Effect of body mass index on inpatient rehabilitation outcome after stroke in a Southeast Asian cohort: a prospective study

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Abstract

Introduction: We examined the association between admission body mass index (BMI) and discharge rehabilitation functional outcome using the functional independence measure (FIM) in a Southeast Asian cohort of stroke patients during inpatient rehabilitation.

Methods: A prospective, observational cohort study of stroke patients admitted to a single inpatient rehabilitation unit was conducted. Using the World Health Organization Asian standards, BMI was classified as underweight (<18.5 kg/m²), normal (18.5–22.9 kg/m²) and overweight (≥23 kg/m²). The primary outcome measure was discharge FIM, and secondary outcomes included FIM gain, FIM efficiency and FIM effectiveness.

Results: Two hundred and forty-seven stroke subjects were enrolled. The mean age of the cohort was 59.48 (standard deviation [SD] 12.35) years; 64.4% (n = 159) were male and 52.6% (n = 130) had ischaemic stroke. The distributions of underweight, normal and overweight based on BMI on admission were 10.9% (n = 27), 33.2% (n = 82) and 55.9% (n = 138), respectively, and the distributions upon discharge were 11.7% (n = 29), 38.1% (n = 94) and 50.2% (n = 124), respectively. Significant small decreases in BMI from admission to discharge were found (median [interquartile range] 23.58 [23.40–24.70] vs. 23.12 [22.99–24.21]; P < 0.001). Similarly, clinically significant FIM gains (mean ΔFIM 26.71; 95% confidence interval 24.73, 28.69, P < 0.001) were noted after a median length of stay of 36 days. No significant relationships were found between BMI and discharge FIM (P = 0.600), FIM gain (P = 0.254), FIM efficiency (P = 0.412) or FIM effectiveness (P = 0.796).

Conclusion: Findings from this study unequivocally support the benefits of acute inpatient stroke rehabilitation. Patients in the obese BMI range tended to normalise during rehabilitation. Body mass index, whether underweight, normal or overweight, did not correlate with discharge FIM.

Keywords: Body mass index, functional independence measure, obese, rehabilitation, stroke

INTRODUCTION

Stroke is the third leading cause of death and disability globally.[1] Obesity is a well-known risk factor for stroke and premature death acting through cardiovascular disease.[2] However, obesity based on the body mass index (BMI) may be associated with greater survival among hospitalised elderly patients and patients with chronic diseases such as cardiovascular disease, diabetes mellitus and end-stage renal disease.[3-6] This is termed the ‘obesity paradox’.

With regards to functional recovery after stroke, the literature also suggests a trend towards the obesity paradox, with patients of higher-than-normal BMI having a better functional outcome compared to their thinner counterparts. In a Caucasian study, overweight stroke patients in any age group had better functional progress measured by functional independence measure (FIM).[7] Similarly, two studies from Asian cohorts also reported similar findings. Zhao et al.[8] reported a large

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study from the China National Stroke Registry in which overweight patients were associated with favourable 3-month functional recovery, measured with the modified Rankin scale. Jang et al.\textsuperscript{[9]} reported better functional outcomes measured by FIM among acute first-ever ischaemic stroke survivors aged 65 years or older who were extremely obese, but no association was noted in younger stroke survivors aged under 65 years across all categories.

Regarding the relationship between BMI and inpatient rehabilitation outcome, such as FIM,\textsuperscript{[10]} there is a paucity of local data as to whether BMI impacts rehabilitation outcomes. Addressing this gap could potentially redirect future stroke-care pathways and resource allocation, especially in the managing patient with abnormal BMI. In this study, we aimed to: (a) describe the demographic, clinical and rehabilitation characteristics of a cohort of stroke patients on admission and discharge from rehabilitation; (b) compare the changes between admission and discharge BMI after inpatient rehabilitation; and (c) investigate if there are correlations between BMI and discharge rehabilitation outcome.

**METHODS**

Between 31 January 2019 and 31 January 2020, a single-centre, prospective, observational cohort study involving stroke patients undergoing inpatient rehabilitation was conducted. Ethics approval was granted by the National Healthcare Group Domain Specific Review Boards (NHG-DSRB 2018/01084). The study was also registered with www.clinicaltrials.gov (NCT 04625933). All subjects or their next of kin gave written informed consent before enrolment.

The study was conducted at the Tan Tock Seng Rehabilitation Centre, Singapore, which accepts referrals from acute stroke units nationwide. Patients were transferred to the rehabilitation centre after preliminary screening by physiatrists. All patients were offered intensive multidisciplinary rehabilitation (3 h daily, 5.5 days a week), including 60 min/day each of physiotherapist-, occupational therapist- and speech therapist-supervised therapy, focusing on early mobilisation, verticalisation, ambulation and prevention of complications. Robot-aided locomotor therapies were also prescribed where clinically indicated. Dieticians reviewed patients with neurogenic dysphagia with suboptimal oral intake, nasogastric or gastrostomy feeding on a weekly basis. Weekly rehabilitation team conferences were held to review goals, functional progress and discharge planning. For this study, FIM was the main functional outcome measure.\textsuperscript{[10]}

Subjects were enrolled based on the following inclusion criteria: (a) first-ever clinical stroke (ischaemic or haemorrhagic) diagnosed by acute neurologists or neurosurgeons and confirmed on computed tomography or magnetic resonance imaging of the brain, and (b) aged ≥21 years. Subjects were excluded based on the following exclusion criteria: (a) non-stroke diagnosis (e.g., traumatic brain injury, subarachnoid haemorrhage), (b) rehabilitation was not the primary reason for inpatient admission, (c) failure to complete the rehabilitation programme due to either an acute transfer off the rehabilitation centre or discharge against medical advice, (d) incomplete or missing BMI and FIM data, and (e) patients who were not of Asian ethnicity.

Based on the following outcome variables, we constructed a data collection form. Outcome measures included age (years), gender (male/female), stroke type (ischaemic/haemorrhagic), length of stay (LOS) in the rehabilitation unit (days), discharge outcome (home/institutional care), admission serum albumin level, admission and discharge BMI, admission and discharge total, subset motor and cognitive FIM, FIM gain, FIM efficiency and FIM effectiveness.

Serum albumin, a common biomarker of nutritional status,\textsuperscript{[11]} was drawn within 72 h of stroke onset. Low serum albumin level was defined as <35 g/L.\textsuperscript{[12]} The BMI was chosen as the primary indicator to measure relative obesity due to its simplicity and strong correlation with body fat and health risks. It is inexpensive to measure, easily available and fairly accurate.\textsuperscript{[13]} The BMI was calculated using the formula — body weight (in kg) divided by the square of height (in m\(^2\)) and measured within 72 h of admission and planned discharge from inpatient rehabilitation. With reference to the World Health Organization (WHO) Asian standards, BMI was further categorised into (a) underweight (BMI <18.5 kg/m\(^2\)), (b) normal (BMI 18.5–22.9 kg/m\(^2\)) and (c) overweight (BMI ≥23 kg/m\(^2\)).\textsuperscript{[3]}

Due to stroke-related motor impairments, customisation was required to obtain body weight and height measurements to derive patients’ BMI. For patients who could sit unsupported, a weighing chair scale was used to measure body weight (seca 944®, seca Deutschland, Hamburg, Germany). For patients with poor sitting balance, a multifunctional wheelchair scale (seca 665®) was used to measure body weight. Height was measured with a standard measuring tape. For patients who were able to stand without support, height was measured in a standing position with feet flat and back straight against a wall. For patients who were not able to stand unsupported, height was measured in the supine position with both legs extended and feet in dorsiflexion at the end of bed.

The FIM, which was the primary outcome measure during rehabilitation, was measured within 72 h of admission and discharge by rehabilitation therapists, all of whom were trained and certified in the use of FIM score. The FIM is an 18-item instrument comprising 13 motor items and five cognitive items, with each item graded on a 7-point ordinal scale (1 denotes complete dependence and 7 denotes complete independence). It assesses the ability to perform activities of daily living across
During the study period, 247 stroke patients were enrolled, and all of them completed research interventions without dropouts or adverse events. The baseline demographic, clinical and rehabilitation characteristics of the patients are shown in Table 1. The distributions of underweight, normal and overweight BMI on admission to rehabilitation were 10.9% (n = 27), 33.2% (n = 82) and 55.9% (n = 138), respectively, and the distributions upon discharge from rehabilitation were 11.7% (n = 29), 38.1% (n = 94) and 50.2% (n = 124), respectively. After a median LOS in rehabilitation of 5 weeks, overweight subjects demonstrated a significant reduction in BMI, from overweight to a normal BMI range (P < 0.001). The mean serum albumin level on admission for the underweight BMI category was 38.15 g/L (standard deviation [SD] 4.78), with only 18.5% of underweight patients showing low serum albumin level. There was a statistically significant but weak correlation between serum albumin on admission and admission BMI (P = 0.021, r = 0.147). Significant gains in total, subset motor and cognition FIM scores were also found post-rehabilitation (P < 0.001).

The results of linear regression analysis of dependent and independent variables are presented in Table 2. Age had a significant linear negative relationship with motor and total discharge FIM, FIM gain and FIM effectiveness, but not with discharge cognitive FIM and FIM efficiency. Besides, serum albumin level on admission had a significant relationship with motor, cognition and total discharge FIM and FIM effectiveness, but not with FIM gain and FIM efficiency. There were no statistically significant differences between groups even after adjustment for age and gender. There was a trend toward higher improvement in FIM gain and FIM effectiveness in the underweight BMI group, although this was not statistically significant.

**DISCUSSION**

We assessed the association between BMI, discharge FIM, FIM gain, FIM efficiency and FIM effectiveness in 247 acute poststroke rehabilitation patients. Our results showed that BMI in any category were not associated with either admission or discharge rehabilitation functional status measured by FIM.

Our cohort’s mean age of 59.5 years was 9 years lower than the mean age of stroke, with 2.5 times higher proportion of haemorrhagic stroke subtype (47.4% cohort vs. 18.6% 2018 registry) reported in the Singapore Stroke Registry.[14] Our cohort’s age was also generally lower than the mean age of participants in studies conducted in the USA (65 years), China (63 years) and Israel (67 years).[17,18,19] This was likely due to preadmission selection in accordance with national guidelines, whereby older stroke survivors aged >65 years were admitted to community hospitals, whilst patients with more complex and severe haemorrhagic strokes were admitted to tertiary rehabilitation centres, such as Tan Tock Seng Hospital Rehabilitation Centre.[10] Thus, our findings would lack generalisability to the general stroke population.

According to WHO, Singapore has the second highest prevalence of overweight persons in Southeast Asia.[17] More than half (55.5%) of our cohort were overweight (BMI >23.0 kg/m²) at the point of admission to rehabilitation. Of these, 35.5% (n = 49) had BMI ≥23.0–24.9 kg/m² and 64.5% (n = 89) had BMI ≥25 kg/m². Being overweight is known to increase the risk of stroke, gait dysfunction and poststroke mortality and morbidity, and these would in turn affect discharge FIM and FIM gain.[18–20]

Beninato *et al.*[21] reported the minimal clinically important difference (MCID) after stroke for total FIM, motor FIM and cognitive FIM as 22, 17 and 3, respectively. Overall, significant changes in FIM gain, exceeding MCID reference ranges of mean total, motor and cognition FIM of 26.7, 21 and 5.8, respectively, regardless of the BMI class, were achieved in our cohort. The overweight BMI group tended to show higher FIM gains and FIM effectiveness as compared to the normal and overweight BMI groups, respectively (P > 0.05), although these differences did not reach statistical significance. Our findings differ from those of Kimura *et al.*[22] who reported that underweight patients admitted for subacute stroke had poorer functional recovery. For our younger stroke cohort, age (β = −0.477, P < 0.05) and serum albumin level at admission (β = 1.369, P < 0.001) were found to be stronger predictors than BMI in any category and possibly protective against a poorer rehabilitation outcome at discharge. Serum albumin level on admission to rehabilitation significantly predicted better total FIM, motor FIM and cognition FIM,
with $\Delta 1.369$ total FIM points for each $\Delta$gram of albumin, while age predicted total and motor FIM, but not cognitive FIM [Table 2]. Hence, findings from our study imply that during rehabilitation, we should pay more attention to monitoring and optimising albumin levels, an important nutritional parameter, rather than BMI.

Overall, our findings showed that BMI in any category was neither associated with nor predictive of rehabilitation functional outcome as measured by the discharge FIM score or the ability to make significant functional gains after inpatient rehabilitation. All patients in the three BMI categories achieved significant FIM gains (total, motor and cognitive). Thinner patients tended to achieve insignificantly higher FIM gains as compared to their obese counterparts; thus, our study findings differ from the ‘obesity paradox’ alluded to in larger population-based studies.[7–9] This might be because the majority of underweight patients in our study were nutritionally replete, as only 18.5% had low albumin levels. We speculate that higher lean muscle mass in the underweight BMI class could augur higher functional reserves and thus better FIM outcomes, and that younger stroke cohorts are less likely to have age-dependent sarcopenia. Conversely, the BMI reduction of $\Delta 0.46$ during inpatient rehabilitation in overweight groups, either through controlled caloric restriction or healthier hospital diet, might have been excessively rapid, thus inducing greater losses of lean body mass, with possible negative effects on functional recovery. This was speculative, as data on body composition, muscle mass, bone mass and fat mass were not available in this study.

### Table 1. Baseline demographic, clinical and functional characteristics of subjects ($N=247$).

| Variable                        | Total ($n=247$) | Underweight ($n=27$) | Normal ($n=82$) | Overweight ($n=138$) | $P$   |
|---------------------------------|----------------|----------------------|-----------------|----------------------|------|
| Age (yr)                        | 59.48±12.35    | 60.96±15.09          | 62.27±10.16     | 57.53±12.68          | 0.018* |
| Gender (male)                   | 159 (64.4)     | 18 (66.7)            | 53 (64.6)       | 88 (63.8)            | 0.958 |
| Type of stroke                  |                |                      |                 |                      |      |
| Ischaemic                       | 130 (52.6)     | 14 (51.9)            | 41 (50)         | 75 (54.3)            | 0.822 |
| Haemorrhagic                    | 117 (47.4)     | 13 (48.1)            | 41 (50)         | 63 (45.7)            |      |
| Duration of rehabilitation (day)| 36 (37.9–43.1) | 36 (33.07–46.48)    | 36 (35.91–44.72)| 36 (37.03–44.51)    | 0.984 |
| Discharge destination           |                |                      |                 |                      |      |
| Home                            | 210 (85.0)     | 23 (85.2)            | 62 (75.6)       | 125 (90.6)           | 0.006* |
| Community hospital              | 25 (10.1)      | 3 (11.1)             | 12 (14.6)       | 10 (7.2)             |      |
| Nursing home                    | 12 (4.9)       | 1 (3.7)              | 8 (9.8)         | 3 (2.2)              |      |
| Serum albumin level on admission (g/L) | 38.73±4.26     | 38.15±4.78           | 37.87±4.59      | 39.36±3.86           | 0.032* |
| BMI on admission (kg/m$^2$)     | 24.05±5.18     | 16.33±1.28           | 20.99±1.13      | 27.37±4.31           | <0.001 |
| BMI on discharge (kg/m$^2$)     | 23.60±4.83     | 16.81±1.38           | 20.74±1.28      | 26.62±4.18           | <0.001 |
| FIM score on admission          |                |                      |                 |                      |      |
| Motor                           | 35.22±16.06    | 32.07±15.03          | 36.44±15.33     | 35.11±16.68          | 0.572 |
| Cognition                       | 20.04±10.24    | 17.15±9.66           | 19.91±10.51     | 20.69±10.16          | 0.731 |
| Total                           | 55.34±23.77    | 49.22±22.51          | 56.35±22.88     | 55.93±24.51          | 0.547 |
| FIM score on discharge          |                |                      |                 |                      |      |
| Motor                           | 56.22±19.42    | 54.85±19.56          | 55.71±19.42     | 56.80±19.51          | 0.917 |
| Cognition                       | 25.85±8.65     | 23.81±9.02           | 25.15±9.29      | 26.67±8.13           | 0.103 |
| Total                           | 82.04±25.76    | 78.68±27.50          | 80.85±26.08     | 83.41±25.31          | 0.600 |
| FIM gain                        |                |                      |                 |                      |      |
| Motor                           | 21±12.16       | 22.78±11.56          | 19.27±12.72     | 21.69±11.90          | 0.915 |
| Cognition                       | 5.81±6.60      | 6.67±5.16            | 5.23±6.96       | 5.98±6.64            | 0.531 |
| Total                           | 26.71±15.79    | 29.44±14.65          | 24.50±16.16     | 27.49±15.72          | 0.254 |
| FIM efficiency                   |                |                      |                 |                      |      |
| Motor                           | 0.57 (0.60–0.75)| 0.64 (0.49–0.81)    | 0.44 (0.51–0.79)| 0.61 (0.60–0.79)     | 0.428 |
| Cognition                       | 0.09 (0.14–0.22)| 0.15 (0.11–0.27)    | 0.06 (0.10–0.29)| 0.09 (0.13–0.21)     | 0.083 |
| Total                           | 0.74 (0.75–0.95)| 0.79 (0.63–1.06)    | 0.62 (0.63–1.06)| 0.70 (0.74–0.98)     | 0.412 |
| FIM effectiveness               |                |                      |                 |                      |      |
| Motor                           | 0.41±0.24      | 0.42±0.25            | 0.38±0.25       | 0.42±0.24            | 0.796 |
| Cognition                       | 0.39±0.35      | 0.44±0.33            | 0.36±0.37       | 0.40±0.35            | 0.657 |
| Total                           | 0.41±0.24      | 0.43±0.25            | 0.39±0.24       | 0.42±0.23            | 0.796 |

*Data presented as median (interquartile range). *Statistically significant. BMI: body mass index, FIM: functional independence measure, SD: standard deviation.
While excessively high BMI in patients with severe stroke-related motor impairments and maximal dependency would place immense challenges on therapists and nurses in terms of transfers out of bed/chairs, mobilisation and safe handling, the presence of robot-aided locomotor devices, mobile hoists and assistive devices possibly mitigates such difficulties, allowing overweight patients to mobilise safely and adequately, thus achieving comparable total FIM and motor FIM gains. Thus, our findings suggest that BMI in any category does not impair patients’ ability to attain functional benefits during inpatient rehabilitation. Age and serum albumin level at rehabilitation were important predictors, with the latter acting as a low-lying therapeutic target.

The study had several limitations. First, this was a single-centre study with a relatively small sample size. Second, there may be selection bias related to national stroke rehabilitation admission guidelines, where mild stroke survivors were discharged home with early supported poststroke discharge home services, while elderly patients received rehabilitation in community hospitals; both groups were underrepresented in our sample (mean age <60 years and mean admission guidelines, while elderly patients received rehabilitation in community hospitals; both groups were underrepresented in our sample (mean age <60 years and mean admission guidelines, while elderly patients received rehabilitation in community hospitals; both groups were underrepresented in our sample (mean age <60 years and mean admission guidelines, while elderly patients received rehabilitation in community hospitals; both groups were underrepresented in our sample (mean age <60 years and mean admission guidelines, while elderly patients received rehabilitation in community hospitals; both groups were underrepresented in our sample (mean age <60 years and mean admission guidelines, while elderly patients received rehabilitation in community hospitals; 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an analysis of prediction of BMI with functional outcome at 6–12 months poststroke.

To our knowledge, this is the first study to investigate whether BMI at the commencement of inpatient rehabilitation has an effect on eventual post-discharge rehabilitation outcome. This study concurs with other studies with regards to the undisputed benefit of intensive poststroke rehabilitation unit care for those with moderate–severe stroke to significantly improve function, reduce disability and discharge patients home. Findings from this study also suggest that BMI in any category does not significantly impact or predict the ability to achieve functional independence or demonstrate functional gains after inpatient rehabilitation. Long-term follow-up of this cohort is a logical next step to study the impact of BMI.

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Conflicts of interest
There are no conflicts of interest.

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