Body composition of active persons with spinal cord injury and with poliomyelitis

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ORIGINAL ARTICLE

ABSTRACT

This study sought to evaluate the body composition of subjects with active spinal cord injuries and polio. **Method:** Two groups of males and females, active, free-living, of similar ages and body mass index (BMI), were distributed according to the source of deficiency: SCI - low spinal cord injury (T5-T12) and P - survivors of poliomyelitis infection. Body composition was analyzed by DEXA (fat and lean mass); bioelectrical impedance by vector analysis (BIVA analysis; resistance and reactance). Participants of the same gender were compared according to the source of deficiency, and both groups had their values compared to a reference population, when available. **Results:** Mean vectors were assessed with Hotelling's T^2 test and compared by Mahalanobis distance (D). DEXA analysis pointed out the men of P group with higher absolute amount of lean mass, and consequently the higher body lean mass index; both groups presented lower values than a reference study. With regard to BIVA analysis, P men presented higher resistance than SCI men and, consequently, a lower phase angle. **Conclusion:** Considering body composition as an indirect indicator of nutritional status, the present study suggests that, even with both groups presenting lower values than a reference population, there is a possibility of an increased nutritional risk for polio individuals than SCI, and this risk seems to be higher in men than in women. Further investigation, adopting biochemical and dietetic markers, and a higher sample size, certainly could better explore and understand our results.

Keywords: body composition, motor activity, nutrition assessment, paraplegia, poliomyelitis

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INTRODUCTION

Lesions of the central nervous system, traumatic (such as spinal cord injury) and non-traumatic (such as poliomyelitis), result in different degrees of paralysis. Paralysis reduces autonomy, compromises one's nutritional state, and increases the risk of developing a series of diseases.[1] Although recent years have seen an important increase in the number of studies related to lesions of the nervous system, a greater understanding and monitoring of the people afflicted is still necessary. Recent data indicates that mortality related to spinal cord injury is mostly caused by factors that could have been prevented and/or treated.[2]

Most studies related to paralysis are focused on traumatic lesions, especially due, in current times, to great urban violence, such as assaults with firearms and traffic accidents, among other things. However, it is important to remember the other types of lesions of the nervous system, which affect different genders and different ages. For example, although poliomyelitis is considered practically eradicated across the world, many people still live with its sequelae, yet few studies investigate the nutritional state of these people.[3] In addition, regardless of the origin of the deficiency, the studies are mostly made with males; few of them include females.[4]

When trying to emphasize the importance of evaluating the nutritional state of people with handicaps, we must keep in mind that a reduction in body lean mass can be a factor related to nutritional risk. The skeletal muscle, in addition to being considered the main reserve of body proteins, is capable of directing the production of antibodies, the healing of wounds, and the production of white cells in the blood, as much in acute as in chronic events. Therefore, if there is any depletion of the skeletal muscle, this means less protein to guarantee the appropriate nutritional state and, consequently, health.[5,6]

Taking into consideration the points discussed above, it is important then to consider that the analysis of body composition, in identifying muscle mass, is an indicator of the nutritional state. Among the different methods and techniques to analyze body composition, we can mention the use of dual energy X-rays (DEXA). Analysis by DEXA allows the differentiation of muscle mass, bone mass, and adipose mass. It has been hailed as a good method to use with people with spinal cord injury, it is considered fast, accurate, and is a relatively simple procedure.[7] However, the wide application of this method is limited by factors such as the price of the equipment and the need for highly specialized technicians and specific locations to perform the analyses. Thus, it is important to search for alternative methods to monitor the alterations in the body composition (and, therefore, the nutritional state) of people with some kind of immobility.

The analysis of body composition by electrical bioimpedance (BIA) is considered practical, low cost, non-invasive and it is an easy procedure.[8] Nevertheless, it is a difficult method to be adopted in studies on people with handicaps, due to the need to interpret specific regression equations. In the literature, there are no formulas that may be considered appropriate for people with paraplegia (paralysis of the lower limbs) or quadriplegia (paralysis of the upper and lower limbs), or even people with sequelae from poliomyelitis, due to the extreme variability among these individuals. In order to help with this type of difficulty, we can mention a relatively new proposal to interpret bioimpedance - the vector analysis (BIVA). In this type of investigation, the resistance (R) and the reactance (Xc) are obtained at 50 kHz and normalized by height, before being plotted in the form of a two-axis vector.[9] It must be considered that Xc is the resistive effect produced by the interfaces of the tissues and by the cellular membranes to an alternating electrical current, while R is the pure opposition to a biological conductor. The phase angle generated reflects the contribution between R and the capacitance (arc tangent of the relationship of capacitance to R, transformed into degrees). The values of Xc and of the phase angle have been shown to be of prognostic importance in the course of many diseases such as cancer,[10] in viral infection by HIV,[11] or in Alzheimer's Disease.[12] Based on all this information, we suggest that an analysis by BIVA is a good tool to evaluate people with paraplegia, especially where a more robust and sensitive analysis such as DEXA is not feasible.

A great deal of recent information has made it clear that physical activity, parallel to appropriate dietary control, is a fundamental factor in the acquisition and/or improvement of the quality of life for any person, including those with handicaps. These interventions are capable of improving body composition, pulmonary function, cardiovascular system, strength and physical conditioning, in addition to providing important psychological changes.[13,14] However, in order to extract the maximum benefit from physical activity, many evaluations are necessary, including that for nutritional state.[15]

OBJECTIVE

Considering the above, and also considering the reduced information available in the literature on the nutritional state of people with paraplegia and other handicaps, the present study seeks to evaluate the body composition of people with spinal cord injuries and with sequelae from poliomyelitis, using DEXA and BIVA analyses.

METHOD

The recruiting of participants was made in different clubs involved with sports for people with physical handicaps in the city of São Paulo-SP, Brazil, and all those were included who fitted into the criteria described below. This is, therefore, a non-probabilistic sample of convenience.

Males and females were included in the study if they satisfied the following conditions: they should present lower spinal cord injury, from T5 to T12 and complete lesion (group SCI), or poliomyelitis sequelae in only one of the lower limbs (group P), and should be in that condition for at least one year. Also, the participants should be involved in physical exercise groups (wheel-chair basketball) for at least one year, exercising at least twice a week for a minimum period of one hour. The age of the participants should be between 20 and 40 years old. The different genders were paired by age and body mass index (BMI = weight/height^2).

People who volunteered to participate were duly oriented as to the objectives of the study and its procedures, and the project was approved by the Committee for Ethics in Research by the University of São Paulo - Pharmaceutical Sciences School, protocol no 50/2001.

Anthropometry

The participants were weighed on a digital scale (Filizola®, precision 100 g), wearing light clothes. Those wearing prostheses or other orthopedic equipment were asked to remove them, and were weighed without those devices. The participants who could not be weighed in the standing position were seated on the scale platform so that their body weight was distributed on the center of the platform. Then the participants were placed on a bed, in the supine position. Their legs were extended, their heads were positioned in the Frankfurt plane, and their feet put in dorsal flexion. The body length was determined using a non-elastic anthropometric tape, measuring them from head to foot.

Analysis by DEXA

The body composition was analyzed by DEXA with the Lunar equipment (Lunar Corporation; Madison, Wiscosin, USA). All the participants were analyzed on the same day of the anthropometric measurements. The subjects lay on the equipment bed for a period of approximately 20 minutes, while the analysis was being done on the whole body. From the results, the following variables were included on the data spreadsheet: adipose mass (AM) and lean mass (LM). Also, from those results the percentage of body fat (%F) was calculated, and also the relative index of lean mass (RILM), which consists of the sum of appendicular lean mass divided by the square of the body length.[16]

Analysis by electrical bioimpedance

The bioimpedance analysis (Biodynamics 350e®) was made after a night of resting and fasting, on the day after the DEXA evaluation was made. The participants arrived at the laboratory between 7:00 AM and 9:00 AM and were previously warned not to perform physical exercises on the day before, and not to ingest food three hours before the test, but to drink water normally. The analysis was made with the participants in the supine position on a non-conductive surface, with the electrodes properly placed on their hands and feet, at the specifically determined points. It is important to point out that on those people with poliomyelitis, the electrodes were placed on the side not affected by paralysis, and this was the reason to exclude the individuals with two affected limbs from the study. Before beginning the analysis, the subjects were kept in the supine position for 10 minutes, to allow the distribution of body water. The BIA data was then analyzed by resistance (R) and reactance (Xc), plotted onto a R/H Xc/H graph. For plotting the graph, we utilized software specific for vector analysis (Piccoli A Pastori G. BIVA SOFTWARE 2002. Department of Medical and Surgical Sciences, University of Padova, Italy).

Statistical Analyses

The data is presented as average ± standard deviation (SD). Within the same gender, the different origins of paralysis of the lower limbs (SCI and P) were compared by the Student t-test for independent samples. The analyses were made with the help of the Statistica software 7.0 (Statsoft, Inc.). The Hotteling T^2 test was used to test the equality of averages of the vectors associated with the bioimpedance analysis of different groups. If the null hypothesis of equality had been rejected, simultaneous confidence intervals would have been created to determine which components of the main vector differed between the two groups. The Mahalanobis distance (D) between the two groups was also calculated. For these last two analyses, the BIVA software was adopted (Piccoli A, Pastori G. BIVA SOFTWARE 2002, Department of Medical and Surgical Sciences, University of Padova, Italy). The acceptable level of statistical significance was established as $p < 0.05$ for all the analyses made. In the bioimpedance analyses, it was possible to make a statistical comparison with a reference population without paraplegia from the information generated in the National Health and Nutrition Examination Survey.[17] However, there are no available studies in the literature yet with reference populations for the analyses of body composition by DEXA. For this reason, the present study, only for the effect of discussing the data, utilized information available in the literature that analyzed body composition by methods other than DEXA.[18]

RESULTS

For this study there were 24 males and 13 females who volunteered. From those, two males were excluded (one for having poliomyelitis sequelae on the upper limbs, and another, with spinal cord injury, for having it for less than one year). One female was excluded also for having injured her spinal cord less than one year before. Therefore, 22 males and 12 females were included in the study.

Table 1 describes the participants' main anthropometric and body composition measurements. For the males, the SCI group presented greater values of lean mass (LM) than the P group. In relation to the BIVA analysis, the males in the P group showed greater values of resistance than the males in the SCI group. For the females, no significant differences were identified between the origins of paraplegia, for any of the variables.

Figure 1 describes the analysis by BIVA. The P group seems to have shown less satisfactory results than the SCI group, especially among the males. The males from the P group showed greater resistance per unit of height (R/H) than the SCI group and, consequently, a smaller phase angle. The females in the P group showed greater R/H than the ones from the SCI group. The distance calculated between the SCI and P vectors (D value) was statistically significant among males, but not among females. Regarding the population reference values the males in the SCI group, as well as the females, had results closer to the reference population than those in the P groups.

DISCUSSION

The present study investigated and compared the body composition of active people with poliomyelitis or spinal cord injury, whenever possible utilizing data from a reference population. As main findings, people with paralyses (SCI or P) showed diminished values of lean mass and had distinctive electrical behavior (more resistance, less reactance, and smaller phase angle) in relation to a reference population without paralyses. Also, the results seem to be less satisfactory for those participants with poliomyelitis.

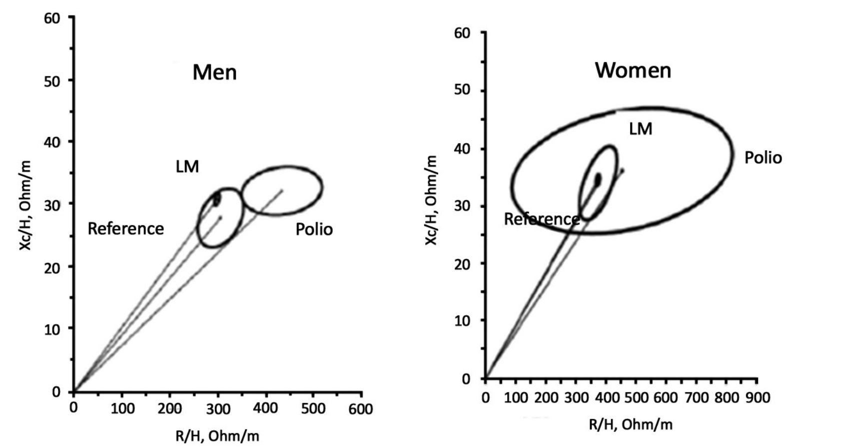
Experimental observations with BIVA analysis have demonstrated distinctive values of resistance, reactance, and phase angle in individuals pathologically underweight (as in the cases of cachexia or anorexia),[9] in elderly with sarcopenia,[19] and in different situations of loss of motoneurons.[20] High values of resistance may mean a low state of hydration or a low quality of muscle mass. In some situations (such as those mentioned above), there is loss of body lean mass, while the adipose mass is preserved or even increased.[21] If we extrapolate this statement to the comparison made in the present study between P and SCI groups, we observe that SCI shows greater lean mass, with no difference in the body fat, which can indicate the possibility that the P group showing a less favored nutritional state, taking the muscle mass as an indicator.

The results regarding the fat and body muscle mass analyzed by DEXA from the NHANES III[17] are not available yet in the scientific literature, which prevented us from

Table 1. Anthropometric and body composition variables for the participants in the study

Variable	Males		Females	
	SCI (n = 15)	*p* (n = 18)	SCI (n = 7)	*p* (n = 5)
Age (years)	28.7 ± 7.5	31.9 ± 8.6	34.0 ± 7.6	27.7 ± 5.5
BMI (Kg/m²)	22.7 ± 3.3	22.5 ± 3.5	23. 4 ± 3.9	27.3 ± 6.3
AM-Adipose Mass (Kg)[1]	16.5 ± 12.3	14.0 ± 7.5	19.9 ± 8.0	27.2 ± 17.4
MM-Muscle Mass (Kg)[1]	48.7 ± 6.4*	39.0 ± 5.2	34.7 ± 3.3	39.5 ± 2.3
% body fata	21.9 ± 13.4	23.8 ± 11.2	32.8 ± 8.8	36.4 ± 14.8
RILM[3] (Kg/m²)	21.4 ± 4.2*	15.0 ± 4.7	15.7 ± 2.4	17.9 ± 2.1
Resistance/Ht (Ω/m)[2]	306.2 ± 65.1*	434.5 ± 128.9	374.2 ± 44.5	453.4 ± 163.0
Reactance/Ht (Ω/m)[2]	27.8 ± 6.4	32.1 ± 5.9	33.9 ± 4.6	36.0 ± 4.8

* significant difference ($p < 0.05$- *t*-test for independent samples); [1] analysis by DEXA; [2] analysis by BIA; [3] RILM (relative index of lean mass) = appendicular muscle mass measured by DEXA)/height²



Groups	T^2	*p* value	D
SCI *vs* reference	4.8	0.09	0.58
P *vs* reference	140.9	0.00	2.87
SCI *vs* P	13.9	0.00	1.30

Groups	T^2	*p* value	D
SCI *vs* reference	0.1	0.97	0.12
P *vs* reference	8.5	0.01	1.69
SCI *vs* *P*	1.7	0.51	0.90

D= *Mahalanobis distance* between two groups ; R/H= resistance normalized by height; T^2 = statistics for the Hotelling's T^2 test; Xc/H = reactance normalized by height; Reference population, same gender and age bracket.

Figure 1. Positioning of bioimpedance vectors for both groups and for the reference population (NHANES III)

using this data to compare with the participants in the present study. The only source of information on these components of body composition from the NHANES III was published by Chumlea et al.,[18] however, these values were estimated from the electrical bioimpedance analysis. Another problem with using this American reference is that the data is evaluated by race. Considering the great miscegenation of the Brazilian population, sometimes it is practically impossible to classify a person as white or black. Thus, only so that there is some type of reference for comparison, we extracted the data from the publication by Chumlea et al.,[18] for the age bracket of the present study, combining the races and establishing a range between the minimum and maximum values found. In this way, in the mentioned study for males, the body fat percentage ranged between 21.8 and 25.4%, and for females it was between 31.0 and 38.0%. Correlating this data with the present study, we can affirm that the fat percentage of people with handicaps is found similar to the values of a population without impairments. Using the same type of approach to the absolute muscular mass, the data from Chumlea et al.,[18] indicates values for males between 55.7 and 63.6 kg, and for females between 40.8 and 46.4 Kg. These values place the participants of the present study below what was expected, which could therefore be considered as low muscularity. Despite both groups (SCI and P) being in this muscular condition, the statistical analysis made indicates lower values in P than in SCI. This can lead to speculating that the quality of the muscle in P may be less favorable than in SCI. And considering this speculation, it is possible to suppose that the nutritional state indicated by body composition of people with P is more unfavorable than those with SCI. Obviously, more investigation is necessary to confirm these affirmations.

It is recognized that paralysis is related to changes in the composition of the body tissues, and literature data confirms this affirmation. In a study with females placed immobilized in bed for 60 days, the fat from the bone marrow of the lumbar vertebra increased an average of 2.5%. The osteoblasts and adipocytes are derived from the same progenitor cell (mesenchymal stem cell) in the bone marrow.[22,23] This important information explains the fact of immobilization promoting changes in the composition of the tissues, but do not explain why the P group showed unfavorable results in relation to the SCI group. One possibility is that because the poliovirus is generally acquired in infancy, the loss and/or modification of tissues had been occurring for a greater period of time, much longer than in the participants of the SCI group. However, it would be expected that these losses would stabilize in adulthood, unless other complications such as post-polio syndrome had occurred, which was not the case with these participants.[24]

The unfavorable results in the P groups were also observed among the females, but in lesser proportion and without statistical significance. On the one hand, it must be taken into consideration that this absence of significance may be due to the small size of the sample, but on the other hand, it can be speculated that there is a hormonal component that explains this lesser difference among the women. All of them were in their fertile period of life, without any sign of menopause (all of them were less than 40 years old), and that may represent estrogenic protection. Bauman et al.,[25] in a study with discordant twins for spinal cord injury, indicated in these women a tendency to greater serum concentration of total estradiol.

Nevertheless, even taking into consideration the great limitation of our representative sampling, the present study draws attention to the fact that, while monitoring active people with paraplegia, it is important to give special attention to any poliomyelitis sequelae. Generally, in these active groups, a greater concern is observed with people with SCI, especially for the double loss (motor and sensory). Even with polio being essentially a motor affliction, our results signalized a worse muscular state (and, therefore, a greater risk for the nutritional state), despite the practice of physical exercise. Additional data on nutritional evaluation, with the use of biochemical and diet markers, and a higher number of subjects, will certainly explore and elucidate these findings better.

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