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TITLE

Relationship Between Body Mass Index and Rehabilitation Outcomes in Subacute Stroke with Dysphagia

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ABSTRACT:

Aim: The aim of the study was to investigate the association between body mass index and rehabilitation outcome in hemiparetic patients with stroke in subacute phase.

Design: This was a prospective study testing the correlation between body mass index and the effectiveness of rehabilitation, measured using Barthel Index scores. We enrolled patients with subacute stroke (n = 664; age, 68 ± 14 years; length of hospital days, 84 ± 34). We assessed the body mass index and Barthel Index both at admission and discharge. The effectiveness of rehabilitation was computed as the percentage increment in Barthel Index score with respect to the maximum achievable improvement.

Results: Effectiveness of rehabilitation was significantly correlated with the body mass index at discharge ($R = 0.111$, $P = 0.004$) and percentage change in body mass index ($R = 0.253$, $P < 0.001$), but not with body mass index at admission ($R = 0.006$, $P = 0.869$).

Conclusions: In addition to body mass index value, our findings suggest that rehabilitation outcomes can be influenced by the change in body mass index during rehabilitation.

Key Words: Body Mass Index, Undernutrition, Rehabilitation, Stroke, Obesity Paradox

Introduction

Corpulence is not only a disease itself, but the harbinger of others." This sentence was written by Hippocrates in the 4th century BC. Today, obesity is defined as a medical con- dition with an excess of body fat that may produce a negative effect on health.1 Obesity is the sixth most important risk factor contributing to the overall burden of disease worldwide, with 1.1 billion adults classified as overweight or obese, with a decrease in life expectancy. (1)

However, in patients with stroke, obesity has sometimes been reported as a protective factor; this particularity has been termed the "obesity paradox."2 This paradox involves findings that overweight and obese patients with stroke had lower risk of mortality than patients with normal weight. (2,3). This paradox has been generally accepted for several years, although contrasting results have also been reported. (4) Furthermore, an age-dependent effect of obesity on poststroke mortality has been found; the as- sociation of higher body mass index (BMI) with mortality risk was found to be strongest in younger individuals and it declined linearly with increasing age. In elderly patients (age >70 yrs), excess body weight might have a protective effect.(5)

Recently, the waist-to-hip ratio or waist circumference has been suggested as more precise measurements of obesity than BMI. Remarkably, the obesity paradox disappears when obesity is measured using the waist-to-hip ratio instead of BMI.(6) In physical medicine and rehabilitation, the obesity paradox has been observed with regard to life expectancy and with rehabil- itative outcomes of patients with stroke. Patients undergoing inpatient rehabilitation for stroke who are overweight have been found to have greater probability of better recovery than those with normal weight and obese patients.(7)

One study found among 10.905 inpatients affected by stroke, during the period of 1 yr, a mortality rate of 14.9% in underweight, 7.8% in normal weight, 7.1% in overweight, 7.2% in obese, and 11.5% in severely obese patients. Moreover, favorable functional recovery was observed in 52.4% of underweight, 55.0% of normal weight, 61.0% of overweight, 59.2% of obese, and 60.3% of severely obese stroke survivors. In that study, overweight was associ- ated with favorable 3-mo functional recovery.(8)

The previously cited studies focused on different changes in functional outcome with respect to BMI recorded at admis- sion to the hospital. These studies did not consider the changes in BMI during recovery. The aim of our study was to investigate how rehabilitation outcomes, assessed by the recovery of autonomy in activities of daily living (ADLs), can be affected by BMI and by its changes.

MATERIAL AND METHODS

In this study, we analyzed the data of 767 patients who recovered in our hospital between 2006 and 2016. Inclusion criteria were first stroke admission to a specialized multidisciplinary rehabilitation facility, subacute phase of stroke, and absence of other severe disabling orthopedic or neurological conditions. Of the 767 patients, 664 (86.6%) completed the rehabilitation protocol and were discharged after 84 ± 34 days of inpatient rehabilitation. In these patients, the mean ± SD age was 68 ± 14 yrs, 360 were women (54.2%), 109 had hemorrhagic.

stroke (16.4%), 85 were obese at admission (12.8%), 224 were overweight (33.7%), 330 had normal weight (49.7%), and 25 were underweight (3.8%). Time from acute event within 1 month (18 ± 17 days) and duration of hospitalization (84 ± 34 days) were quite homogenous within the entire sample because these were related to the procedures of our hospital and to the guide- lines provided by the National Health Ministry. Patients with dysphagia received special diets. Food texture was chosen ac- cording to the level of dysphagia, from a semiliquid and semi- solid diet (examples of food: smoothie and/or homogenized foods, pureed fruit), semisolid soft diet (well-cooked pasta, pasta with tomato sauce, and spreadable cheeses), soft semi- solid diet (pureed pasta, semolina, cream of rice, meatballs, hamburgers, scrambled eggs, omelette, boiled boneless fish), soft diet (macaroni, dry pasta, potatoes, zucchini, carrots, common foods without double textures), and up to normal food for patients without dysphagia. Barthel Index (BI) and BMI were assessed at hospital admission and discharge. Body mass index was evaluated as the weight (kilogram) divided the height (square meter). The change in BMI was evaluated as the percentage difference between discharge and admission divided by the value at admission. Barthel Index is a validated clinical scale comprising 10 items, which is useful for measuring patient in- dependence in ADLs. The change in BI has been evaluated using effectiveness, a parameter reflecting the percentage proportion of improvement that was achieved after rehabilitation with respect to the maximal achievable improvement and calculated as [(dis- charge score − initial score)/(maximum score − initial score)] 100.9,10 This approach allows for normalization of the data of BI score, accounting for baseline differences. We performed an analysis of the participant groups using the category of BMI at admission and BMI at discharge, as factors potentially influencing the effectiveness of treatment in terms of BI score improvement. Post hoc comparisons were performed using Tukey's correction. Spearman correlation coefficient R was computed for analyzing the correlation between parameters. This study was approved by the ethical committee of the Santa Lucia Foundation and patients signed a written informed consent.

RESULTS

From admission to discharge, patients improved their in- dependence in ADLs, assessed by BI score. However, patients' weight generally declined, as shown by the values of BMI re- ported in Table 1. The effectiveness reflects the proportion of potential improvement that was achieved during rehabilitation. (9)

Lower effectiveness was found for underweight patients. Analysis of variance revealed a significant influence on the effectiveness of rehabilitation due to BMI category at discharge ($F(3,652) = 5.874$, $P = 0.001$); only a partial and nonsignificant effect of BMI category at admission was found ($F(3,652) = 2.206$, $P = 0.086$). The interactions of these two factors were not significant ($F(4,652) = 1.324$, $P = 0.259$).

Tukey's corrected post hoc comparisons showed that underweight patients represented the only group related to effectiveness that was significantly different from (i.e., lower than) the effectiveness in all other groups ($P = 0.027$ vs. normal weight, $P = 0.004$, vs. overweight, $P = 0.009$, vs. obese).

When this analysis was performed only on patients with dysphagia (65%), the results were confirmed (a significant effect of BMI category at discharge, $P = 0.011$, but not BMI at admission, $P = 0.220$). Conversely, no significant effect of BMI at discharge or admission was found for patients without dysphagia ($P = 0.223$, $P = 0.281$, respectively).

The correlation between BMI and BI score on the whole sample was not statistically significant ($R = 0.045$, $P = 0.243$) at admission, but this was statistically significant at discharge ($R = 0.126$, $P = 0.001$). Effectiveness was found to be significantly correlated with BMI assessed at discharge ($R = 0.111$, $P = 0.004$) but not with BMI assessed at admission ($R = 0.006$, $P = 0.869$). The most important result was the statistically significant correlation between effectiveness of rehabilitation and percent-

age change in BMI ($R = 0.253$, $P < 0.001$). Figures 1 and 2 show the mean values of effectiveness for the BMI categories at admission and discharge. The figures clearly show that weight loss (and hence, a reduction in BMI) was related to a decrement of effectiveness, whereas an increase to a higher BMI category was related to an increment of effectiveness. This correlation was observed in the group of patients with dysphagia ($R = 0.258$, $P < 0.001$) but not in those without dysphagia ($R = 0.070$, $P = 0.291$). The correlation between rehabilitation effective- ness and percentage change in BMI was statistically significant for all BMI categories at admission: $R = 0.506$ for underweight ($P = 0.019$), $R = 0.334$ for normal weight ($P < 0.001$), $R = 0.159$ for overweight ($P = 0.018$), and $R = 0.245$ for obese ($P = 0.033$) patients. Figure 3 shows the results of our study ac- cording to patients with and without dysphagia.

DISCUSSION

The fundamental result of our study was the significant correlation between effectiveness of neurorehabilitation and the change in BMI during rehabilitation. As clearly shown in Figure 2, a reduction in weight was associated with a reduction in the effectiveness of rehabilitation, even in patients who were overweight or obese at admission. This result could be related to dysphagia and related difficulties in feeding. Dysphagia is one of the most common morbidities after stroke and increases the risk of dehydration, malnutrition, and clinical complications, hence resulting in a poor prognosis.11 In turn, malnutrition affects ADLs in convalescent patients after stroke: it is known that nutritional improvement and energy intake at ad- mission are associated with recovery of ADLs after cerebrovascular events. (12) Percutaneous endoscopic gastrostomy can usually be performed in dysphagic stroke patients; some stroke survivors with dysphagia with a high BMI and cognitive Functional Independence Measure scores regain complete oral intake without gastrostomy. (13)

Weight loss after stroke may be caused by a global negative caloric intake and, in turn, may cause an aggravation of sarcopenia that occurs because of paresis and reduced physical activity. (14) A global catabolic/anabolic imbalance may develop with increased catabolic drive and failing anabolic stimulation, especially in the acute phase after the stroke (15): it then becomes essential to contain weight loss and minimize BMI variation during hospitalization.

Our results also showed that an increase in BMI was related to better recovery, supporting the possibility that BMI improvement may positively enhance recovery in terms of autonomy in ADLs. Table 1 shows an average loss of BMI common to all the categories, meaning that most patients lost weight (but not all of them, with standard deviations higher than mean values). The increment of BMI observed in a portion of patients was associated with a gain in the effectiveness of rehabilitation, as shown in Figures 1 and 2, statistically confirmed by the correlation found between effectiveness and percentage change in BMI. Hence, monitoring of BMI during recovery, especially in patients with dysphagia, seems to be fundamental for patients with stroke in subacute phase during their rehabilitation. Our results provide scientific support to the recent commentary by Scherbakov et al.16 regarding clinical evidence that patients with stroke are susceptible to weight loss, which is correlated with poor outcome. As noted by those authors, data were lacking about this aspect, with the exception of those obtained in mice by Dirnagl (17) showing that weight loss is highly correlated with the volume of infarct size. Other authors like Rist et al.(18) did not observe a consistent pattern for the probability of regaining independence in ADLs when stroke and 3 yrs after stroke, and considering physical activity. Previous results have shown that chronic stroke patients with a higher BMI were less likely to demonstrate improvement in motor impairment and functional mobility performance in response to ambulation training, irrespective of treatment intervention. (19)

Furthermore, prolonged weight loss could be associated with cognitive impairment that may, in turn, impair the outcome of multidisciplinary rehabilitation based on neuromotor and neurocognitive programs. (20)

With respect to the obesity paradox, our study introduces two fundamental factors that should be considered: underweight and dysphagia. More than the positive role of obesity, our results showed the negative role of underweight. The so-called obesity paradox could be interpreted as meaning that the absence of underweight is a positive factor. Thus, our results show that BMI should be continuously monitored in stroke patients because its reduction may affect the efficacy of rehabilitation. The most important factor for improving underweight is dysphagia, which may in turn reduce the effects of rehabilitation. Hence, the care of patients should also be focused on rehabilitation of dysphagic deficits as well as on the correction of dietary deficiencies. As shown in Figure 3, a reduction of BMI is a negative prognostic factor of neurorehabilitation outcome in patients with dysphagia. Hence, the obesity paradox in stroke recovery seems to be a fashionable theory that can lead to viewing obesity in a positive light, when it is one of the major causes of cardiovascular morbidity. (21)

Indeed, an important risk of malnutrition and dehydration occurs after stroke because of a reduction or modification of food intake and dysphagia-related problems.22 Similarly, mortality risk in populations with stroke has been associated with weight loss more than weight per se. (23)

A limit of our study was the absence of any indices of nutrition or measure of nutritional intake. Further investigations should consider this aspect for better identification of factors besides BMI that potentially affect functional outcome.

Early and ongoing detection and treatment of malnutrition are recommended during rehabilitation of patients with stroke, both during recovery as well as at follow-up. (24) As has been demonstrated, nutritional improvement correlates with rehabilitation outcomes in terms of recovery of ADLs among malnourished patients with stroke. (25)

We believe that an important step could be taken in stroke care if greater attention were paid to patient nutritional status as supporting rehabilitation and neuroplasticity during recovery. Further investigations should take into account this aspect for better identification of factors besides BMI that potentially affect functional outcome.

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TABLE 1. Barthel Index score and BMI (kilogram per square meter) at admission and discharge as well as relevant change (the difference between discharge and admission for BMI and effectiveness in terms of BI score improvement divided by the maximum possible improvement)

Time	Factor	Underweight	Normal Weight	Overweight	Obese
Admission	BMI	18.3 ± 2.3	22.6 ± 2.2	27.1 ± 2.0	33.5 ± 4.0
	BI	14.7 ± 15.9	25.2 ± 25.3	32.5 ± 28.0	29.4 ± 28.0
Discharge	BMI	17.1 ± 1.2	22.3 ± 1.7	26.9 ± 1.3	33.0 ± 3.6
	BI	43.5 ± 35.6	64.7 ± 32.7	70.2 ± 31.0	69.5 ± 32.7
Change	BMI	−1.2 ± 2.1	−0.3 ± 1.5	−0.2 ± 1.6	−0.5 ± 1.6
	Effectiveness	38.5 ± 36.0%	59.9 ± 33.9%	64.9 ± 33.0%	65.0 ± 33.4%

FIGURE 1. Mean and standard deviation of effectiveness evaluated in terms of Barthel Index improvement, with respect to category of BMI at admission and discharge.

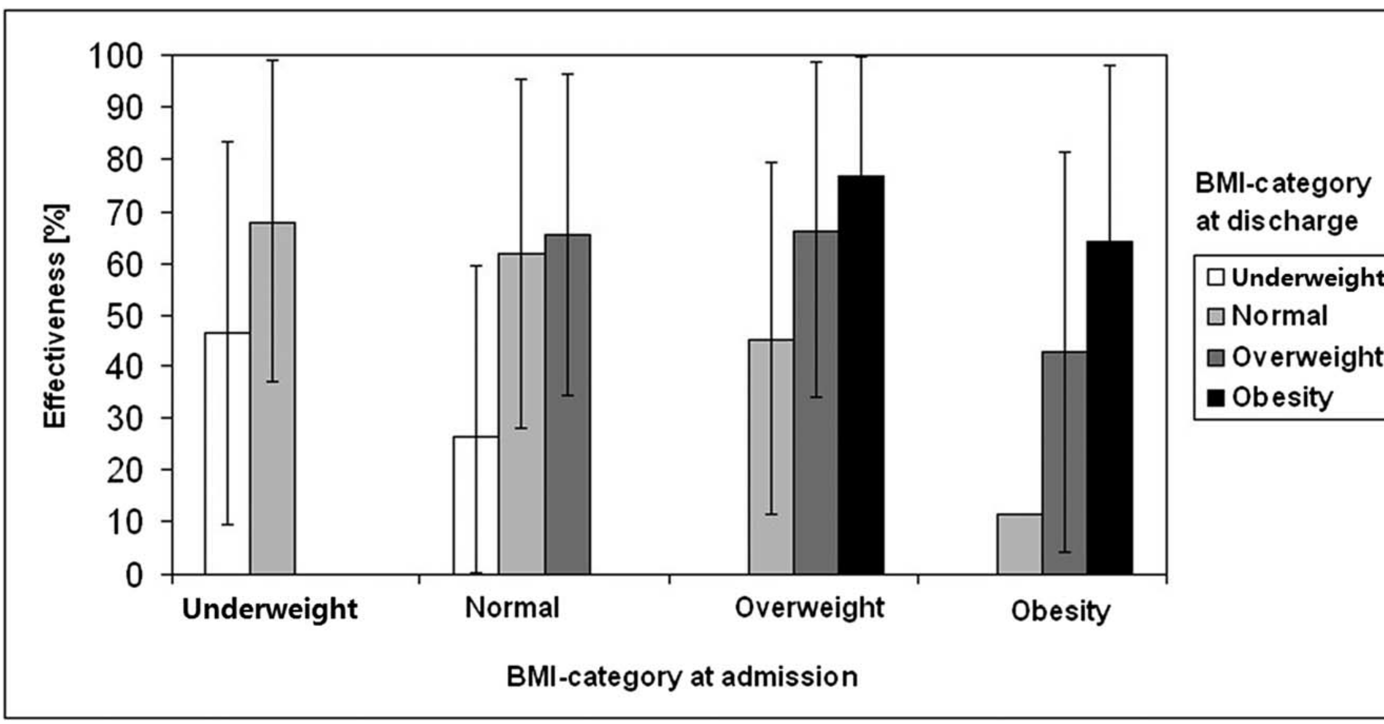

FIGURE 2. Box and whisker plots of the effectiveness of treatment for the entire sample (upper plot) and for BMI category at admission (lower plots). Boxes show the lower quartile, median (bold line), and upper quartile values; whiskers represent 1.5 times the interquartile range; crosses indicate the data values beyond the ends of the whiskers.

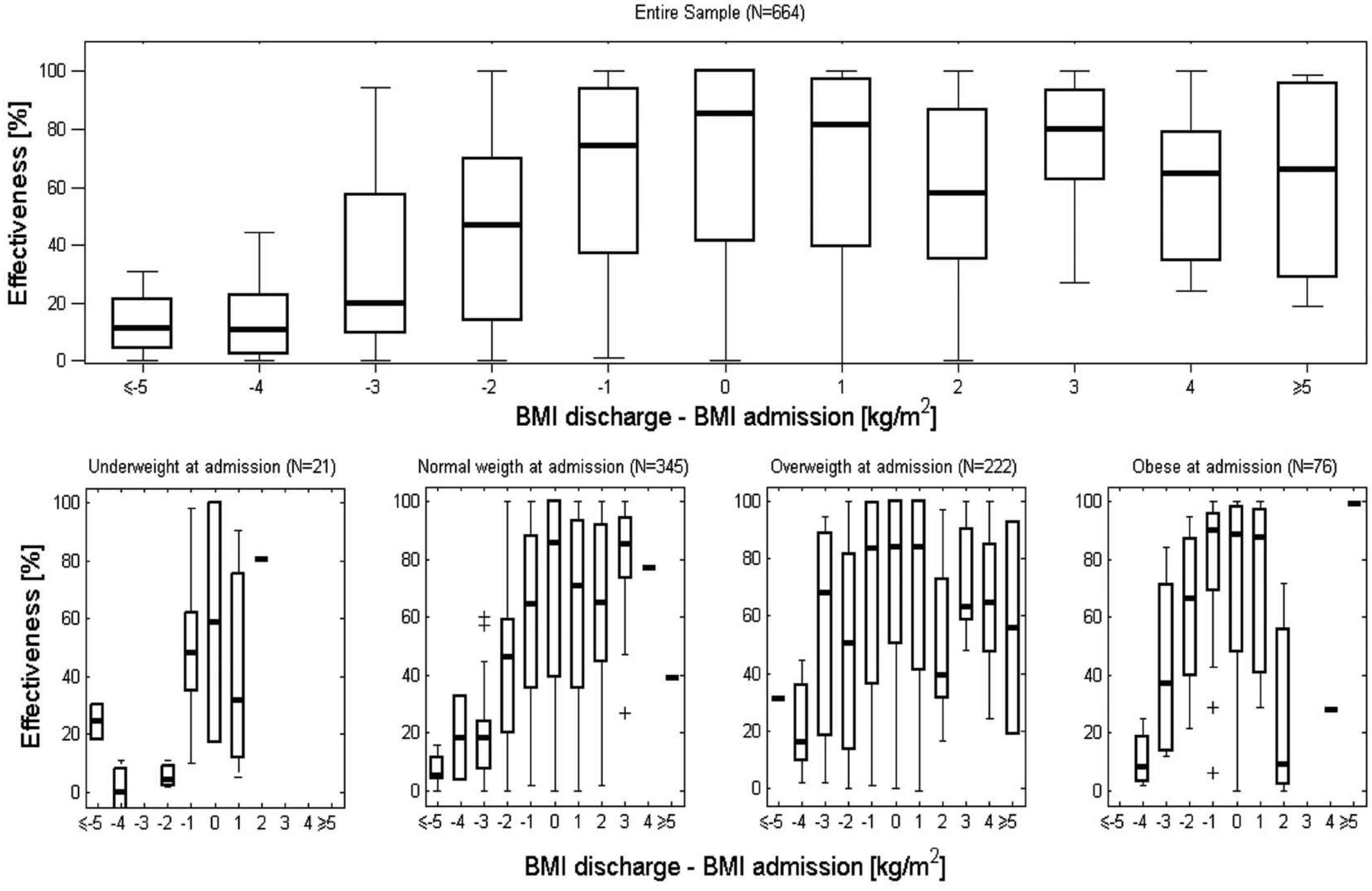

FIGURE 3. Median values of BI scores at admission (empty circles, dotted lines) and at discharge (empty circles, solid lines) and relevant improvement in terms of effectiveness (solid circles, solid lines) for patients with (black) and without (gray) dysphagia, with respect to BMI category at discharge.