Body adiposity index a better marker of body fat than body mass index in wheelchair rugby players after cervical spinal cord injury (CSCI) - preliminary investigations

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Abstract

Objective: CSCI-related dysfunction frequently determines and generates other deficits and disorders. The aim of this study was to assess the accuracy of BAI, when compared to BMI in wheelchair rugby players after cervical spinal cord injury.

Methods: The study group consisted of 14 Caucasian males competing in wheelchair rugby players, aged 25–40 years (32.6 ± 5.1 years), who had sustained CSCI. All subjects were measured for body height, waist and hip circumference in centimeters, while body mass was expressed in kilograms. Body fat content was measured with the use of Viscan Tanita AB-140 utilize BIA. The existence of significant bivariate correlations among variables such as BAI, BMI, height, weight, hip circumference and % visceral fat and trunk fat determined by BIA was ascertained by means of determining Pearson correlation coefficients.

Results: BMI calculated according to the standards of the general population indicated that 80% of participants fell within the norm (BMI<25), while according to BAI standards it was 40%. After classifying the participants by the cut-off points of BMI >25 kg/m² and BAI >21%, significant relationships were observed between BAI and the following indicators WC (r=0.9), % TF (r=0.9), % VF (r=0.8), WHR (r=0.8). Such a trend was not observed for BMI.

Conclusions: The BAI can be considered a good tool for evaluating adiposity in patients with spinal cord injury. BAI is very specific and sensitive.
Rajan et al. (2008) and Laughton et al. (2009) suggest that body mass index cut of points should be lowered to better identify obese individuals with spinal cord injury. They believe that subjects with chronic spinal cord injury and BMI values > 22 kg/m² should be considered as being at high risk for obesity and obesity-related chronic diseases [20,21]. However, there is no agreement as to which index should be applied universally for defining obesity. That is why BMI is known to be of limited accuracy, and its diagnostic value is different for males and females with similar body adiposity. To address this limitation Bergman et al. (2011) introduced an alternative index, the Body Adiposity Index (BAI) in samples of Mexican-American and African-American populations. BAI can be measured without weighing, what makes it useful in settings where measuring accurate body weight is difficult. BAI allows estimating adiposity and cardiovascular risk, what has been confirmed in recent studies [14,15,22-24].

The aim of this study was to compare several estimates of body fat content, i.e., BAI, BMI, waist-to-hip ratio (WHR) and waist and hip circumferences regarding their accuracy (specific and sensitive) in predicting the percentage body fat (PBF) with the results obtained using a Viscan visceral and trunk fat analyzer. An additional objective of our research was to determine the relationship between BAI, BMI and other adiposity indices such as WC and WHR as well as cardiovascular and metabolic risk factors. Furthermore, to analyze BAI and BMI regarding their capacity to discriminate between overweight and obesity in wheelchair rugby players after cervical spinal cord injury.

Materials and methods

Subjects and Study Protocol

The study group consisted of 14 Caucasian males competing in wheelchair rugby players, aged 25 – 40 years (32.6 ± 5.1 years), who had sustained CSCI (Table 1). Mean training experience was 7 ± 3.5 years. All subjects practiced wheelchair rugby by exercise once a week for three hours. They had no indication of cardio metabolic problems, their normal distribution.

Participant characteristics.

Table 1. Participant characteristics.

| Variable                  | Age (years) | Age at time of injury | Years post injury | Completeness of injury |
|---------------------------|-------------|-----------------------|-------------------|------------------------|
| Age (years)               | 32.6 ± 5.1  | 20.1 ± 3.6            | 12.5 ± 5.7        | Complete: 11 (79%)     |
| Age at time of injury     |             |                       |                   | Incomplete: 3 (21%)    |
| Years post injury         |             |                       |                   |                        |
| Completeness of injury    |             |                       |                   |                        |

Table 1. Participant characteristics.

Results

When evaluating body composition, the participants were classified according to the risk of obesity. The classification was consistent with the standards adopted by WHO (Table 4). BMI calculated according to the standards of the general population indicated that 80% of participants fell within the norm (BMI > 25), while according to BAI standards it was 40%. All the cervical spinal cord injury study participants the value recommended by WHO was exceeded (WHR=0.9 or more).

The analysis of variance ANOVA revealed a significantly higher

The new method estimating abdominal fat by BIA represents a reliable tool for clinical evaluation of trunk fat [26].

This is a novel device for direct measurements of body fat of subjects who for various reasons cannot assume an upright posture. The study was performed according to a standard protocol of the manufacturer: VISCAN is specifically designed for a wide range of needs from large scale research projects to routine clinical practice. Conveniet to work with disabled, critically ill and elderly patients, measurements are taken in under 30 seconds. Viscan is easy to set up and use – no training required, gives highly accurate and repeatable results with minimal or no personal contact. Before the measurements are taken the subject assumes a lying position for about 10 minutes prior to the evaluation. Hands are placed on the chest, and the area to be tested is exposed. In subjects with severe spasticity - the lower limbs are stabilized by the person performing the test. Measurements are non-invasive and last about 30 seconds. The test is performed after an overnight fast. This is the basis for calculating body composition by an algorithm which includes age, sex and body height [26,27]. The investigated variables determined by BIA include trunk, visceral and subcutaneous fat. The latter was also used to estimate body fat content. BMI was calculated by the formula: BMI=weight (kg)/height (m²) 17. The BAI was calculated using the equation suggested by Bergman and colleagues, BAI= ((hip circumference)/(height)1.5) - 18 [14].

WHR was then calculated, which helps to identify individuals with abdominal fat accumulation. WHO recommends the use of waist circumference measurement because it correlates closely with BMI and WHR, and is an approximate index of intra-abdominal fat mass and total body fat. BMI standards, i.e., BMI > 25, and BAI cut-off points for men 20-39 years old (BAI>21%), were used to identify overweight and obese subjects [14,17].

The study was approved by the local Bioethical Committee of the Academy of Physical Education in Katowice, Poland (KB/15/2013). All tested subjects gave their written consent for participation in the study; anthropometric measurements were taken in a separate room.

Statistical analyses

Statistical analyses were performed with STATA statistical software (release 7, StataCorp, College Station, TX). All the data were tested for their normal distribution.

Results

Results are presented as means ± SD for normally distributed data and as means with 95% accuracy. The analysis of variance ANOVA was used to evaluate differences in indexes and anthropometric characteristics for BAI and BMI between cut-off points for BMI > 25 kg/m² and BMI > 21% (Tables 2 and 3). The existence of significant bivariate correlations among parameters such as BAI, BMI, body height, weight, hip circumference, % visceral fat and trunk fat determined by BIA was ascertained by means of determining Pearson correlation coefficients.

The analysis of variance ANOVA revealed a significantly higher
The correlations of cut of points for BMI or BAI – mean values and standard deviations (±SD) of the studied anthropometric variables of wheelchair rugby players after CSCI.

**Discussion**

Increased fat mass and coronary heart disease include secondary complications of chronic spinal cord injury. In the able-bodied population BMI is a widely used marker of obesity and predictor of CHD risk. Waist circumference is an accurate and reproducible measure of abdominal visceral fat, and is also associated with the risk of CHD (more than BMI) in the disabled population [28]. BMI measure was approved in the "triglycerides and cardiovascular risk in African-American population study. The relationship between fat content evaluated by DXA and obesity classified with BAI was very high and equaled r=0.85 [14,22-24]. Our study confirms significant relationships between BAI and %TF r=0.9; %VF r=0.8, especially when considering obese and overweight subjects with BAI > 21%. At the same time there was a moderate and an inverse correlation in the group with BMI < 20.9 %TF r=(-0.5) and %VF r=(-0.7). Such a trend was not observed for BMI (Table 3).

BAI can be measured without weighting, which can make it useful in conditions in which an accurate measurement of body mass is problematic, for example in patients with spinal cord injury. It can be easily computed without the need of sophisticated equipment or specific software.

This study has several limitations which warrant further discussion. The first limitation is related to the small number of subjects evaluated in this research. Another limitation is the type of subjects considered, which included only wheelchair rugby players. It must be indicated that this a pilot study and for further research a greater number of subjects with CSCI (wheelchair rugby players and sedentary disabled males) must be evaluated to verify the sensitivity and specificity of BAI as a tool for measuring body fat content. This pilot study leads to the conclusion that BAI could be a good tool for evaluating adiposity, especially in disabled subjects, such as those with spinal cord injury. However numerous scientists indicate that BAI still needs to be tested among different ethnic groups and in disabled subjects [14,22-24,29]. Our results correspond with those of Suchanek et al. [2012] [30]. We can state that the BAI index is not universally valid, can’t be used as a replacement of the BMI index in subjects after cervical spinal cord injury, since it does not accurately reflect body fat mass, what may lead to an increased risk of obesity. BAI identified 60% (n=8) of obese and
overweight subjects in our pilot study, where obesity was defined by waist circumference > 90 cm (50%; n=7) and compared to BMI only 20% (n=3) (Table 4). The results of BAI and WC were similar for the Viscan BIA method evaluations. The WC method is known for low accuracy but is still recommended for subjects after cervical spinal cord injury. Considering that BIA Viscan is a method know for high accuracy, it seems a reliable tool for clinical evaluation of trunk fat [26]. Considering the results of our study we may recommend BAI for identifying obesity in subject after CSCI as a more sensitive and specific method than BMI.

Conclusion

The BAI can be considered a good tool for evaluating adiposity in patients with spinal cord injury. The most important advantage of BAI over BMI is that precise measurements of body weight are not necessary. The fact that a high, statistically significant correlation between BAI and %VF (r=0.8) was registered among obese and overweight subjects as well as a moderate and inverse correlation between BAI < 20.9% and %VF (r=-0.7) in comparison to all (r=0.2) the subjects with CSCI suggests, that BAI is a very specific and sensitive index. The adiposity indexes that include waist circumference (WC, BAI) may be better candidates than BMI to evaluate metabolic and cardiovascular risks in clinical practice and research for patients with spinal cord injury. Furthermore, the WHR index is not suitable for estimation of body fat in wheelchair rugby players after CSCI.

Table 4. Classification of wheelchair rugby players after CSCI according to population norm for somatic variables.

| Cut of point | WC [cm] | VF [%] | TF [%] | BMI [kg/m²] | BAI [%] |
|--------------|---------|--------|--------|-------------|---------|
| < 90         | > 90    | < 13   | > 13   | < 30        | > 30    | < 24.9 | > 25 | < 20.9 | > 21    |
| N            | 7       | 7      | 6      | 8           | 5       | 9      | 11    | 3     | 6       | 8 |
| Mean         | 85.7    | 98.7   | 10.4   | 17.5        | 25.1    | 37.5   | 21.8  | 27.2  | 18.6    | 23.4  |
| SD           | ±4.1    | ±5.2   | ±1.8   | ±4.7        | ±3.1    | ±4.6   | ±2.3  | ±0.8  | ±2.4    | ±2.4  |
| p value *    | 0.01*   | 0.01*  | 0.002* | 0.001*      | 0.001*  |        |       |       |         |       |

*statistical significance p<0.05; % WC[cm] - waist circumference, TF[%]- trunk fat percentage, VF[%]- visceral fat percentage; BMI [kg/m²]- body mass index; BAI[%]- body adiposity index

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