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Analysis of body composition values in men with different spinal cord injury levels

Análise dos valores de composição corporal em homens com diferentes níveis de lesão medular

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Abstract

Introduction: The proportion between lean body mass and fat mass is a predictor of metabolic diseases. Thus, quantifying body composition variables, starting an analysis of reference values according to the spinal cord injury (SCI) levels, became important for planning and monitoring physical activities. **Objectives**: 1) Determine reference values for the sum of skinfolds (ΣSF) and fat mass percentage; 2) detect body composition differences between SCI levels; 3) correlate ΣSF to time since injury and body mass index (BMI). **Materials and methods**: Seventy four male patients with SCI, aged from 18 to 52 years, were classified into quadriplegia (QP – C4 to C8), high paraplegia (HPP – T1 to T6), and low paraplegia (LPP – T7 to L3). Body composition was assessed by means of skinfolds. **Results**: There was no significant difference between QP, HPP, and LPP for the variables time since injury, height, total body mass, ΣSF, fat mass percentage, lean body mass, and BMI. Only age differed between the groups QP and LPP ($p < 0.05$). The variable ΣSF did not correlate to injury level (rho = -0.08; CI 95%: -0.537 to 0.420) or to time since injury (rho = 0.18; CI 95%: -0.050 to 0.393). There was no significant difference between complete and incomplete injury for all anthropometric variables. The ΣSF positively correlated to BMI (rho = 0.68; CI 95%: 0.539 to 0.739). **Final remarks**: TT, HPP and LPP showed no significant differences in the body composition values. The BMI showed a good correlation to ΣSF between groups.

Keywords: Body composition. Physical activity. Anthropometry. Spinal cord. Rehabilitation.

Resumo

***Introdução**: A proporção entre massa corporal magra e de gordura é um preditor de doenças metabólicas. Assim, quantificar variáveis de composição corporal, iniciando uma análise de valores de referência de acordo com o nível da lesão medular (LM), tornou-se importante para o planejamento e monitoramento de atividades físicas. **Objetivos**: 1) Determinar valores de referências de somatório de dobras cutâneas (ΣDC) e percentual de gordura em diferentes níveis de LM. 2) Detectar diferenças de composição corporal entre níveis de LM. 3) Correlacionar ΣDC com tempo de lesão e índice de massa corpórea (IMC). **Materiais e métodos**: Setenta e quatro pacientes homens com LM, de 18 a 52 anos, foram divididos em tetraplegia (TT – C4 a C8), paraplegia alta (PPa – T1 a T6) e paraplegia baixa (PPb – T7 a L3). A composição corporal foi avaliada pelas dobras cutâneas. **Resultados**: Não houve diferença significativa entre TT, PPa e PPb para as variáveis tempo de lesão, estatura, massa corporal total, ΣDC, percentual de gordura, massa corporal magra e IMC. Apenas a idade diferenciou entre os grupos TT e PPb (P < 0,05). A variável ΣDC não se correlacionou com o nível de lesão (rho = -0,08; IC95%: -0,537 a 0,420) ou com tempo de lesão (rho = 0,18; IC95%: -0,050 a 0,393). Não houve diferença significativa entre lesão completa e incompleta para todas as variáveis antropométricas. O ΣDC correlacionou-se positivamente com o IMC (rho = 0,68; IC95%: 0,539 a 0,739). **Considerações finais**: TT, PPa e PPb não apresentaram diferenças significativas nos valores de composição corporal. O IMC apresentou boa correlação com ΣDC entre os grupos.*

***Palavras-chave**: Composição corporal. Atividade física. Antropometria. Medula espinal. Reabilitação.*

Introduction

Body composition assessment is the analysis of the distribution of different tissues, organs, and body components (1, 2). Determining the proportion of lean body mass and fat mass is an important predictor of cardiovascular diseases, diabetes type II, and dyslipidemia. Moreover, this relation may point out characteristics regarding performance in physical activities, as well as their changes may reveal the physiological responses of some training (2, 3).

Body composition analysis in people with spinal cord injury is different from that in healthy people. Spinal cord injury, defined as a trauma affecting sensory and motor control in the affected region, changes the proportion of components in body composition, which are used to calculate body density in both populations (3-6). Moreover, it promotes a number of morphological and functional changes, such as decreased bone and muscle mass, as well as decreased amount of water in the body, and increased body fat (3, 7). A possible answer to explain this increased fat is the decreased energy expenditure in higher injuries (8-12). In fact, it has already been found out a high prevalence of obesity among adolescents with spinal cord injury (6). Besides correlating to the risk factors for metabolic syndrome (glucose intolerance, hyperlipidemia, hypertension), obesity compromises ambulation and transfers, and it increases the risk for bedsores and the risk involved in surgeries among this population (6).

The physiological, morphological, and functional responses still vary considerably depending on the level of spinal cord injury (8-16). Thus, some studies categorize the spinal cord injury levels into groups, so that more systematized comparisons can be carried out (8-18). Usually, the divisions are characterized as quadriplegia, due to impairment of the upper limbs, high paraplegia, due to changes in the autonomic nervous system and muscles of the abdominal circumference, and low paraplegia.

Although it is not the gold standard, the dual-energy X-ray absorptiometry (DEXA) is used as reference with regard to the validity of methods for assessing body composition (3). However, formulas for calculating the body fat percentage did not have a good correlation to this assessment, although they are usually widely adopted in studies involving men with spinal cord injury (13, 14, 19-22). This limitation leads such measures to serve only for comparative analysis of the individual her/himself over time, instead of a relation to reference values. Some authors suggest using the sum of skinfolds as another parameter in the same type of analysis (1, 5).

The American Association of Spinal Cord Injury (ASIA) has created international standards for neurological classification of traumatic spinal cord injuries among this population. The motor level of spinal cord injury is categorized according to the strength responses from key muscles corresponding to each myotome in the spinal cord segment. The extent of impairment due to the injury – ASIA Impairment Scale (AIS), in turn, varies from A to E. Complete injuries are classified as A, incomplete, as B, C, or D, and individuals without injury are classified as E (23).

The need for quantifying the body composition variables, starting an analysis of reference values, and for associating them with the functional level of the spinal cord injury, has become important for a better planning of activities, adequate monitoring of the different types of training, besides being used as instruments to encourage patients. The magnitude of these variables is influenced by the impairment generated by spinal trauma (8-16, 24).

The objectives of this study are: 1) determine reference values for the sum of skinfolds (ΣSF) and body fat percentage at different levels and the extent of spinal cord injury; 2) detect differences in body composition between levels and the extent of spinal cord injury; 3) correlate ΣSF to time since injury and body mass index (BMI) (25, 26).

Materials and methods

Sample

The convenience sample consisted of 74 male subjects with traumatic spinal cord injury who were hospitalized at Rede Sarah de Hospitais de Reabilitação, Unidade Lago Norte Brasília, within the period from July 2007 to April 2010. This study was approved by the Research Ethics Committee of Hospital Sarah (Opinion 668).

The inclusion criteria were: male individuals, over 18 years of age, diagnosed with traumatic spinal cord injury, and authorized by the medical team to continue the rehabilitation program with no restrictions.

The exclusion criteria were: patients who could not be assessed due to any reason, for instance, difficulty in positioning for assessment.

Anthropometric measurements

The anthropometric measurements taken were skinfold thickness, body mass, and height, which were obtained by the same assessor.

Skinfolds: we used plicometer (Lange) to measure, in millimeters, the skinfolds of the biceps and triceps, as well as the subscapular, pectoral, mid axillary, suprailiac, and abdominal regions, besides the thigh, and leg, according to previous standardization (1,2).

Body mass: measured with weighing scale (Filizola) and calculated by determining the difference between the wheelchair mass and the total mass (patient plus the wheelchair).

Height: measured in the supine position with the plicometer designed by the sector responsible for creating equipment for the hospital (Equiphos).

Procedures

The study is characterized as cross-sectional, i.e. observational and analytical. Data on the individuals assessed were collected from the electronic medical record and the database of the Physical Education Team. The individuals participated in body composition assessments from July 2007 to April 2010 and they were admitted to a rehabilitation program at Rede Sarah de Hospitais de Reabilitação, Unidade Lago Norte de Brasília. Such assessments are part of the treatment program for these patients, contributing to the decision making process to advise on the regular physical activity practice. All assessments were performed by the same assessor during the first week of hospitalization at the institution mentioned above.

The individuals were classified according to ASIA (23) and the neurological level was obtained from the electronic medical record. For analytical purposes, the patients were categorized into 3 groups: quadriplegia (QP) – C4 to C8, high paraplegia (PPA) – T1 to T6, and low paraplegia (LPP) – below T7. The division of the first group when compared to the other two is due to the classification of quadriplegia by ASIA and the impairment of upper limbs (23). The separation between the second and third groups took place because of the changes deriving from the sympathetic autonomic nervous system and of the trunk instability. This division criterion is commonly used in studies with spinal cord injury (8, 12).

The ASIA Impairment Scale (AIS) ranged from A to D. Due to the small number of patients with incomplete injuries (n = 25) to be distributed among the groups TT, PPA, and PPB, an assessment of the injury extent was performed with the total sample.

In this study, for comparing body composition, we used the body mass, the sum of 9 skinfolds, and the body fat percentage calculated by means of the formula proposed by Durnin & Womersley, in 1962 (13, 14, 19, 20), which uses the skinfolds of the biceps and triceps, as well as the subscapular and suprailiac regions. Complying with the Bulbullian protocol (4), measurements of upper limbs and trunk were performed in sitting position on a wheelchair and those of lower limbs in supine position, all of them in the patient's right side (Figure 1). The skinfolds were consecutively collected and, then, a second measurement was performed and we used average as the final result. In case of a difference greater than 5% between two measurements, a third measurement was performed and the median was used as the final result (1).

As a result of the fat percentage, we also calculated for analysis: 1) body fat mass – kg G (body mass multiplied by the fat percentage); 2) lean body mass – kg LBM (body mass minus body fat mass); 3) percentage of lean body mass – % LBM (100% minus the fat percentage).

Statistical analysis

The distribution of variables under analysis was performed by means of the Komolgorov-Smirnov normality test, as the sample was greater than 50 individuals. We found out that the variables total body mass, body fat percentage, lean body mass percentage, lean body mass, and BMI had a normal distribution. On the other hand, the variables age, time

Figure 1 - Standardization of positioning to measure the skinfolds
Legend: A= Biceps; B= Triceps; C= Subscapular; D= Pectoral; E= Mid axillary; F= Suprailiac; G= Abdominal; H= Thigh; I. Leg.
Source: Research data.

since injury, sum of skinfolds, and fat mass showed a non-parametric distribution.

For characterizing the results, we used descriptive statistics by means of average and standard deviation. Spearman's correlation was used to check the relation between the sum of skinfolds and the variables injury level, time since injury, and BMI. In order to check differences between the average values inter-groups, we performed the variance analysis test (ANOVA), type one-way, and in case of significance, a post hoc analysis, with Bonferroni's test. Since it is more conservative, this test reduces the chance of finding unreal differences (error type I). The t-test for independent samples was used to compare the complete and incomplete injuries. The significance was considered only for $p < 0.05$.

The statistical softwares *SPSS* (version 13.0) and MedCalc (version 9.0.1.0) were used for data processing. The statistical significance adopted was $p < 0.05$.

Results

The groups TT, PPA, and PPB did not differ with regard to their basal characteristics time since injury and height. Age ranged between TT and PPB (24.8 and 29.8 years, respectively, $p < 0.05$) (Table 1). Thirty-four percent of the impairment level of injuries was classified as incomplete.

The three groups did not differ significantly ($p > 0.05$) for the variables time since injury, height, total body mass, ΣSF, fat percentage, lean body mass, and BMI (Table 2). The values may be compared to other studies which also used the formula proposed by Durnin & Womersley (Table 3).

There was no significant difference between complete and incomplete injuries for all variables under analysis (Table 4).

The sum of skinfolds did not show a good correlation between the variables level and time since injury (rho = -0.08; CI 95%: -0.537 to 0.420; and rho = 0.18, CI 95%: -0.050 to 0.393, respectively). However, ΣSF was positively correlated to BMI (rho = 0.68; CI 95%: 0.539 to 0.739) (Graph 1).

Discussion

Body composition did not differ significantly between the groups quadriplegia, high paraplegia, and low paraplegia for all variables under study, despite the higher amount of muscles preserved in the lower injuries. However, even among the most impaired groups, there were individuals with preservation of muscles below the motor level (incomplete injuries).

The large amount of incomplete injuries (around 34.0%) increases the confusing variables, compromising an adequate inter-group analysis. Individuals with quadriplegia or incomplete high paraplegia have more active muscles, increased energy expenditure and basal metabolic rate. These components directly interfere with body composition due to changes in energy expenditure and cost (8-12).

However, despite a trend towards a better body composition for individuals with incomplete injuries (lower values of the sum of skinfolds, fat percentage and mass, and higher relative and absolute lean body mass values), there was no significant difference between complete and incomplete injuries. The same research group found similar results in a previous

Table 1 – Characteristic of the sample mean and standar deviation

Groups	n	Anos (years)	Height (cm)	Time of Injury (meses)	AIS Complete	AIS Incomplete
C4 a C8 (TT)	32	24,8 (± 6,4)*	178,1 (± 5,7)	46,6 (± 30,3)	46,9%	53,1%
T1 a T6 (PPa)	19	27,7 (± 7,2)	176,0 (± 7,2)	33,8 (± 22,9)	89,5%	10,5%
T7 a L3 (PPb)	23	29,8 (± 7,9)	177,9 (± 7,0)	44,3 (± 33,5)	73,9%	26,1%
Total	74	27,1 (± 7,2)	177,1 (± 6,0)	42,4 (± 29,8)	66,2%	33,8%

Legend: QQ = quadriplegia; HPP = high paraplegia; LPP = low paraplegia; AIS = ASIA Impairment Scale.

Source: Research data.

Note: * Significant difference compared to the group PPb ($P < 0,05$).

Table 2 – Results of the body evaluation in the group and subgroups

	Total		QP		HPP		LPP	
Body Mass (kg)	69,0	(± 12,5)	67,9	(± 11,7)	69,7	(± 13,0)	68,7	(± 13,2)
ΣSF (mm)	162,2	(± 73,7)	169,8	(± 78,8)	159,3	(± 72,3)	149,1	(± 65,6)
%FM	21,7	(± 7,1)	22,3	(± 7,6)	21,3	(± 7,1)	20,7	(± 6,4)
Kg F	15,6	(± 7,2)	15,8	(± 7,3)	15,6	(± 7,6)	14,8	(± 6,8)
%LBM	78,3	(± 7,2)	77,7	(± 7,6)	78,7	(± 7,1)	79,3	(± 6,4)
Kg LBM	53,4	(± 7,1)	52,1	(± 6,4)	54,1	(± 6,5)	54,0	(± 8,2)
BMI	21,9	(± 3,6)	21,4	(± 3,6)	22,9	(± 4,0)	21,6	(± 3,2)

Legend: TT = quadriplegia (C4 - C8); HPP = high paraplegia (T1 - T6); LPP = low paraplegia (T7 - L3); ΣSF = sum of skinfolds (mm); %FM = fat mass percentage.
Source: Research data.
Note: There was no significant difference (P > 0,05) between groups QQ, HPP e LPP for all variables.

Table 3 – Values of fat mass percentage of Durnin and Womersley (1962) and anthropometric variables in several studies in individuals with spinal cord injury

Author	Year	Country	Group	n	Ratio M:F	Physical Activity	Age (years)	Injury time (month)	Body Mass (kg)	Heigh (cm)	BMI	%FM
Bulbulian, et al. (5).	1987	EUA	⍰T1	22	22:00	Athletes	27,7	-	70,0	177,0	22,3	18,7
Spungen, et al. (23)	1995	EUA	C4 – C7	12	-	-	28,5	20,1	66,8	180,7	20,5	18,4
Maggioni, et al.(21)	2003	Itália	C6 – L1	13	13:00	Sedentary	33,8	167	84,0	181,0	25,6	19,6
Ribeiro, et al.	2010	Brasil	C4 – C8	32	32:00	-	24,8	46,6	67,9	178,1	21,4	22,3
			T1 – T6	19	19:00	-	27,7	33,8	69,7	176,0	22,9	21,3
			T7 – L3	23	23:00	-	29,8	44,3	68,7	177,9	21,6	20,7

Legend: Ratio of M:F = ratio of men to women in each study; BMI = body mass index; %FM = fat mass percentage calculated using the formula of Durnin e Womersley (1962).
Source: Research data.

study (24). Perhaps, the small number of patients with incomplete injuries may have created unrealistic equality between the analyses (error type II). Confirming these data through literature is difficult, because most studies do not specify the injury extent (4, 19-22, 27); a study using only subjects with complete injuries (3) and another one had only injuries A and B (28). The latter, in turn, did not perform comparisons between groups.

The variable sum of skinfolds did not show a good correlation to level and time since injury. It was expected that this correlation was significant and positive, because the lower the injury level, the greater the preservation of muscles (8-12). A study (20) also found no correlation between these variables (20). Thus, as argued with regard to the differences of these variables between the groups, the amount of incomplete injuries seems to have influenced on these correlations.

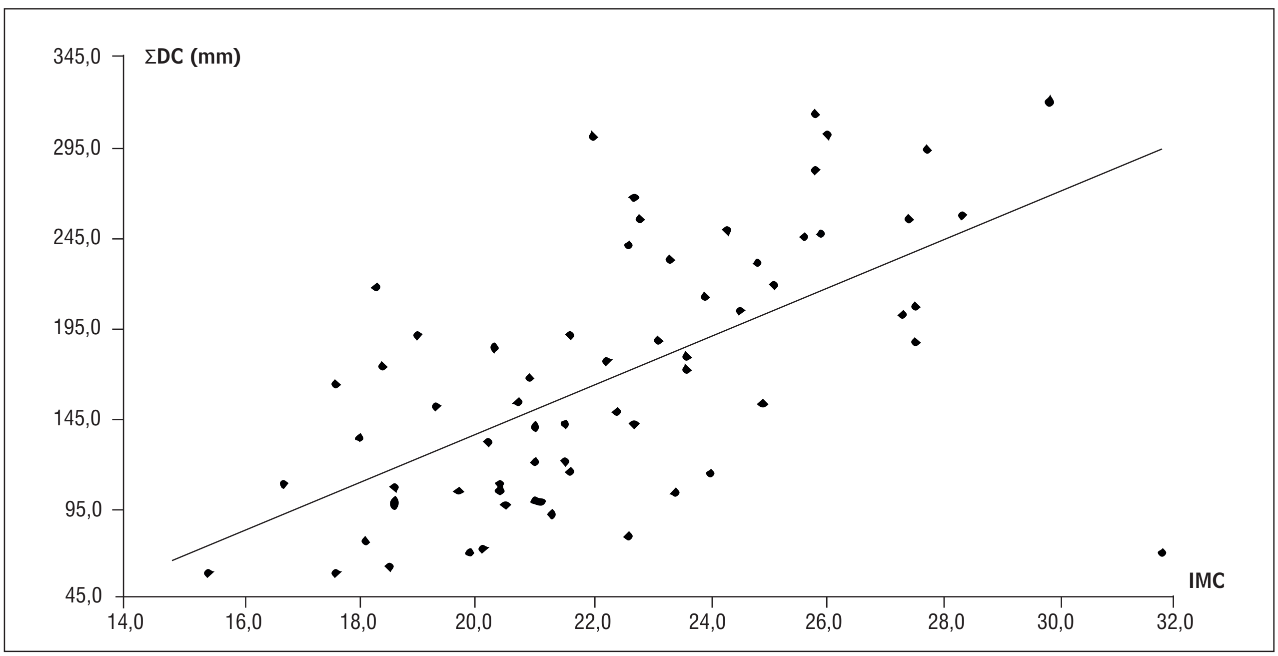
Table 4 – Results of the evaluation for complete and incomplete injuries

	Complete Injury (n = 49)		Incomplete Injury (n = 25)	
Body Mass (kg)	67,8	(± 11,5)	70,2	(± 13,9)
ΣSK (mm)	168,6	(± 72,0)	145,1	(± 73,2)
%FM	22,2	(± 7,0)	20,3	(± 7,1)
Kg FM	15,7	(± 7,0)	15,0	(± 7,5)
%LBM	77,8	(± 7,0)	79,7	(± 7,1)
Kg LBM	52,1	(± 6,4)	55,3	(± 7,8)
BMI	21,9	(± 3,6)	21,9	(± 3,6)

Legend: ΣSF = sum of skinfolds (mm); %FM = fat mass percentage; Kg F = fat mass (kg); %LBM = lean body mass percentage; Kg LBM = lean body mass (kg); BMI = body mass index.
Source: Research data.
Note: There was no significant difference (P > 0,05) between complete (AIS A) and incomplete injury (AIS B, C e D) for all variables.

that, besides not predicting adequately body fat, BMI does not constitute a good tool for assessing fitness. In fact, a study (31) showed a good association between the classifications of BMI to the prevalence of diabetes among war veterans with spinal cord injury.

The values of body fat percentage in each of the three groups were higher than those found in other studies assessing individuals with spinal cord injuries, from C4 to L1, with the same formula proposed by Durnin & Womersley (4, 20, 22). It is not possible to say whether the differences observed are related to social and cultural characteristics or the measurement techniques. Only one study (4) referred in its methodology to the measurement techniques (4). Furthermore, the sampling number is smaller than that used in this study and the injury impairment extent, according to AIS, was not specified (Table 3). Thus, the results found serve as reference with regard to low values of fat percentage in the groups quadriplegia, high paraplegia, and low paraplegia. These values, however, may not be classified as ideal and appropriate from a health perspective. For this, we must perform other comparisons to health markers, such as lipid profile, cardiovascular capacity, or even strength level.



Graph 1- Correlation between the sum of skinfolds and body mass index
Souce: Research data.

On the other hand, the sum of skinfolds was positively correlated to BMI (rho = 0.68; CI 95%: 0.539 to 0.739). However, there is no consensus in the literature. While some recent studies show similar responses (29, 30), others differ with regard to the results found (25,26). Nevertheless, all articles agree

Although this investigation provides a large sample, when compared to other studies with the same outcome, there is a need for analyzing the same variables with an even larger number of subjects or for carrying out a study only with traumatic complete spinal cord injuries (AIS A). Studies correlating the body fat percentage and the sum of skinfolds with indicators of health risks (e.g. lipid profile) must be carried out to assess whether the patterns observed in these studies are ideal.

Conclusion

This study provides an initial analysis to determine body composition values at different spinal cord injury levels. The use of patterns as initial reference enables a more adequate control of responses in the physical activities, as well as a motivational factor favoring health and improved functionality.

Yet, we did not observe significant differences in body composition between the groups. There was also no significant correlation between the sum of skinfolds and the variables level and time since injury. Perhaps, this was due to a sample with many patients with incomplete injuries, depriving each group of its homogeneity characteristics.

Finally, the BMI showed a good correlation to the sum of skinfolds. However, this analysis has to be assessed with caution, taking into account the limitations of BMI with regard to this specific population.

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