


Body Composition in Sickle Cell Disease Patients in the Steady State

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Abstract

Introduction: Previous studies in sickle cell disease (SCD) patients have demonstrated low muscle mass (MM) and high fat mass (FM) percentages compared to individuals with normal hemoglobin. The relationship between the evolutions of body composition (BC) parameters in the active SCD population is not well elucidated. The aim of the present study was to assess the body composition in active adult SCD patients in sub-Saharan Africa during the inter-critical period. **Methodology:** We conducted a descriptive and analytical cross-sectional study over an 8-month period. Eighteen SCD patients (sex ratio = 1) reported regular physical activity (RPA) corresponding to level 3 (RPA of moderate intensity) of the 4-level Saltin-Grimby physical activity scale were recruited. Anthropometric and BC parameters such as BMI, percentage FM and percentage MM were evaluated using an impedance meter. **Results:** The study population had a mean age of 26 ± 7 years and a mean BMI of 20.5 ± 1.9 kg/m². We found a significantly higher percentage of FM in women compared to the men ($25.6\% \pm 10.2\%$ vs $11.1\% \pm 2.1\%$; $p = 0.001$). For the proportion of MM, all the women had a normal percentage. The men mostly had high levels of MM compared with reference norms. Men had significantly greater MM percentages than women ($45.4\% \pm 1.8\%$ vs. $26.5\% \pm 1.4\%$; $p < 0.0001$). A positive correlation was noted between FM and age ($p = 0.007$; $r = 0.6$) and a negative correlation was found between FM and MM ($p = 0.001$; $r = -0.7$). **Conclusion:** RPA appears to have positive effects on BC in active population with SCD, and a greater-than-expected effect was observed

on MM in male patients. Promoting regular, adapted physical activity would be a promising way of improving BC parameters and quality of life in the SCD population. Further studies with larger cohorts will be needed to better substantiate these results.

Keywords

Sickle Cell Disease, Body Composition, Physical Activity

1. Introduction

Sickle cell disease (SCD) is the most common hemoglobinopathy in the world, causing health disparities between countries and races [1]. SCD limits the participation of individuals in physical and social activities. However, several studies showed that moderate exercise was not harmful in SCD patients [2]. Exercises above the anaerobic threshold can be potentially harmful for homozygous sickle cell patients (SS) [3]. This is due to disease-related complications or medical conservatism, by restricting or even prohibiting physical activity. This may contribute to their tendency to express body composition (BC) parameters different from those of healthy subjects. BMI, commonly used to measure adiposity, cannot estimate or quantify fat mass. Body composition analysis is required to quantify fat mass (FM) and muscle mass (MM), and it is recognized that a balanced body composition is essential for health [4]. Historically, malnutrition is described in individuals with SCD however, more recent studies have shown a change in the profile of the nutritional status and distribution of body composition of SCD patients mainly adult individuals. Many complications associated with the disease have a nutritional origin [5]. Many specific techniques are used for measuring body composition, but in our context bioelectrical impedance analysis (BIA) remains the most promising due to its accessibility, ease of use and reproducibility. The validity of body composition measurement by BIA thus depends heavily on the correspondence between the subject examined and the reference population from which the regression equations are obtained. Body composition varies according to age, ethnic origin, health status, etc. [6]. However, related-improvement in muscle mass and reduction in fat mass to regular physical activities have been observed in general population [7]. The aim of the present study was to assess the body composition in active adult SCD patients sub-Saharan Africans during the inter-critical period (vaso-occlusive crisis outside).

2. Methodology

2.1. Study Design

We conducted a descriptive and analytical cross-sectional study over an 8-month period from August 1, 2019 to March 31, 2020.

2.2. Study Population

The study population is drawn from a group of Senegalese SS homozygous sickle cell adults patients followed in the National Center of Blood Transfusion of Dakar (Senegal). All SS patients who were seen at the clinic and met the following criteria were pre-selected to participate in the present study:

- age between 18 and 36 years;
- regular physical activity (RPA);
- no vaso-occlusive crisis (VOC) in the previous year;
- no fever and osteonecrosis during the study period;
- no blood transfusion during the last three months.

All patients reported regular physical activity (RPA) corresponding to level 3 (RPA of moderate intensity) of the 4-level Saltin-Grimby physical activity scale (SGPALS). This scale refers to the past year and asks how much the person moves and makes physical efforts during their leisure time. Level 3 corresponds to time spent in physical activity (intensive gardening, running, swimming, tennis, badminton, and similar activities), at least 2 to 3 hours a week [8]. The use of the SGPALS in adolescents has recently been validated by the work of Beldo *et al.* [9].

Patients with conditions likely to alter body composition parameters, such as liver disease, heart disease, kidney disease, cancer or other conditions (pregnancy) were not included. Subjects under specific treatment (steroids and diuretics) or with surgical equipment were also excluded from the study.

2.3. Protocol

Anthropometric and body composition parameters were taken in the morning between 9 am and 12 am by the same operator. Participants came fasting and avoiding vigorous exercise at least 1 hour before body composition parameters were assessed. Subjects were also invited to use the toilet before measurements.

Height measurements were taken to the nearest 0.1 cm, using a stadiometer following standard protocols. Body composition parameters were then determined using an impedance meter (Omron BF 511: Medizintechnik, Mannheim, Germany) consisting of eight electrodes in a tetrapolar arrangement. The BF511 measures the body fat percentage by the Bioelectrical Impedance Analysis (BIA) method. Parameters were measured in barefoot subjects wearing light clothing, following the manufacturer's instructions and providing information on the subject's age, sex and height. Measurements were taken while standing on metal pads and grasping a pair of electrodes attached to a handle with the arms stretched forward perpendicular to the body. The BIA measurement method involves sending an extremely weak electrical current of 50 kHz and less than 500 μ A through the body, which is not felt while operating the BF511. Body composition measurements were performed twice on each patient and were collected by well-trained personnel. The body composition parameters used in the present study were BMI, percentage fat mass (FM) and percentage muscle mass (MM). The values obtained

were then compared with reference standards described in the literature [10] [11].

2.4. Statistical Analysis

Descriptive analysis of observed data was expressed by the mean and standard deviation for numeric data and percentage (%) for categorical data. Means were compared using Student's t-test. The Chi² test was used to compare percentages between groups. The Pearson correlation test was used to test for relationships between parameters. Data analysis, including group comparisons and correlations, was performed using SPSS statistical software (version 26, IBM, Chicago, IL). The results were considered statistically significant at a p-value < 0.05.

Ethical considerations

Informed consent was obtained from all patients for being included in the study. The protocol was approved by the ethics committee of the Cheikh Anta DIOP University of Dakar, Senegal (0218/2018/CER/UCAD). Patients were reassured of the anonymity and confidentiality of the information collected. The research complies with the ethical standards of the Declaration of Helsinki.

3. Results

The study population characteristics data are shown in **Table 1**. The study included 18 patients, 9 of whom were women (sex ratio = 1), with a mean age of 26 ± 7 years (18 - 36 years) and a mean BMI of 20.5 ± 1.9 kg/m².

As show in **Figure 1**, the classification of fat mass according to sex. A high proportion of fat mass was found only in women. However, there was a significantly higher percentage of fat mass in women compared to men (25.6% ± 10.2% vs. 11.1% ± 2.1%; p = 0.001).

The classification of muscle mass according to sex is shown in **Figure 2**. All the women had a normal percentage of muscle mass. The men, on the other hand, mostly had high levels of muscle mass compared with reference norms. Men had significantly greater muscle mass percentages than women (45.4% ± 1.8% vs. 26.5% ± 1.4%; p < 0.0001).

Correlations between anthropometrics and body composition parameters are presented in **Figure 3** and **Figure 4**. A negative correlation was found between fat mass and muscle mass, with greater variation noted in women (p = 0.001; r = -0.7). A positive correlation was also noted in **Figure 4** between fat mass and age (p = 0.007; r = 0.6).

Table 1. General population characteristics (sex-ratio = 1).

Parameters	Mean ± SD	Median	Min - Max
Age (years)	26 ± 7	26	18 - 36
Weight (kg)	58.8 ± 10.7	56.8	35 - 77
Height (m)	168.3 ± 12.4	178	133 - 183
BMI (kg/m ²)	20.5 ± 1.9	19.8	18.6 - 24.9

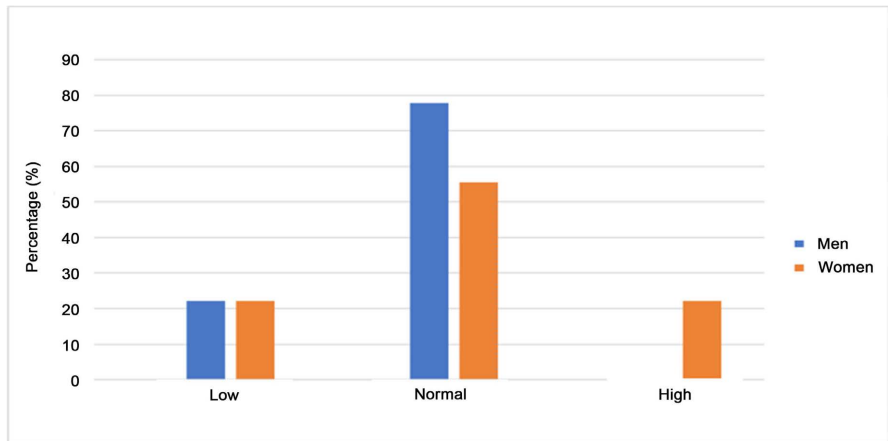


Figure 1. Classification of fat mass according to sex.

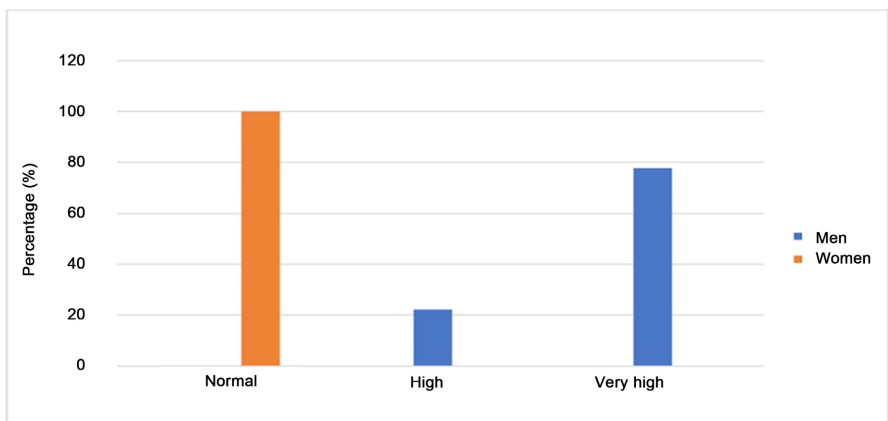


Figure 2. Classification of muscle mass according to sex.

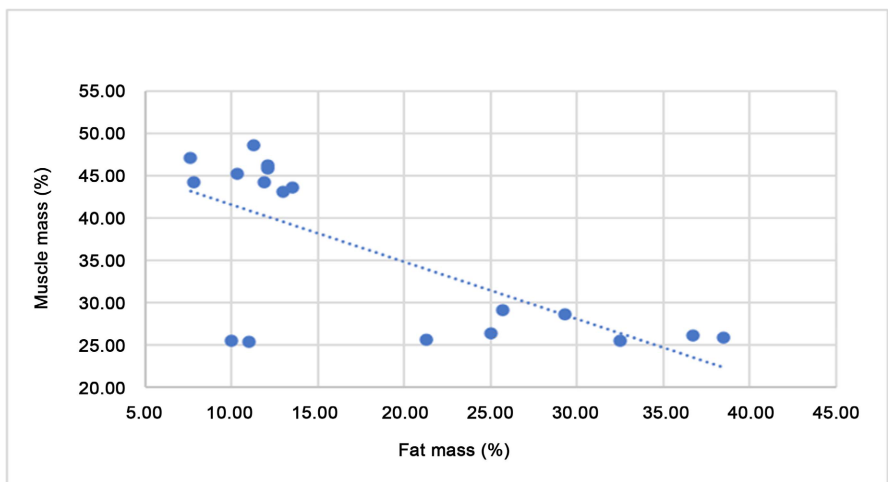


Figure 3. Correlation between fat mass and muscle mass.

4. Discussion

This study investigated body composition parameters in an adult population of inter-critical sickle cell patients who had been practicing RPA for at least one year.

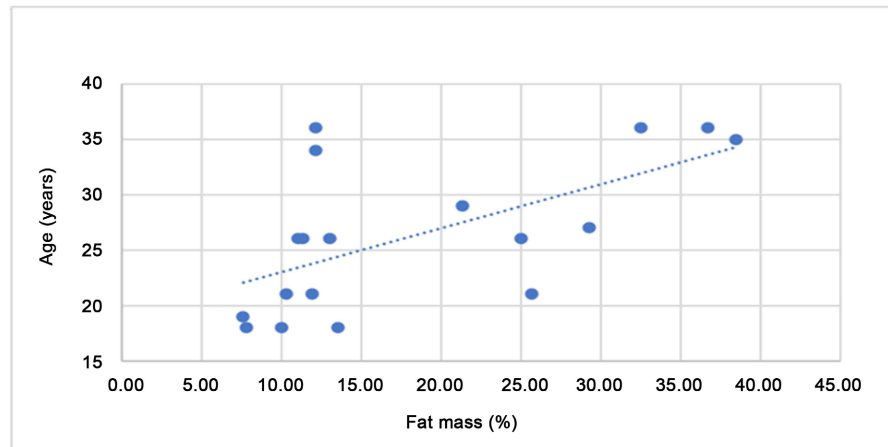


Figure 4. Correlation between fat mass and age.

Normal percentages of fat mass and muscle mass were found in the majority of active patients. Body composition can vary according to age, state of health and physical activity. In fact, in healthy subjects practicing regular physical activity, even if BMI does not change, muscle mass (MM) and fat mass (FM) would vary in the opposite direction, with a tendency for MM to increase. In principle, this phenomenon should be exacerbated in sickle-cell patients, who more often than not have low muscle mass [5].

Body composition parameters are widely used to assess the growth and nutrition of children, particularly those with sickle cell disease, who are known to have slowed growth, impaired skeletal maturation and delayed puberty [12]. However, the mechanisms behind altered body composition parameters in the population with SCD are not yet fully elucidated. Indeed, recent studies have associated it with the hyper-metabolic state following increased bone marrow activity and cardiac output due to chronic anemia, and chronic organ damage due to falciformations [13]. The pathophysiology of SCD, involving chronic inflammation, oxidative stress, and hypermetabolism, contributes to increased nutritional requirements and altered dietary patterns [5]. Chronic hemolysis has been shown to have an impact on the nutritional status of people with SCD [12]. Compared with their healthy counterparts, children with SCD show muscle atrophy. The more sedentary lifestyle, poor nutritional status, and observed growth retardation may explain the observed muscle atrophy. In adult patients with SCD, overt amyotrophy has also been observed. In addition, an altered distribution of muscle fiber type was noted. Specifically, the percentage of type I fibers was higher than that of type IIa fibers, with a disappearance of type IIa fibers, while the amount of type I fibers remained unchanged [14]. Although these results may be explained by repeated episodes of ischemia-reperfusion, which are known to induce significant muscle structural remodeling, it has been suggested that the reduction in the proportion of type IIa fibers could be explained, at least in part, by the low intensity of physical activity performed by patients [14] [15]. Indeed, low-intensity activities do not require recruitment of type II fibers. Overall, amyotrophy and altered muscle fiber

type distribution are most likely the result of the hyper-sedentary lifestyle of patients with SCD [16]. The significant difference in fat and muscle mass profiles between men and women can be explained, on the one hand, by physiological differences in normal body composition between the two sexes and, on the other, by the effects of RPA on body composition, which differs according to sex [17].

This article has certain limitations, notably the lack of taking into account all body composition variables such as lean mass, bone mass, estimated energy expenditure and haematological data for a better interpretation of the results.

5. Conclusion

Hemolysis has an impact on the nutritional status of patients with SCD. The present study shows that alterations of body composition are not important in active patients. Indeed, the effect that RPA appears to have on muscle mass in male patients is much greater than expected. These results are unexpected, as they far exceed the muscle mass corresponding to the level of physical activity practised. Further studies are needed to better elucidate these observations and to encourage the promotion of regular, supervised physical activity to improve the quality of life of the population with SCD.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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