

Article

Body Cell Mass from Bioelectrical Impedance Analysis in Patients with Stroke Undergoing Rehabilitation

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Abstract: The majority of BIA parameters have been investigated in relation to post-stroke recovery, except for body cell mass (BCM), which measures the body's cellular components involved in oxygen consumption and nutritional status. The aim of this longitudinal prospective study was to investigate in a cohort of subacute post-stroke patients undergoing rehabilitation the body composition parameters from BIA and the relationship between these parameters, in particular BCM, with both the performance in activity of daily living (ADL), measured by Barthel's Index at admission (BI T0), and the recovery in ADL, measured by change in BI from baseline (Δ BI). We analyzed 66 patients, before and after a six-week rehabilitation program and we found that patients' body composition after the rehabilitation protocol did not change. All lean mass and muscle quality parameters measured by BIA are positively correlated with BI T0. Moreover, patients with better recovery had higher values of BCM, such as other lean mass parameters and their related height-adjusted indices. Furthermore, BCM was independently associated both with ADL performance at admission, and most notably with recovery. These results suggest that assessing BCM at admission not only would improve the valuation of the nutritional status in post-stroke patients but would also potentially predict their recovery.

Keywords: bioelectrical impedance analysis; BIA; body cell mass; body composition; post-stroke; rehabilitation; fat-free mass; muscle mass; muscle quality; phase angle



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1. Introduction

Stroke is one of the principal causes of death, morbidity, and disability worldwide [1] and the role of rehabilitation is critical for recovering after the stroke insult [2,3]. The clinical spectrum of stroke patients is extremely varied, with inconsistent and frequently inadequate recovery of motor function in response to rehabilitation treatment [4]. In fact, 30 to 60% of patients have functional deficits in the paretic arm even after rehabilitation treatment, resulting in compromised activities of daily living [5]. In addition, impaired nutritional status and malnutrition are prevalent throughout all phases of stroke care [6]. Malnutrition has been shown to negatively impact clinical outcomes, mortality, and overall healthcare expenditures among stroke survivors [6–10]. To date, however, there are no standardized methods for assessing the risk of malnutrition in post-stroke patients, and there is a lack of nutritional care best practices [11].

Body composition assessment allows to detect nutritional or skeletal muscle disorders among stroke survivors, such as overweight, obesity, sarcopenia, and sarcopenic obesity [12,13]. Body composition changes with age and can be affected by physical activity [14] and pathological conditions such as stroke. In particular, even though there have been inconsistent findings about changes in fat mass following strokes [15], it has been suggested that lean and muscle mass are important for stroke survival and management.

In fact, neurological disorders, inflammation, and immobility related to stroke could lead to progressive muscle atrophy [12,16]. This condition, known as “stroke-related sarcopenia”, could contribute to worse recovery after rehabilitation [17–19], whereas an improvement corresponds to a better functional outcome [20].

There are several methods to assess body composition: among them, computed tomography (CT) and dual-energy X-ray absorptiometry (DEXA) are considered the gold standard. However, these devices are expensive, are not transportable, and need highly qualified personnel for the analysis, and they also expose patients to ionizing radiation of diverse intensities [21]. On the other hand, bioelectrical impedance analysis (BIA) is commonly used to analyze body mass compartments due to its low cost, simplicity, safety, and non-invasiveness. BIA measures the electrical properties of the tissues and indirectly evaluates the body composition compartments [22]. Different body composition parameters can then be estimated by means of predictive equations including BIA variables, sex, age, stature, and weight.

Recently, there has been a rapid increase of studies on body composition in terms of the BIA parameters in relation to functional and clinical outcomes after stroke [17,23–30]. In particular, muscle mass and muscle quality parameters have been shown to be associated with functional independence measure at discharge [24,30], modified ranking score at discharge [17], and the Fugl–Meyer of upper limb at discharge [25]. In addition, the results of a recent retrospective multiple linear regression analysis demonstrated that the phase angle (PhA) and muscle mass were independently associated with better recovery after acute stroke [27].

Moreover, the skeletal muscle index (SMI) estimated with BIA together with muscle-strength assessment is employed for sarcopenia diagnosis according to the revised European Consensus, from the European Working Group of Sarcopenia in Older People 2 (EWGSOP2) [31].

In this context, the study of body composition appears essential to better characterize the general health status of patients admitted to a rehabilitation unit after a stroke injury.

Noteworthy, some BIA-derived parameters were not sufficiently explored in post-stroke patients, especially in relationship to recovery outcome after a rehabilitation treatment. To our knowledge, body cell mass (BCM), has not yet been studied in post-stroke patients undergoing rehabilitation. BCM represents the metabolically active portion of fat-free mass and indicates the cellular components of the body involved in oxygen consumption and resting metabolism [22,32] and has been suggested as a marker of malnutrition [33]. Because of that, BCM might be related to stroke clinical conditions that could influence patients’ recovery.

Given the above, in addition to other body composition parameters often analyzed, it is important to investigate BCM. A more comprehensive analysis of body composition could support a tailored rehabilitation intervention, including nutritional implementation and dietary modification.

This study aims to investigate, in a cohort of subacute post-stroke patients hospitalized for rehabilitation treatment: (i) body composition parameters assessed by BIA at admission and at discharge; and (ii) the relationship between these parameters and the functional mobility and independence recovery, focusing on BCM.

2. Materials and Methods

2.1. Study Design and Participants

This observational longitudinal study is still ongoing (NCT04923165). We analyzed the preliminary data based on a cohort of post-stroke patients, admitted to our rehabilitation unit between June 2021 and September 2022. Patients were sequentially enrolled and evaluated at admission (T0) and after a 6-week rehabilitation program (T1).

The following inclusion criteria were applied: (i) first ischemic or hemorrhagic stroke, diagnosed by magnetic resonance imaging (MRI) or computed tomography (CT); (ii) age range between 18 and 85 years; (iii) time from stroke onset less than six months; (iv) ade-

quate cognitive and language skills to sign the informed consent and to understand the advice for the administration of the assessment scales.

The following exclusion criteria were applied: (i) a prior stroke; (ii) cognitive and behavioral disorder, decreased compliance, preventing doing active therapy or understanding and signing informed consent; (iii) presence of pacemakers, which can interfere with bioelectrical impedance analysis. The Ethical Committee of Don Carlo Gnocchi Foundation, Milan, Italy approved the study protocol on 14 October 2020 (FDG_6_14/10/20). All patients analyzed gave their written informed consent after a detailed explanation of the study's aims and rehabilitation treatment.

2.2. Rehabilitation Treatment

Patients were placed through a rehabilitation program that included traditional physical therapy, executed for 45 min a day, for six days a week. Rehabilitation treatment included passive, active-assisted, and active mobilizations, exercises for muscle-strength recovery, stretching, sensorimotor stimulation, functional and task-oriented training, postural passages and transfers, proprioceptive exercises, motor-coordination and balance training, walking training, sitting and standing training, and activities of daily living recovery training. They also performed task-oriented exercises such as reaching and grasping movements (e.g., reaching and picking up a glass or other objects), activities of daily living (e.g., transfers, dressing, brushing/combining hair, depending on subject's ability), to increase the subject's participation in order to promote neuroplasticity and improve upper limb motor recovery.

Additionally, each patient used a set of robotic devices for robotic therapy of the upper limb, five times *per* week, each session lasting 45 min. Four robotic devices were employed in the robotic treatment: (i) Motore (Humanware, Pisa, Italy), a robotic device that allows passive, active, and active-assistive planar shoulder and elbow joints movements; (ii) Amadeo (Tyromotion, Graz, Austria) a robotic device for passive, active, and active-assistive finger flexion and extension movements; (iii) Pablo (Tyromotion, Graz, Austria) a sensor-based system that enables unsupported 3-dimensional movements of shoulder, elbow, and wrist joint, both unimanual and bimanual; and (iv) Diego (Tyromotion, Graz, Austria) a robotic system that enables 3-dimensional, unimanual and bimanual, movements of the shoulder joint, with arm weight support. Patients who underwent upper-limb robotic therapy carried out both physical and cognitive activities; the robotic equipment assisted them by providing visual and audible feedback [34,35].

2.3. Clinical Assessment and Anthropometric Measurements

On admission (T0), demographic, anamnestic, and clinical information were documented. Disease burden was assessed by means of the 56-point Cumulative Illness Rating Scale (CIRS) [36]. Dysphagia, without indicating severity, was registered at T0.

Body weight and height assessments were included in the anthropometric measurements. Body weight was measured weekly for monitoring any consistent weight changes and it was recorded at T0 and T1. A calibrated balance scale (Seca 750, Seca Hamburg, Germany) was used to measure the weight of autonomous patients, while a chair weighing scale (Wunder DE5, Wunder Sa.Bi. srl; Milan, Italy) was employed for nonautonomous ones. After an overnight fast, measurements were obtained early in the morning. Height was recorded at T0 for each patient who could stand, reporting data in meters (m), accurate to the nearest 0.1 cm. The height of those unable to stand was measured and checked with the knee height [37]. Then, we assessed the body mass index (BMI, kg/m²) at T0 and T1.

2.4. Bioelectrical Impedance Analysis

The use of a tetrapolar whole-body bioelectrical impedance analysis (BIA) device (101 anniversary sport edition, Akern, Florence, Italy) was utilized to perform bioelectrical impedance analysis (BIA) in order to evaluate the subject's body composition at both time points T0 and T1.

This apparatus is a bioelectrical impedance analyzer that operates at a single frequency and generates a sinusoidal current operating at 50 kHz. Before beginning measurements, operators were given instructions to ensure that data acquisition was carried out appropriately, to minimize estimation errors as much as possible.

Specifically, patients should lie supine for at least 2 min before testing to allow for even distribution of body fluids. Following that, certified electrodes were placed on the foot (metatarsus region) and hand (metacarpus region) of the hemisoma without hemiparesis, with a distance of 5 cm between the two electrodes. To prevent alterations in measurements, the skin at the contact point must be clean and not greasy, dry, or wet. In the final step, we ensured that the four limbs did not adhere to the body and were evenly spaced. Because of the possible alteration of bioelectric resistance due to body temperature, patients with fever or hypothermia were not analyzed. In addition, the absence of pacemakers was ascertained.

The bioimpedance analysis measures the bioelectrical impedance (Z) of biological tissues. Z is a complex quantity composed of resistance (R_z), which represents the resistance of electrolytes to the flow of an electric current, and reactance (X_c) which is affected by the capacitance of the cell membrane. Body composition parameters can then be estimated by means of a predictive equation, using regression analysis including several variables such as R_z , X_c , sex, age, stature, and weight [33,38].

In order to analyze body composition, lean mass, fat mass, and muscle quality parameters are measured in this study.

Total fat-free mass (FFM), appendicular skeletal muscle mass (ASMM), and body cell mass (BCM) were measured for body lean mass assessment. The fat-free mass index (FFMI), skeletal muscle mass index (SMI), and body cell mass index (BCMI) were then calculated by dividing the FFM, ASMM, and BCM measures for the height squared of each patient.

Total fat mass (FM) was included along with its index (fat mass index, FMI), which was calculated as described previously for the body lean mass assessment.

The BIA-derived PhA, calculated from R_z and X_c obtained from the BIA analysis and expressed in degrees, was also included for muscle quality assessment. The manufacturer recommends a normal range from 5° to 7° , and the variation may be influenced by age, gender, ethnicity, body composition, amount of physical activity, and body fat [39].

All the parameters were valued from proprietary manufacturer algorithms using Bodygram Plus software (Akern, Florence, Italy).

2.5. Functional Mobility Assessment: Performance in Activity of Daily Living

Patients at T0 and T1 were assessed their performance in activity of daily living (ADL), by means of the modified Barthel index (BI). Modified BI is a measure of physical disability used to evaluate how patients with disabling conditions, including stroke, behave when engaging in daily living activities. It measures, in a 20 min questionnaire, what patients do in practice, evaluating the following items: feeding, personal hygiene, dressing, bathing, bladder control, bowel control, toilet transfers, stair climbing, ambulation/wheelchair, ambulation, chair/bed transfer. Each item has a specific score, and the total of all items can range from 0 to 100. Higher scores indicate better functional independence, while lower scores indicate a greater degree of mobility and self-care disability [40].

2.6. Statistical Analysis

Patients' demographic and clinical features were reported using descriptive statistics, where numerical data were expressed as the mean and SD, and categorical data were presented as counts and percentages.

Moreover, to compare the body composition variables between admission (T0) and discharge (T1), we used the Wilcoxon signed rank test.

The correlation of the body composition parameters from BIA analysis with the functional status, as measured by the modified BI at T0, was investigated using the Spearman's rank correlation coefficients. We also performed bivariate analyses to verify the possible

effect of age, sex, BMI, type of stroke, paresis in the dominant art, smoking, comorbidities, CIRS, and time from stroke onset; Spearman's rho correlation test, or Mann–Whitney U test, was used as appropriate. We then performed a multiple linear regression analysis with BI at T0 as the dependent variable and BIA parameters adjusting for confounding variables that turned out to have a significant association in the bivariate analyses.

After treatment, patients were classified as responders if the change from baseline of the modified Barthel Index ($\Delta BI = BI_{T1} - BI_{T0}$) was higher than 10 points; otherwise, they were classified as non-responders. This threshold was detected in our sample, using the approach suggested by Castiglia et al. [41]. Then, we compared the body composition variables at baseline between patients with better or worse recovery, using the Mann–Whitney U test.

In addition, to further examine the potential association between BIA parameters and recovery, we first analyzed the effect of previously mentioned confounding variables and BI at T0 with bivariate analyses using the Pearson chi-squared or the Mann–Whitney U test as appropriate. Variables significantly different between responders and non-responders in the bivariate analysis were entered into a multivariable logistic regression, together with the BIA parameters for predicting the probability of response. A *p*-value lower than 0.05 was deemed significant. Statistical analysis was performed using SPSS version 28 (BM Corp., Armonk, NY, USA).

3. Results

3.1. Participants and Baseline Characteristics

We screened 120 patients and 66 were enrolled and evaluated (women $n = 37$; mean age 69 ± 12 years), according to the inclusion criteria.

The baseline characteristics (demographic and clinical features, disability assessment, and anthropometric measurements) of the enrolled sample are reported in Table 1. Dysphagia was calculated without considering its severity; none of the patients required enteral nutrition (e.g., gastrostomy, nasogastric tube) or parenteral nutrition.

Table 1. Baseline characteristics of the sample ($n = 66$). Data are reported in mean $\pm$ standard deviation or number (percentage).

Baseline Characteristics	Sample Group ($n = 66$)
Age (years)	69 ± 12
Women (%)	37 (56%)
Men (%)	29 (44%)
<i>Antropometric value</i>	
Weight (kg)	69.4 ± 15.6
Height (m)	1.66 ± 0.10
BMI (kg/m^2)	25.0 ± 4.9
<i>Index stroke type</i>	
Ischemic	51 (77%)
Hemorrhagic	15 (23%)
<i>Affected side</i>	
Right	33 (50%)
Left	33 (50%)
Smoking	32 (49%)
<i>Comorbidities</i>	
Hypertension	54 (82%)
Type 2 Diabetes	18 (27%)
Dyslipidemia	28 (42%)
Heart disease	18 (27%)
Dysphagia	21 (32%)

Table 1. *Cont.*

Baseline Characteristics	Sample Group (<i>n</i> = 66)
<i>Cumulative Illness Rating Scale (CIRS)</i>	
CIRS severity	1.9 ± 0.8
CIRS comorbidity	5.6 ± 1.7
Time from stroke onset (days)	103 ± 51
<i>Activity of daily living (ADL) Assessment</i>	
Modified Barthel Index T0 (0–100)	45 ± 19

3.2. Change in Body Composition

Table 2 reports the BIA parameters for the sample group. We included both total and height-adjusted measurements. In our sample, body composition in terms of the body fat mass parameters, body lean mass parameters, including BCM, and PhA did not change significantly after the six-week rehabilitation program. Moreover, PhA values measured at T0 and T1, were below the normal range from 5° to 7°.

Table 2. Bioelectrical impedance analysis parameters at baseline (T0) and at discharge (T1) of patients enrolled (*n* = 66).

Body Composition of the Sample (<i>n</i> = 66)			
	T0	T1	<i>p</i>
<i>Body Fat composition</i>			
FM (kg)	18.6 ± 9.2	17.9 ± 8.3	0.220
FMI (kg/m ²)	6.8 ± 3.4	6.5 ± 3.1	0.155
<i>Body lean mass composition</i>			
FFM (kg)	50.7 ± 10.1	51.2 ± 10.6	0.221
FFMI (kg/m ²)	18.3 ± 2.7	18.4 ± 2.8	0.279
ASMM (Kg)	18.9 ± 5.2	19.0 ± 5.2	0.289
SMI (kg/m ²)	6.8 ± 1.4	6.8 ± 1.4	0.253
BCM (kg)	23.3 ± 7.1	23.8 ± 7.6	0.257
BCMI (kg/m ²)	8.4 ± 2.3	8.6 ± 2.5	0.217
<i>Muscle quality</i>			
PhA (degree)	4.6 ± 1.1	4.7 ± 1.2	0.097

Data are reported in mean ± standard deviation. *p*-values refer to the Wilcoxon signed rank test. FM, fat mass; FMI, fat mass index; FFM, fat-free mass; FFMI, fat-free mass index; ASMM, appendicular skeletal muscle mass; SMI, skeletal muscle index; BCM, body cell mass; BCMI, body cell mass index; PhA, phase angle.

3.3. Body Composition and Performance in ADL

We first examined which BIA's parameters were associated with the Barthel Index at admission. The Spearman's correlation test (Table 3) showed a significant correlation with all the body lean mass parameters; in particular, BCM showed the higher value of Spearman's rho correlation coefficient. In contrast, no significant correlations were found for the body fat mass composition parameters. Finally, muscle quality, as measured using the PhA, was also positively correlated with the Barthel Index.

3.4. Body Composition and Recovery

When comparing the body composition BIA parameters at baseline in patients with a worse recovery (*n* = 34) or with a better recovery (*n* = 32) (Figure 1), we detected a significant difference in the lean mass parameters. Patients with a better recovery showed higher values of FFM (54.1 ± 9.8 vs. 47.5 ± 9.5, *p* = 0.011), FFMI (19.0 ± 2.5 vs. 17.5 ± 2.8, *p* = 0.031), ASMM (20.5 ± 4.8 vs. 17.3 ± 5.1, *p* = 0.010), SMI (7.2 ± 1.2 vs. 6.3 ± 1.5, *p* = 0.007), BCM (25.6 ± 6.7 vs. 21.1 ± 6.9, *p* = 0.013) and BCMI (9.0 ± 2.2 vs. 7.8 ± 2.3, *p* = 0.022) with respect to the patients with worse recovery. On the contrary, no significant

differences were found in the body fat mass parameters. Finally, even if not significantly, PhA values appeared higher in patients with better recovery, with respect to those with worse recovery (4.9 ± 1.1 vs. 4.4 ± 1.0 , $p = 0.078$).

Table 3. Correlations between Barthel Index and body composition parameters measured by bioelectrical impedance analysis (BIA) at admission (T0).

Barthel Index T0		
	Spearman's Rho	p-Value
<i>Body Fat composition</i>		
FM T0	0.155	0.356
FMI T0	0.076	0.543
<i>Body lean mass composition</i>		
FFM T0	0.375 **	0.002
FFMI T0	0.366 **	0.003
ASMM T0	0.395 **	0.001
SMI T0	0.399 ***	<0.001
BCM T0	0.414 ***	<0.001
BCMI T0	0.386 ***	0.001
<i>Muscle quality</i>		
PhA T0	0.354 **	0.004

FM, fat mass; FMI, fat mass index; FFM, fat-free mass; FFMI, fat-free mass index; ASMM, appendicular skeletal muscle mass; SMI, skeletal muscle Index; BCM, body cell mass; BCMI, body cell mass index; PhA, phase angle. ** p -value < 0.01; *** p -value < 0.001.

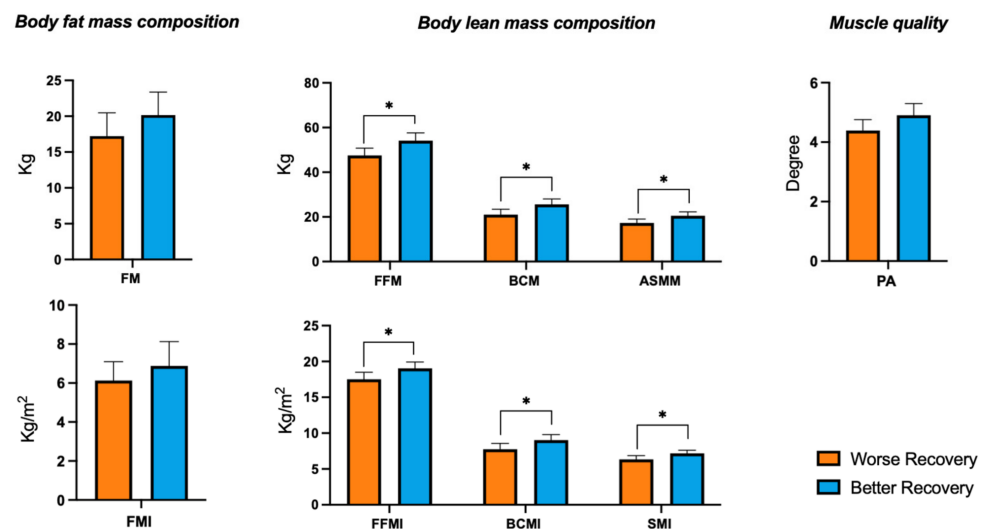


Figure 1. Analysis of body composition parameters at admission and rehabilitation recovery. Comparison of BIA parameters at baseline between patients with better recovery ($\Delta BI > 10$) or with worse recovery, ($\Delta BI \leq 10$). FM, fat mass; FMI, fat mass index; FFM, fat-free mass; FFMI, fat-free mass index; ASMM, appendicular skeletal muscle mass; SMI, skeletal muscle Index; BCM, body cell mass; BCMI, body cell mass index; PhA, phase angle. Mean bars and 95% of CI are reported. * refers to the statistically significant difference ($p < 0.05$), according to the Mann–Whitney U test.

3.5. The Role of BCM

Focusing on BCM, we first investigated its association with performance in ADL measured by BI T0. The linear regression analysis showed a significant association between BI T0 and BCM, even adjusting for sex and age as confounders (Table 4).

Table 4. Linear regression results for Barthel index at baseline (BI T0).

BI T0	B	95% CI		SE B	p	R ²	ΔR^2
		LL	UL				
BCM T0	0.78	0.03	1.52	0.37	0.041 *	0.23	0.24
Age	−0.38	−0.77	0.02	0.20	0.060		
Sex	−6.15	−16.16	3.87	5.01	0.224		

B: unstandardized regression coefficient; CI: confidence interval; LL: lower limit; UL: upper limit; SE B: standard error of the coefficient; R²: coefficient of determination; ΔR^2 : adjusted R². * *p*-value < 0.05

Finally, from the logistic regression analysis (Table 5), we found that BCM at T0 was positively associated with a better recovery, regardless of BI at T0, sex, and the presence of paresis on the dominant arm.

Table 5. Multiple logistic regression analysis for recovery in ADL.

	B	SE	p	Z	95% CI	
					LL	UL
BCM T0	0.10	0.05	0.038 *	2.08	0.01	0.19
BI T0	0.00	0.01	0.916	0.11	−0.03	0.03
sex	−0.23	0.60	0.700	−0.39	−1.41	0.95
Paresis on dominant arm	1.02	0.51	0.046 *	1.99	0.02	2.01
Intercept	−4.80	2.01	0.017 *	−2.01	−8.74	−0.87

B: estimate; SE: standard error; CI: confidence interval; LL: lower limit; UL: upper limit t; BCM T0: body cell mass at baseline; BI T0: Barthel Index at baseline; * *p* < 0.05.

4. Discussion

The results presented herein confirmed the well-known relationship between muscle mass and muscle quality parameters measured by BIA with rehabilitation outcome in post-stroke patients. Additionally, we found that BCM measured at admission may be a novel biomarker for the evaluation of post-stroke rehabilitation treatment. In fact, BCM T0 is not only positively correlated with baseline ADL performance, but it is also positively associated with patients' recovery, regardless of their performance at admission.

After a stroke insult, there could be an impairment in body composition [12], so the BIA analysis may be helpful in determining the proper rehabilitation and nutrition management in post-stroke patients [13]. As recently published, lean body mass at admission, especially muscular tissue, plays a role in surviving from stroke [13]. A muscle healthy condition is crucial for the recovery: muscle mass deficit, in terms of lower value of skeletal muscle index (SMI), has been proven to be an independent poor outcome predictor in acute stroke patients [17]. Moreover, stroke-related sarcopenia, which is a condition characterized by loss of muscle strength, mass, and function, had a negative effect on functional recovery [19,23], whereas its improvement corresponds to a better functional outcome [20]. Another commonly measured BIA-derived parameter is PhA, which it is associated with cell membrane integrity, cells function, and hydration [39]. Recent research examined the importance of PhA as a biomarker for the evaluation for the diagnosis of malnutrition/undernutrition [42] and of the effectiveness of rehabilitation treatment in post-stroke patients [24,26,27].

Our study confirmed the actual link between lean and muscle mass and muscle quality and functional status at baseline in subacute post-stroke patients admitted to rehabilitation. In fact, the FFM, ASMM, and their relative indices (height-squared-adjusted: FFMI, SMI), as well as PhA were positively correlated with the ADL at baseline. On the other hand, there was no correlation between the baseline ADL and any of the fat mass-related measurements. Even though PhA between two groups is not significantly different, it is important to note that the PhA mean values in both groups were under the normal range, indicating a muscle quality impairment.

From our results, besides the above-discussed BIA parameters, BCM also appears to play a role in the evaluation of post-stroke recovery. BCM had the higher correlation with the baseline ADL. Moreover, higher values of BCM and BCMI at admission were seen in patients with a better recovery. These results could be connected with the known link between BCM and nutritional status. BCM evaluation identifies the metabolically active part of FFM, in contrast to bone and extracellular water. Hence, it reflects the body's cellular components involved in oxygen consumption and resting metabolism [22,32]. BCM is associated with the resting energy expenditure (REE), which represents energy consumption to maintain essential life functions while at rest [32]. It has also been suggested that measuring BCM is important for the nutritional screening and management of critically ill patients. In fact, low values of BCM reflect a malnutrition status for such serious subjects [33].

As found in our logistic regression analysis, BCM was independently associated with better recovery of post-stroke patients. Notably, the performance in ADL at baseline, sex, and paresis in the dominant arm did not influence this association. The sample size of this study was insufficient to verify the effect of more confounders as independent variables in the regression analysis. We are planning to verify if BCM may effectively predict the recovery in post-stroke patients on a larger sample.

Another result is that, in our study, we found no differences in patients' body composition parameters after six weeks of rehabilitation treatment. The literature on this topic is very poor, and in disagreement. One study reported that muscle mass did not differ in post-stroke patients after a four weeks of rehabilitation treatment [43], while another one found a loss of lean and fat mass and an increase in muscle mass after a five-week rehabilitation program [44]. In addition, this study showed that in post-stroke patients, SMI increased with rehabilitation of 1–6 months and that the increase was independently associated with length of hospital stays [45].

In our opinion, the intervention time is too short to observe a positive change in body composition. In fact, elderly patients with strokes may suffer from a decline in muscle mass related to aging and immobility [12], and they should be treated with a specific rehabilitation protocol that considers adequate nutritional intervention and exercise training. In fact, it has been shown that a specific exercise training program [46] together with adequate supplementation [47] could ameliorate the body composition of post-stroke patients.

The preliminary results presented herein deserve future study on a bigger sample in order to confirm the data. In fact, one limitation of this study is due to a limited sample recruited only in a single rehabilitation facility. A multicentered study planned in the near future will deal with this restriction and will increase the sample size.

5. Conclusions

An analysis of the patient's body composition is important to determine the general health status of subacute post-stroke patients undergoing a rehabilitation treatment. Moreover, BCM is a BIA parameter that should be assessed at admission not only to improve the valuation of the nutritional status in post-stroke patients, but also to potentially predict their recovery.

Examining and monitoring the body composition and the nutritional status of stroke patients hospitalized in a rehabilitation unit are critical in order to guide and prepare for prompt nutritional assistance as well as dietary intervention.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Comitato Etico della Sezione “IRCCS Fondazione Don Carlo Gnocchi” del Comitato Etico IRCCS Regione Lombardia.

Informed Consent Statement: After a detailed explanation of the study’s aims and rehabilitation protocols, all patients involved in the study signed the informed consent.

Data Availability Statement: The data supporting the results of this study are accessible from the corresponding author upon reasonable request.

Conflicts of Interest: The authors declare no conflict of interest.

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