedance parameter differences found between SW training level groups suggest an improvement of tissue qualities, such as muscle, with SW practice. Future longitudinal studies should corroborate if SW training modifies these parameters.

KEY WORDS: Body composition; Electric impedance; Gymnastics; Sports

INTRODUCTION

Bioelectrical impedance analysis (BIA) is a low-cost, portable, simple-to-use, non-invasive, and reliable method to assess body composition (Marra *et al*., 2019). This technique measures the whole-body impedance, which is the opposition of an alternating current through the body composed of resistance and reactance (Norman *et al*., 2012). On the one hand, resistance reflects the opposition of a biological conductor to the alternating electrical current flow, and it represents conductivity through ionic solutions. On the other hand, reactance is the resistive effect due to capacitance from the body, which reflects the dielectric properties of cell membranes and tissue interfaces (Baumgartner *et al*., 1988; Norman *et al*., 2012). This information predicts body composition through equations and provides different bioelectrical parameters, such as phase angle (Norman *et al.*, 2012).

Phase angle, which has gained popularity in health and sports performance fields (Di Vincenzo et al., 2019; Mattiello et al., 2020), is an index of cell membrane integrity and vitality, expressing the quantity and quality of soft body tissues (Lukaski *et al*., 2017). It has been found that phase angle is a useful predictor for impaired muscle function, quality of life, mortality, sarcopenia, and muscle strength, as well as an effective tool for nutritional status assessment (Beberashvili *et al.*, 2014; Zhang *et al*., 2014; Ding *et al*., 2022). Therefore, the assessment of phase angle through BIA seems useful to assess the quality of body tissues in athletes.

Studies have compared BIA parameters in sports considering the training status. For example, elite and youth elite road cyclists had higher reactance and phase angle levels than amateur cyclists (Giorgi *et al*., 2018). Furthermore, the

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bioimpedance vector was higher in elite volleyball players than in sub-elite and low-level groups (Campa & Toselli, 2018). In addition, a study in climbers found that federated athletes had higher trunk phase angles than recreative climbers (Olate-Gómez *et al*., 2021). For this reason, training status and experience appear to be linked to BIA parameters; thus, the assessment of these variables and comparison between training statuses is relevant for novel sports.

Street Workout (SW) is a novel and outdoor sport based on calisthenic exercises, which are performed on bars, parallel bars, floors, or rings in parks or on beaches (Thomas *et al*., 2017; Taipe-Nasimba & Chirivella, 2020). In this regard, practice is performed with or without equipment because exercises use one's body weight as resistance. Research on SW has increased slightly in recent years, covering different fields. For example, research on psychological profiles indicated that practitioners are predominantly young males motivated for health and their physical appearance (Taipe-Nasimba & Chirivella, 2020). Another study identified the injury profile, reporting that the most frequent diagnosis is tendinopathy, whereas the shoulders and the upper and mid-back are the most injured body parts (Ngo *et al*., 2021). Furthermore, a morphological study using anthropometry found that competitive SW athletes had a balanced-mesomorphic somatotype, high development of upper limbs and trunk, high muscle mass levels, and low fat mass levels (Sanchez-Martinez *et al.*, 2017). Finally, a study evaluated the effect of calisthenic exercises, commonly performed in SW, and found improvements in posture, push-up and pull-up repetitions, and fat mass in comparison to the control group (Thomas *et al.*, 2017). However, despite the previous research, a comparison of bioelectrical impedance parameters in SW based on training level has not been undertaken. For this reason, the objective of this study is to compare the bioelectrical impedance parameters and body composition between untrained (novice) and trained (experienced) adult SW athletes.

MATERIAL AND METHOD

Participants. Thirty-seven male SW athletes from Viña del Mar (Chile) voluntarily participated in this study between August and October 2015. Inclusion criteria were i) healthy male above 18 years old, ii) current practice of SW, iii) anthropometric and bioelectrical impedance assessment, and iv) free of acute muscle-skeletal injuries. Fifteen participants were excluded due to missing BIA data; therefore, the final sample was composed of 22 athletes. In addition, participants had to sign an informed consent form, which indicated the study protocol and objectives. Moreover, this research met the current Declaration of Helsinki criteria for human research.

Training experience categories. Participants were categorized by training status as trained, defined as at least one year of resistance training experience or an athlete participating in a competitive sport at the high school, collegiate, or professional level, or untrained, defined as less than one year of resistance training experience (Williams *et al.,* 2017).

Anthropometric measurements. Body weight (OMROM, HN-289-LA, Kyoto, Japan) and height (SECA, model 213, GmbH, Germany) were measured by certified ISAK anthropometrists at the IRyS Laboratory of the Pontificia Universidad Católica de Valparaíso.

BIA parameters. Segmental (right and left arm, trunk, and right and left leg) impedance, reactance, and phase angle values were acquired through BIA at 50 kHz frequency (InBody S10, InBody Co, Ltd, Seoul, Korea). Mean scores of the segmental impedance, reactance, and phase angle values were computed.

Body composition. Whole-body fat mass, percentage of fat mass, fat-free mass (FFM), skeletal muscle mass, soft lean mass, bone mineral content, visceral fat mass, and segmental lean mass were obtained through BIA.

Statistical analysis. Data analysis was performed using IBM SPSS Statistics Version 25 for Mac (IBM Corp). Data are presented as mean and standard deviation for parametric data or median and interquartile range (IQR; P25–P75) for non-parametric data. Likewise, data distribution was evaluated using the Shapiro–Wilk test. Then, mean comparisons of independent samples were performed using t-test statistics for parametric data and Mann–Whitney U for non-parametric data. The significance level was set at $p<0.05$.

RESULTS

Demographic and anthropometric data of trained and untrained SW athletes are shown in Table I. Trained athletes had higher SW training experience than untrained participants (p=0.004), with a mean difference of 1.75 years. No differences were found concerning age, height, weight, and body mass index.

Table II shows trained and untrained SW athletes' segmental and mean impedance, reactance, and phase angle values. Trained athletes had lower impedance values in the right arm (-4.0 %; p=0.049), left arm (-6.2 %; p=0.027), and trunk (-18.7 %; p=0.004), whereas reactance values were similar between groups. The trained group had higher segmental phase angle values in the right arm (+12.7 %; p=0.004), left arm (+14.5 %; p=0.001), and trunk (+14.8 %; p=0.006), as well as a greater mean phase angle (+12.0 %; p=0.007) than the untrained group.

Table III presents the body composition values of the SW training experience categories. No differences were found between groups in whole-body fat mass, FFM, skeletal muscle mass, visceral mass, bone mineral content, and segmental lean mass.

Table I. Demographic and anthropometric data of trained and untrained Street Workout athletes.

Variable	Trained (n=6)	Untrained (n=16)	*p-value*
Age (year)	26.3 (21.0-28.9)	21.8 (20.5-24.7)	0.098
Experience (months)	23.5 ± 10.5	2.5 ± 2.1	**0.004**
Weight (kg)	65.7 (64.7-66.9)	71.5 (64.5-73.9)	0.407
Height (cm)	167.5 ± 4.1	172.9 ± 6.1	0.058
Body mass index (kg/m^2)	23.6 ± 1.6	23.7 ± 2.4	0.951

Data are shown as mean ± standard deviation, or median (P25-P75). Significance is shown in bold, p<0.05.

Table II. Bioelectrical impedance parameters of trained and untrained Street Workout athletes.

Variable	Trained (n=6)	Untrained (n=16)	*p-value*
Impedance RA (Ω)	269.2 (259.3-278.3)	280.3 (271.2-303.2)	**0.049**
Impedance LA (Ω)	267.7 (258.2-279.0)	285.5 (274.2-302.1)	**0.027**
Impedance TR (Ω)	14.8 ± 2.0	18.2 ± 2.3	**0.004**
Impedance RL (Ω)	212.5 ± 19.2	222.2 ± 24.3	0.391
Impedance LL (Ω)	214.7 ± 17.1	227.3 ± 25.8	0.285
Mean impedance (Ω)	196.8 (194.4-200.6)	205.6 (199.9-219.2)	0.059
Reactance RA (Xc)	33.1 (30.7-35.9)	31.5 (30.6-33.6)	0.590
Reactance LA (Xc)	32.8 (31.0-36.3)	31.6 (30.6-32.7)	0.449
Reactance TR (Xc)	3.3 (2.8-3.6)	3.4 (3.2-3.5)	0.590
Reactance RL (Xc)	29.0 ± 4.7	28.0 ± 3.6	0.602
Reactance LL (Xc)	29.1 ± 5.0	28.2 ± 3.5	0.644
Mean reactance (Xc)	25.5 ± 3.2	24.7 ± 2.4	0.538
Phase angle RA (°)	7.1 ± 0.5	6.3 ± 0.5	**0.004**
Phase angle LA (°)	7.1 ± 0.5	6.2 ± 0.5	**0.001**
Phase angle TR (°)	12.4 ± 1.0	10.8 ± 1.1	**0.006**
Phase angle RL (°)	7.8 ± 0.9	7.2 ± 0.7	0.149
Phase angle LL (°)	7.8 ± 1.0	7.2 ± 0.7	0.110
Mean phase angle (°)	8.4 ± 0.7	7.5 ± 0.6	**0.007**

Data are shown as mean ± standard deviation, or median (P25-P75). LA: left arm; LL: left leg; RA: right arm; RL: right leg; TR: trunk. Significance is shown in bold, p<0.05.

Table III. Body composition values through the bioelectrical impedance of trained and untrained Street Workout athletes.

Variable	Trained (n=6)	Untrained (n=16)	*p-value*
Fat mass (kg)	8.3 (6.2-9.6)	10.2 (7.1-13.9)	0.154
Fat mass (%)	11.5 (9.6-14.4)	14.1 (11.5-20.7)	0.134
Soft lean mass (kg)	54.1 (53.4-55.4)	55.8 (54.5-58.9)	0.294
Fat free mass (kg)	57.4 (56.6-58.8)	59.3 (57.8-62.4)	0.294
Skeletal muscle mass (kg)	32.7 (32.1-33.5)	33.8 (32.7-35.9)	0.407
Segmental lean RA (kg)	3.4 ± 0.4	3.3 ± 0.4	0.535
Segmental lean LA (kg)	3.4 ± 0.4	3.3 ± 0.4	0.459
Segmental lean TR (kg)	25.6 (24.9-26.8)	26.0 (25.2-27.1)	0.747
Segmental lean RL (kg)	8.3 (8.1-8.4)	9.1 (8.5-9.3)	0.154
Segmental lean LL (kg)	8.3 (8.1-8.4)	9.1 (8.5-9.3)	0.178
Visceral fat mass (kg/m^2)	44.1 (38.8-51.4)	49.7 (36.9-66.3)	0.541
Bone mineral content (g/cm)	3.4 ± 0.4	3.4 ± 0.5	0.827

Data are shown as mean ± standard deviation, or median (P25-P75). LA: left arm; LL: left leg; RA: right arm; RL: right leg; TR: trunk.

DISCUSSION

This study compared the bioelectrical impedance parameters and body composition between trained and untrained SW athletes. The main findings were that trained SW athletes had lower impedance and higher phase angle values in the upper limbs and trunk and a higher mean phase angle than the untrained group. However, no differences were found in body composition measured through BIA.

Bioelectrical parameters. The differences in impedance and phase angle values between groups in the upper limbs and trunk could be explained by the training characteristics of SW. Firstly, calisthenic exercises in SW (e.g., pull-ups and push-ups) are mainly performed by the upper limbs and trunk. It has been found that strength training improves phase angle (Fukuda et al., 2016; Ribeiro et al., 2017), enhances muscle hypertrophy, and reduces the resistive behavior of bodily tissue, basically because the training type can raise cellular hydration by increasing glycogen storage (MacDougall et al., 1977; Baumgartner et al., 1988; Ribeiro et al., 2017). Thus, the lower impedance and higher phase angle values found in the trained group could result from the higher experience time of strength training focused on the upper limbs and trunk compared to those with less training experience in SW.

Despite the differences in mean phase angles between groups, both had high values. Both groups are above the mean normative phase angle value (6.89±0.72°) for 20–29-year-old males with BMI between 18.5 and 25.0 (Bosy-Westphal et al., 2006), as well as above the normative mean score (6.9°; 95% CI: 6.6–7.2) for 20–29-year-old males reported in a meta-analysis (Mattiello et al., 2020). In addition, another meta-analysis found that physical activity interventions have higher phase angle values than the control group and greater values in more active participants (Mundstock et al., 2019). Likewise, it has been found that muscle strengthening could increase the phase angle more than another type of training (Di Vincenzo et al., 2019). In addition, it has been determined that athletes used to have a higher mean phase angle than normal people (Marra et al., 2019), which could be explained by muscular hypertrophy that increases intracellular fluid volume in trained athletes (Micheli *et al.*, 2014). Thus, the above-mentioned reasons could explain the high phase angle values in both groups and their differences.

Body composition. There were no differences between trained and untrained SW athletes in any body composition variable. In this regard, these results are not in line with our previous research that found differences between trained and untrained SW athletes (Sanchez-Martinez & Hernández-Jaña, 2022). Our previous study estimated body composition through anthropometry, and the analyses included a slightly larger sample size in each group. The present study used a smaller sample size due to the limited availability of the BIA equipment. For this reason, the smaller power/sample size could partially explain the discrepancy between the studies. The disagreement of methods for body composition estimations has been reported in the literature. Thus, there is inconsistency regarding whether anthropometry or BIA had better reliability for body composition estimations compared to dual-energy x-ray absorptiometry (DEXA) (Wattanapenpaiboon et al., 1998; Sillanpää et al., 2013; Arias Téllez et al., 2019). Interestingly, a study found that a combined method using anthropometry and BIA to assess the percentage of body fat in female athletes had an improved prediction and lower error compared to skinfolds or BIA independently (Foote et al., 2021). Further research should assess the reliability of anthropometry and BIA to estimate body composition in SW athletes, using DEXA as a reference.

Finally, it is relevant to note that despite the similar body compositions of both groups, we found differences in bioimpedance parameters. These results suggest that, independently of the fat, muscle, or bone mass, experienced athletes had a healthier quality of tissues.

Strengths and limitations. The reported bioimpedance parameters of SW athletes are useful as reference values for sports performance and health fields or further research. Nonetheless, there are still some limitations. For instance, a doubly indirect method to measure body composition increases errors; thus, it would be recommended that future studies estimate the reliability of BIA, or anthropometry, to predict body composition using DEXA as a reference. Furthermore, given the design of our study, it cannot be determined if the practice of SW modifies bioelectrical parameters. Thus, longitudinal studies following SW intervention should address this question. Similarly, the small sample size only allows representing subjects with similar characteristics to our participants. Furthermore, this study was restricted to male athletes; therefore, future studies should include female athletes in this novel sport.

CONCLUSION

In summary, experienced SW athletes had lower impedance and higher phase angle in the upper limbs and trunk than novice SW athletes, independently of the similar body composition assessed through BIA. These differences could suggest that SW practice improves the quality of the body tissues; however, further longitudinal studies may corroborate if SW interventions modify bioelectrical variables.

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RESUMEN: El análisis de impedancia bioeléctrica es útil para determinar parámetros bioeléctricos y de composición corporal. A su vez, se han reportado diferencias al comparar estas variables en atletas según su estado de entrenamiento. Sin embargo, no hay evidencia de parámetros de impedancia bioeléctrica en atletas de Street Workout (SW). Por tanto, este estudio tuvo como objetivo comparar los parámetros bioeléctricos y la composición corporal entre atletas de Street Workout entrenados y no entrenados. Veintidós atletas masculinos de Street Workout fueron clasificados como entrenados (n=6; 26.3 años [21.0-28.9]) y no entrenados (n=16; 21.8 años [20.5-24.7]) en función de su experiencia en Street Workout. Se utilizó un impedanciómetro bioeléctrico para estimar los parámetros bioeléctricos y la composición corporal. No hubo diferencias en la composición corporal entre los atletas de SW entrenados y no entrenados. En cuanto a la impedancia, los atletas entrenados tenían valores más bajos en los miembros superiores (brazo derecho: p=0,049; brazo izquierdo: p=0,027) y en el tronco (p=0,004), mientras que los valores del ángulo de fase eran más altos en los miembros superiores (brazo derecho: p=0,004; brazo izquierdo: p=0,001), en el tronco (p=0,006), así como la media del ángulo de fase (p=0,007) que los atletas no entrenados. Las diferencias en los parámetros de impedancia bioeléctrica encontradas entre los grupos según el nivel de entrenamiento de SW sugieren una mejora de las cualidades de los tejidos, como el músculo, con la práctica de SW. Futuros estudios longitudinales deberían corroborar si el entrenamiento SW modifica estos parámetros.

PALABRAS CLAVE: Composición corporal; Deportes; Gimnasia; Impedancia eléctrica

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