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Relationship Between Body Mass Index and Rehabilitation Outcomes in Chronic Stroke

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Abstract

Objective—To evaluate the relationship between Body Mass Index (BMI) and change in motor impairment and functional mobility following a gait rehabilitation intervention in chronic stroke subjects.

Design—Correlation and linear regression analyses of pretreatment and end-of-treatment Fugl-Meyer (FM) scores and modified Emory Functional Ambulation Profile (mEFAP) scores from hemiparetic subjects (n=108, > 3 months post-stroke) who participated in a randomized controlled trial comparing two 12-week ambulation training treatments.

Results—A series of linear regression models which controlled for age, sex, stroke type, interval post-stroke, and training device found change in FM score to be significantly negatively associated with pretreatment BMI ($\beta=-.207$, $p=.036$) and change in the "up and go" mEFAP score to be significantly positively associated with BMI ($\beta=.216$, $p=.03$). Change in floor, carpet, obstacles, or stair climbing mEFAP scores were not significantly associated with BMI.

Conclusions—Chronic stroke subjects with a higher BMI were less likely to demonstrate improvement in motor impairment and "up and go" functional mobility performance in response to ambulation training, irrespective of treatment intervention. Stroke rehabilitation clinicians should consider BMI when formulating rehabilitation goals. Further studies are necessary to determine if obesity is a predictor of longer-term post-stroke motor and functional recovery.

Keywords

Body Mass Index; Stroke; Rehabilitation

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Independent from age, lifestyle, and other cardiovascular risk factors, being overweight or obese is associated with a progressively increased risk of ischemic stroke.[1] The prevalence of obesity, specifically in the elderly population who are already at highest risk of stroke, is increasing worldwide and is associated with both escalating healthcare costs and disability.[2] While obesity is a primary risk factor for stroke and a major public health concern in the elderly patient population, there is limited data available on the impact of obesity on post-stroke rehabilitation outcomes. For the estimated 800,000 Americans who sustain a stroke annually, a primary goal of stroke rehabilitation programs is to maximize long-term functional mobility and ambulation. Obesity would be anticipated to negatively affect the achievement of post-stroke functional mobility and ambulation goals. The primary objective of this study was to evaluate the association between pretreatment body mass index (BMI) and change in motor impairment and functional mobility performance in chronic hemiparetic stroke subjects who participated in an interventional study aimed at improving ambulation.

Our first hypothesis was that stroke participants with a higher BMI would have a lower level of pre-treatment motor impairment, measured by the Fugl-Meyer (FM) score, based on an apparent obesity paradox[3] which proposes that overweight and obese patients may have a pre-stroke elevation in cholesterol levels which preferentially predisposes them to small vessel disease and thus less severe strokes. However, on the basis of an established association between obesity and functional disability in the nonstroke population[4–11], our second hypothesis was that BMI would be positively correlated with pretreatment functional mobility deficits as measured by modified Emory Functional Ambulation Profile (mEFAP) component scores. Our third hypothesis was that BMI would be significantly negatively associated with change in motor impairment level and functional ambulation performance in response to a 12-wk period of ambulation training. This study is the first to examine the association between pretreatment BMI and change in motor impairment and functional mobility performance in response to an ambulation training rehabilitation intervention in the chronic post-stroke patient population. If pretreatment BMI is strongly negatively associated with post-stroke rehabilitation gains, then a high BMI should be recognized as a potential barrier to achieving optimal therapy gains and should thus be independently factored in the formulation of longer-term stroke rehabilitation goals.

METHODS

Study Design

This study is a secondary analysis of data collected in a randomized controlled clinical stroke trial (“parent study”) which enrolled 110 hemiparetic subjects. The objective of the parent study was to compare the lower limb motor relearning effect of a peroneal nerve stimulator (PNS) versus usual care (ankle foot orthosis or no device) treatment. Enrolled subjects were randomized to either a PNS or usual care group and participated in a 12-week ambulation training treatment period using the assigned device. This present study analyzed a subset of pretreatment and end-of-treatment lower extremity motor impairment and functional mobility data collected in the parent study. For purposes of this secondary analysis, the BMI was calculated based on pretreatment weight and height measurements which were available for 108 subjects.

Participants

The protocols of both the parent study and this secondary analysis were approved by the Institutional Review Board of the involved academic medical centers; each subject gave written consent prior to participation. All subjects enrolled in the parent study were a

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minimum of 18 years of age and medically stable. Subjects demonstrated unilateral hemiparesis with ankle dorsiflexion strength of no greater than 4/5 on the Medical Research Council scale while standing. Each subject demonstrated dorsiflexion weakness during ambulation such that inefficient gait patterns with the need for compensatory strategies were exhibited when ambulating a minimum of nine meters. Subjects were excluded for concomitant neurological diagnoses, uncompensated hemineglect, severely impaired cognition and communication, fixed ankle contracture, peroneal nerve injury, genu recurvatum, or history of Botulinum toxin injection to the affected lower extremity in the preceding 3 months. No inclusion or exclusion selection criterion of the parent study was contingent on subject BMI.

Variables

Body Mass Index (Independent Variable)—The BMI[12] is defined as the body weight divided by the square of the height (kg/m2) and is a widely used diagnostic tool to identify weight problems within a population. A BMI below 18.5 is defined as underweight condition; a BMI of 18.5 to 25 is defined as optimal weight; a BMI > 25 is defined as an overweight condition; a BMI > 30 is defined as obese (Class I, BMI 30–35; Class II, BMI 35–40); a BMI > 40 is defined as morbid obesity (Class III).

Lower Extremity Motor Impairment and Functional Ambulation Measures (Dependent Variables)

Fugl-Meyer Assessment—The FM[13] has been widely used as a clinical and research instrument to measure post-stroke motor impairment. Subjects are assessed for the presence or absence of lower extremity reflexes, flexor and extensor synergy patterns, and volitional movement; coordination (tremor, dysmetria); and speed of movement. The validity[13] and the interrater and test-retest reliability of the FMA has been demonstrated.[14–15] The lower extremity portion of the FMA was performed in the parent study for a maximum FMA score of 34. The change of the lower extremity FM score was used as a dependent variable, which was defined as the measure at 12-wks subtracted by the measure at baseline.

Modified Emory Functional Ambulation Profile

The Modified Emory Functional Ambulation Profile (mEFAP) is a clinical test that measures the time to ambulate through five common environmental terrains. Specific tasks include 1) a 5-m walk on a hard floor; 2) a 5-m walk on a carpeted surface; 3) rising from a chair, a 3-m walk, and return to a seated position (the “timed up-and-go” test); 4) standardized obstacle course; and 5) stair ascent and descent. The test was administered using a hand-held stopwatch in the sequence listed and the five component timed subscores were recorded. The validity[16] and interrater reliability[16–17] of the mEFAP have been determined. The change of the mEFAP timed score, for each of the five component tasks, was used as a dependent variable, which was defined as the measure at 12-wks subtracted by the measure at baseline.

Statistical Analysis

In order to understand the demographics of the study population, exploratory analysis was performed. Normalcy of distribution of data was determined by looking at histograms and normal probability plots and by the Kolmogorov-Smirnov (K-S) and Shapiro-Wilk (S-W) tests. Pearson product-moment correlation coefficients (r) were generated to quantify the strength and direction of the association between pretreatment BMI and the pretreatment FM score and five component scores of the mEFAP. A series of linear regression models which controlled for age, sex, stroke type (hemorrhagic versus ischemic), interval post-stroke, and treatment device intervention (PNS versus usual care) were then used to determine the

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strength of association between pretreatment BMI and change in motor impairment and functional ambulation measures in response to the 12-wk treatment intervention. We handled missing data in the models by performing listwise deletion. Residual plots were used to verify normality of the model error terms.

RESULTS

BMI was calculated based on weight and height which were recorded for 108 subjects. Participant characteristics and pretreatment data are presented in Table 1. Pretreatment BMI did not correlate with pretreatment FM score or mEFAP component scores. Change in Fugl-Meyer and mEFAP component scores following the 12-wk intervention is presented in Table 2. For all subjects, there was a statistically significant correlation between pretreatment BMI and change in the Fugl-Myer score ($r=-.218$, $p=.034$) and change in “up and go” mobility score ($r=.224$, $p=.030$) at the end of the 12-wk intervention period. In a series of linear regression models we adjusted for age, sex, stroke type (hemorrhagic versus ischemic), interval post-stroke, and treatment device intervention. We found that change in Fugl-Meyer score continued to be significantly negatively associated with pretreatment BMI ($\beta=-.207$, $p=.036$). Similarly, change in “up and go” mobility score continued to be positively associated with pretreatment BMI ($\beta=.216$, $p=.03$) at the end of the intervention period. Pretreatment BMI ($p>0.05$) was not associated with change in the floor, carpet, obstacles, or stair climbing mEFAP component scores.

DISCUSSION

A primary finding in this study was that BMI was not significantly negatively associated with pretreatment motor impairment (FM score). This finding does not support an obesity paradox[3] which proposes that an overweight or obese patient is predisposed to specific stroke types which result in less severe motor deficits and thus a lower degree of motor impairment. A possible explanation for this finding is that the parent study enrollment criteria, which required a minimum ability to ambulate 30 feet at study entry, may have biased our subject pool by excluding subjects with greater levels of motor impairment, who theoretically may have had lower BMIs. Alternatively, the study sample size may simply have been inadequate to reflect a disparate incidence of specific stroke type and severity related to BMI and associated co-morbidities[18].

A secondary finding in this present study was that BMI was not significantly positively associated with pretreatment functional mobility deficits (mEFAP component scores). This finding is at odds with published literature for both healthy adult and disabled patient populations. Obesity in otherwise healthy adult patient populations has been shown to have a negative impact on functional ambulation,[6–7, 11] balance,[7–8] fall frequency,[7] and physical disability.[4–5,9–10] The coexistence of a high BMI and two or more physical impairments has been demonstrated to significantly increase the adjusted risk of longer-term walking limitation as compared to normal weight persons with no physical impairments.[19] The absence of an association between BMI and pretreatment mEFAP scores in this study may similarly be explained by either an inadequate sample size in the parent study or enrollment criteria which excluded subjects with the greatest level of mobility limitation. Alternatively, a high BMI may be associated with limitation in endurance-dependent functional performance tasks not measured by the mEFAP and thus the mEFAP may be suboptimal as a measurement tool.

An important third study finding was that pretreatment BMI was significantly negatively associated with change in motor impairment (FM scores) and positively associated with change in “up and go” mEFAP performance at the end of the 12-week intervention period.

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In other words, chronic hemiparetic patients with a higher BMI were less likely to demonstrate gains in motor impairment or improvement on their "up and go" performance, irrespective of the treatment intervention (PNS or usual care). These findings are in accord with Kalichman et al[20] who found a negative correlation between BMI and relative improvement of Functional Independence Measure (FIM) score at the end of a 12-week period of inpatient acute stroke rehabilitation. This present study, however, is the first to suggest that BMI may be predictive of response to a rehabilitation intervention in the chronic (>3 mos) post-stroke period. Of note, a significant association with BMI was found only for the "up and go" mEFAP component, the only mEFAP task that commences from a seated position. Prior studies have demonstrated a correlation between paretic and bilateral plantarflexion strength and "up and go" testing[21–22] and thus performance gains on this task, relative to the other mEFAP tasks, may be disproportionately dependent on plantarflexion strength gains. Theoretically, if duration, intensity or frequency of walking was less over the 12-wk intervention period for subjects with higher BMIs, the result may be less plantarflexion strengthening and thus less improvement on the "up and go" mEFAP task relative to the other component tasks. Similarly speculative, the significant negative association between change in FM score and BMI may be related to compliance with the rehabilitation intervention (ie duration, intensity, and distance of walking), irrespective of treatment device, which may have been disproportionately less due to BMI-associated medical co-morbidities.

Interpretation of this secondary analysis is primarily limited by the study design. The parent study was limited to chronic stroke survivors who were able to ambulate up to nine meters and inclusion/exclusion criteria resulted in the exclusion of subjects with more severe motor impairment and functional limitations. Secondly, the BMI is recognized as an imperfect measure which has been criticized for making overly simplistic assumptions about distribution of muscle and bone mass, particularly in the elderly patient population. Thirdly, the linear regression models predict a magnitude of change in FM or mEFAP component scores associated with BMI level that while statistically significant, may not translate into a clinical significant difference for any individual stroke survivor.

In summary, obesity is a growing public health concern in the elderly patient population and is associated with an increased risk of stroke. While being overweight or obese might reasonably be anticipated to negatively affect post-stroke motor impairment and functional mobility, there was not a significant association between pretreatment FM or mEFAP component scores and BMI in chronic stroke survivors. Subjects with a higher pretreatment BMI, however, were less likely to demonstrate improvement in their level of motor impairment and performance on an "up and go" mobility task in response to 12-wks of ambulation training, irrespective of the treatment intervention group. These preliminary findings should be verified using a larger, more generalizable sample size to determine if BMI is actually predictive of response to post-stroke rehabilitation interventions. Regardless, this study suggests that the BMI should be considered when formulating stroke rehabilitation goals and also reiterates the importance of addressing obesity not simply as a risk factor for stroke but also as a potential barrier to maximizing longer-term post-stroke motor and functional recovery.

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Table 1

Demographic data; Mean (std dev) for continuous variables, number of observations in each category for discrete variables.

	All subjects
Number	108
Age (yr)	53.0 (11.1)
Sex (M:F)	65:43
CVA type (Isch:Hem)	77:31
Interval post-CVA (m)	44.3 (88.3)
Intervention (PNS:UC)	53:55
BMI	28.5 (5.4)

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Table 2

Mean pretreatment and mean change in Fugl-Meyer and mEFAP composite scores at end of 12-wk ambulation training intervention.

Measure	Mean Pretreatment Value (SD)	Change (SD)
Fugl-Meyer Score	20.18 (5.90)	.89 (3.25)
mEFAP: Floor (s)	13.67 (9.40)	−1.59 (5.46)
mEFAP: Carpet (s)	14.00 (9.79)	−1.80 (5.44)
mEFAP: Up and Go (s)	26.67 (16.67)	−3.19 (7.84)
mEFAP: Obstacles (s)	43.30 (31.28)	−5.27 (13.69)
mEFAP: Stairs (s)	22.66 (15.49)	−1.47 (12.19)