

Comparative outcome of qualitative and quantitative methods in assessing static body balance among post-stroke male patients in Saudi Arabia

Abstract

Stroke affects body-balance performance in elderly who falls. Best-suited-rehabilitation for post-stroke/ hemiplegics (PSH) patients depends on the accuracy and reliability of methods in assessing their static body balance. This prospectively designed single blinded study was conducted to compare the outcome of balance assessment among male PSH patients between quantitative (computerized Balance Master System: BMS) and qualitative (Tinetti's Balance & Mobility Subscale Score: TBMS and Barthel Index Score: BIS) methods. Data were analyzed using SPSS Windows 12.0.

Results of BMS and TBMS/BIS methods demonstrated high interrater-reliability and concurrent validity of findings based on Limit of Stability(LOS) and Target Sway(TS) tests, when performed on a foam-platform to assess 3 types of sensory organization tests: eye-open(EO), eye-closed(EC) & central-target(CT). Mean post-stroke duration of 30 patients studied was 10.7+8.6 weeks from onset. Of them (mean age 62.3±14.5years), 90% sustained a cerebral infarction and 10% hemorrhage. And, 53% had a right while 47% had left-sided hemiplegia. While, TBMS correlated with BIS, positively ($r=0.83$, $p<0.01$), it correlated with BMS negatively, in terms of (i) LOS for EO ($r=-0.36$, $p<0.03$), and, EC ($r=-0.35$, $p<0.03$) on foam platforms; and (ii) CT for TS ($r=-0.48$, $p<0.001$) on firm platform. Similarly, BIS was negatively correlated with BMS: in terms of (i) LOS of EO performed on foam platform ($r=-0.41$, $p<0.012$) and (ii) LOS of EC ($r=-0.30$, $p<0.05$) and CT/TS of EC($r=-0.40$, $p<0.01$), both performed on firm platform. However, a highly positive correlation existed among all BMS findings: with EC LOS ($r=0.721$, $p<0.01$) and EO LOS ($r=0.604$, $p<0.001$) correlated on both firm and foam platforms.

In conclusion, BMS method proved to be more reliable and valid in LOS parameters including TS for CT, than qualitative assessments of TBMS and BIS. Moreover, findings of BMS is not affected by the psychological aspects of the therapist carrying on the test on PSH-patients which may confounded the findings of qualitative analytic methods.

Keywords: Stroke, Body Balance, Balance Master, Barthel Index Score, Tinetti's Balance and Mobility Subscale

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Introduction

Stroke, a common problem that affects body-balance performance, remains one of the most prevalent medical conditions among adults/elderly who fall.¹ Stroke is the third leading cause of death in developed countries.²⁻⁴ Around 37,000 Australians³ and 500,000 Americans suffer and 145,000 die annually from stroke-related-causes.⁴

In Saudi Arabia stroke remains a major medical problem being the frequent most cause of hospitalization^{7,8} with a prevalence of 178 per 100,000 population⁵ and numbers of first-ever stroke remain 53 per year (crude incidence rate being 48.8/100.000 population.⁶ However, stroke, is reportedly, more prevalent among men and in their 60s,^{6,9-12} though it was observed in younger Arabians more than in the western world (5). Stroke leaves >50% patients physically disabled¹ / handicapped due to problem in their body-balance, mostly within the first 3 post -stroke weeks.¹³

Body balance is a complex process where the position is maintained through postural adjustments in response to either external stimuli or voluntary activities,¹³ coordinated by multiple sensory, motor and biomechanical components, combining visual, vestibular and somatosensory inputs which senses body position in relation to gravity and surroundings.¹⁴ On the other hand, postural sway (PS) in hemiplegic patients was observed with gross symmetrical weight bearing

impairment (61%-80% through non-paretic lower extremity). This can limit or reduce patients' stability in terms of maximal distance in shifting body-weight towards any direction without losing balance¹⁵ were observed among twice as much of their age-matched peers.¹⁶

Human interest in balance deficits is growing due to increasing trend in health care cost. PSH patient who have cognitive impairment, use sedative, and possess lower extremity disabilities as the most common risk factors for falling including abnormality in balance and gait. More than 200,000 hip fracture occurs, annually, due to falls, only in USA, 20% of whom die within 6 months.¹⁷⁻¹⁹ One half of old people experiencing at least one fall developed prolonged fear of falling & 25% have decreased ADL,^{18,19} requiring ability to maintain/change postures and respond to external stimuli.²⁰ However, dependant ADL is reported in 30 to 60% of stroke-survived population.⁶

Selection of best-suited-rehabilitation program for post-stroke/hemiplegic (PSH) patients depends on accuracy and reliability of body balance assessment methods.²¹ Thus, the inter-rater reliability detects the degree of agreement between findings of (i) quantitative (BM) and (ii) qualitative (TBMS & BIS) assessment of body balance.

It is, therefore, important to assess integrity of balance system to evaluate individual's risk of falling²² which requires test-batteries/instruments that are responsive to change and produce reliable and

valid data,²³ necessary to assess controlled mobility and ADLs.²⁴ Body balance can be assessed two-dimensionally- qualitatively and quantitatively: qualitatively by utilizing several standardized measurements, like Berg Balance Scale, Functional Independent Measure, Functional Reach Test, Fugl-Meyer Balance Subscale Scores, Tinetti's Balance and Mobility Subscale (TBMS) and Barthel Index Score (BIS). On the other hand, performance oriented mobility assessment, timed up and go and motor assessment scale^{25,26} remains the principal tools to measure body balance, quantitatively; using Balance Master (BM), Posturography, Smart Balance Master, Pro Balance Master, etc.

Reports showed that findings of TBMS and BIS were reliable in detecting ADLs and balance.^{20,23,27} BMS, on the other hand, allows to measure what one cannot see, feel or quantify using traditional "low tech" methods which can also measure critical parameter like center of gravity. BMS saves time and labor costs to generate & analyze such data, as well. Since the system automatically goes on collecting and scoring data, it relieves treating physician/doctor from "guarding the patient" during test procedures. Further, this computerized force plate technology can perform objective measurements more quickly and reliably to detect correct value (data) and track changes in patient's performance over time. However, reliability of static and dynamic BMS measurement in healthy and stroke patients reportedly ranged from poor to good²⁸ and rarely being inadequate.²³

It was therefore, commented that further research is needed towards establishing validity and reliability of BMS rather than designing new measures- which is essential to separate postural problems into its basic functional components for interventions of balance disorders more specifically.² That was what been conceptualized, planned and conducted in this one year long prospective study to compare the findings between BMS and TBMS/BIS.

Aims and objectives

Investigate the post-stroke balance deficits quantitatively based on computerized Balance Master system (BM) and qualitatively based on ADL using Barthel Index Score (BIS) & Tinetti's Balance/ Mobility Subscale Score (TBMS)

Determine inter-rater reliability and concurrent validity of data generated by BM in terms of LOS and TS of EO, EC and TS CT both on foam and firm platforms.

Compare the above findings generated by these instruments to determine the difference between the quantitative (BMS) and qualitative (TBMS/BIS) assessments.

Materials and methods

Patients and set up

Thirty post-hospitalized male Saudi patients, being at their age of 20 years or more, who survived a stroke for the first time but were in acute stage (during the time of investigation) and attended the Department of Neurology/Physiotherapy of RMH??? Riyadh, Saudi Arabia for physiotherapeutic aids during Mar 2002 to Jun 2002, were studied.

Study design

Single blinded prospective study.

Inclusion criteria: PSH patients (i) having had a confirmed diagnosis of cerebral hemorrhage (ICD-431) or cerebral infraction (ICD-434) following the codes of international classification of diseases

(9th revision of clinical modification: ICD- 9-CM codes), (ii) had a hemiplegia secondary to CVA in acute phase (within 6 months of onset), (iii) had no disease that could compound the effect on their body balance, and (iv) who could maintain stationary/standing position without any mechanical support at least for 20 seconds with minimal assistance.

Blinding of assessment methods: The Qualitative assessments were carried out first by a qualified pre-trained physiotherapist, and the Quantitative assessments were then performed by the investigator himself (and rechecked by the experts (co-investigators) on every 3rd patients not knowing the findings of qualitative method (before comparing that with that of quantitative method).

Assessment/ Evaluation of body balance

A. Qualitative assessment (Subjective) using TBMS and BIS

All these 30 patients were evaluated using BIS (10 tasks of ADL) and TBMS (9 tasks of static balance) were evaluated.

B. Quantitative assessment (Objective) using computerized Master System

The subjects were evaluated quantitatively by BMS following the 6 balance tests (LOS): three of which were performed on 'firm' and other three on 'foam' platforms, in terms of following LOS:

I. Eyes open (EO): patients were directed to stand on a 'firm platform' as steady as possible for 20 seconds with their arms lifted up (beside the body) keeping their eyes open.

II. Eyes closed (EC): patients were directed as above for 20 seconds on a 'foam platform' but keeping their eyes closed.

III. Center target (CT): Subjects were asked to stand targeting the center as steady as possible for 20 sec on a 'firm platform' with their arms lifted.

Data Management: Data entry & cleaning: Visually checked data were entered using MS-Access after rechecking using logical sequence.

Data analysis: Data were analyzed using the statistical software program of SPSS Windows 12.0.

Statistical tools used: Followed by the frequency distribution tables, Spearman's Rank Correlation Coefficient (rS), Pearson Product Moment Correlations Coefficient (r) and independent t-tests, were applied as/and wherever needed.

However, a p-value of <0.05 at a confidence Interval (CI) of 95% was regarded as significant.

Results

Demographically, the mean age of 30 male PSH patients was 62.3±14.5 years, with a mean weight (Wt) and height (Ht) of 162.4±9.33kg and 71.6±9.6cm, respectively. Most of them (90%) sustained a cerebral infarction (n=27) while the rest 10% had cerebral hemorrhage (n=3). Total duration of hospital stay was 10.7±8.6 weeks, on an average. While 53% (n=16) had right-sided hemiplegia and 47% (n=14) had it in their left side. However, sides of lesion (right or left sided-hemiplegia) did not reveal any difference with types of lesion i.e., infraction or hemorrhage (p<0.05), with BIS (p>0.18), with TBMS (p>0.53), with EC LOS (p>0.52) and with EC LOS (p>0.51).

Though age of these patients did not correlate with the findings of BMS (r=0.197, p=0.296) or TBMS (r=-0.260, p=0.165), age was

negatively correlated with BIS ($r=-0.393$, $p<0.05$). On the contrary, while body wt was negatively correlated with BMS ($r= -0.525$, $p<0.01$), it was positively associated with TBMS ($r=0.359$, $p<0.05$) and BIS ($r=0.458$, $p<0.01$). Similarly, height (ht) was also negatively

associated with BMS ($r= -0.690$, $p<0.01$), but had a positive association both with TBMS ($r=0.421$, $p<0.05$) and BIS ($r=0.479$, $p<0.01$) (Table 1).

Table 1 Comparison among the findings of quantitative & qualitative assessment of static balance Correlation

Assessment tool	Age (Mean=62.3±14.5 years)	Height 162.40±9.33 cm	Weight 71.60±9.59 Kg	Duration Interval 10.73± 8.65 weeks
BM: LOS of Eye closed on foam platform	$r = 0.197$ $p = 0.296$ $r = -0.260$	$r = -0.690^{**}$ $p = 0.000$ $r = 0.421^*$	$r = -0.525^{**}$ $p = 0.003$ $r = 0.359^{**}$	$r = 0.020$ $p = 0.916$ $r = 0.148$
TBMS	$p = 0.165$ $r = -0.393^*$	$p = 0.021$ $r = 0.479^{**}$	$p = 0.051$ $r = 0.458^{**}$	$p = 0.434$ $r = 0.434^*$
BIS	$p < 0.05$	$p = 0.0071$	$p < 0.011$	$p = 0.016$

(Pearson) is significant (2-tailed) at the *0.05, and, ** at the 0.01 levels.

Types of lesion: infraction 27 (90%), hemorrhage 3 (10%) with a mean duration of illness 10.73±8.65 weeks.

Table 2 Comparison between findings of qualitative (TBMS Vs BIS) & quantitative (using Static BM) methods.

Assessment Tools	CT LOS with Foam Platform	CT LOS with Foam Platform	CTTS with Foam Platform	CTTS with Foam Platform	Barthel Index
Tinett's Balance & Mobility Subscale (TMBS)	$R = -0.134$, $P = 0.241$	$r = -0.438^{**}$ $p < 0.008$	$r = -0.481^{**}$ $p < 0.004$	$r = -0.098$ $p > 0.304$	$r = 0.837^{**}$ $p < 0.001$
Barthel Index (BIS)	$R = -0.045$, $p > 0.40$	$r = -0.516^{**}$ $p < 0.002$	$r = -0.452^*$ $p < 0.006$	$r = 0.233$ $p > 0.108$	$r = 1.000$

Correlation (Pearson) is significant (2-tailed) at the *0.05, and, ** at the 0.01 levels.

Table 3 Correlation between the eyes open tests and TBMS and BIS

Variables Studied for Possible Association	EO LOS with Foam Platform	EO LOS with Foam Platform	EOTS with Foam Platform	EOTS with Foam Platform
EO LOS with Foam Platform	$r = 1.000$, $p < 0.001$	$r = 0.604^{**}$ $p < 0.001$	$r = 0.505^{**}$, $p < 0.002$	$r = 0.382^*$ $p < 0.019$
EO LOS with foam platform	$r = 0.604^{**}$ $p < 0.001$	$r = 1.000$	$r = 0.444^*$ $p < 0.007$	$r = 0.472^{**}$ $p < 0.004$
EO TS with Foam Platform	$r = 0.505^*$ $p < 0.002$	$r = 0.444^*$, $p < 0.004$	$r = 1.000$,	$r = 0.579^{**}$, $p < 0.001$
EO TS with foam platform	$r = 0.382^*$, $p < 0.019$	$r = 0.472^{**}$ $p < 0.004$	$r = 0.579^{**}$ $p < 0.001$	$r = 1.000$
TBMS	$r = -0.237$ $p < 0.103$	$r = -0.355^*$ $p < 0.027$	$r = -0.043$ $p < 0.411$	$r = -0.072$, $p < 0.353$
BIS	$r = -0.274$, $p < 0.072$	$r = -0.413^*$, $p < 0.012$	$r = -0.289$, $p < 0.061$	$r = -0.172$, $p < 0.182$

Correlation 2-tail (Pearson correlation) is significant at **0.01, and, * at 0.05 level.

Table 4 The correlation between the Eye Closed test and TBMS and BIS

Variables Studied for Possible Association	EC LOS with Foam Platform	EC LOS with foam platform	ECTS with Foam Platform	ECTS with Foam Platform	Tinett's balance & Mobility Subscale
Eye closed limit of stability with Foam Platform	$r = 1.000$	$r = 0.721$ $p < 0.01$	$r = 0.254$ $p < 0.08$	$r = 0.344$ $p < 0.03$	$r = -0.235$ $p > 0.10$
Eye closed limit of stability with foam platform	$r = 0.721^{**}$ $p < 0.01$	$r = 1.000$	$r = 0.432^{**}$ $p < 0.01$	$r = 0.116$ $p > 0.27$	$r = -0.347$ $p < 0.03$
Eye closed target sway with Foam Platform	$r = 0.254$ $p > 0.88$	$r = 0.432^{**}$ $p < 0.01$	$r = 1.000$	$r = 0.081$ $p > 0.33$	$r = -0.273$ $p > 0.07$
Eye closed target sway with foam platform	$r = 0.344^*$ $p < 0.03$	$r = 0.116$ $p > 0.27$	$r = 0.081$ $p > 0.33$	$r = 1.000$ $p > 0.18$	$r = 0.186$ $p > 0.16$
Tinett's Balance & Mobility Subscale (TBMS)	$r = -0.235$ $p > 0.11$	$r = -0.347^*$ $p < 0.03$	$r = -0.273$ $p < 0.07$	$r = 0.186$ $p > 0.16$	
Barthel Index (BIS)	$r = -0.301^*$ $p < 0.05$	$r = -0.424^*$ $p < 0.01$	$r = -0.406^*$ $p < 0.01$	$r = 0.146$ $p > 0.22$	$r = 0.837^{**}$ $p < 0.01$

Correlation 1-tail (Pearson) is significant at ** 0.01 level and at *0.05 levels.

Table 2 describes the inter-rater reliability of TBMS and BIS based on CT. The mean CT for LOS on firm platform was 18.24 (\pm 11.37) and on foam was 37.41 (\pm 29.55). The mean CT-TS on firm and foam platform were 1.14 \pm 1.20 and 2.60 \pm 3.31, respectively. The mean of TBMS was 69.9 \pm 21.51 and BIS 75.50 \pm 21.51. A strongly positive correlation existed between TBMS & BIS ($r=0.84$, $p<0.001$). However, TBMS correlated strongly with two of the CT tests: CT LOS on foam platform ($r=-0.44$, $p<0.00$) and with CT TS on firm platform ($r=-0.48$, $p<0.00$). Moreover, BIS correlated strongly with two of the CT tests: CT LOS on foam platform ($r=-0.52$, $p<0.00$) and with CT TS on firm platform ($r=-0.45$, $p<0.00$).

Table 3 shows the details correlation between qualitative and quantitative balance performance tests in terms of eye open activities and their interrelations. The CT LOS on foam platform was highly correlated in detecting ADL deficit with that of BIS ($r=-0.413$, $p<0.01$), (Table 3). Moreover, the TBMS correlated with EO-LOS on foam ($r=-0.36$, $p>0.03$).

Moreover, there was correlation between a part of EO in Balance Master, such as; EO LOS on firm platform correlated with EO LOS on foam platform ($r=0.60$, $p=0.00$), and; EO TS on firm platform ($r=0.51$, $p=0.002$) and EO TS on foam ($r=0.38$, $p=0.02$). Moreover, EO LOS on foam platform highly correlated with EO TS on foam ($r=0.47$, $p=0.00$) and with the EO TS on firm ($r=0.44$, $p=0.00$). The EO TS on foam highly correlated with EO TS on firm ($r=0.58$, $p=0.00$), (Table 3).

Further, it becomes evident from table 4, that TBMS were negatively correlated with BMS in terms of LOS EC performed on foam platforms ($r=-0.35$, $p<0.03$), and, BIS correlated with LOS of EC on firm platform ($r=-0.30$, $p<0.05$) and EC LOS on foam ($r=-0.42$, $p<0.01$) and EC TS on firm ($r=-0.41$, $p<0.01$) platforms. However, other quantitative tests of BMS revealed weaker correlation with qualitative assessments of TBMS and BIS.

Discussion

Problem in body balance remains the common complaints among in the elderly patients particularly when it is associated with stroke-which should be rehabilitated properly and in-time. Selecting best rehabilitation program depends on accuracy and reliability of the methods-which is crucial (and critical) to construct & maintain body balance appropriately.¹⁷⁻²⁹ We, therefore, compared the findings of quantitative (BM) and qualitative (TBMS/BIS) assessments of body balance in terms of inter-rater reliability and concurrent validity.

Alike other countries, stroke, in Saudi Arabia was reported to be 90%:³⁰ haemorrhage being 10%, lacunar infarction-33% and subarachnoid haemorrhage-3%- which is consistent with Al-Rajeh et al.¹⁰ who mentioned that incidence of stroke in Saudi Arabia remains low his comparison to that of industrialized countries,¹⁰ which well may vary due to age group distributions of study subjects.

Our study subjects (16 with right and 14 with left hemiparesis) revealed significant difference in quantitative (using BM) and qualitative (using TBMS & BIS) assessments, ($p > 0.05$), which is similar to a report by Beynon & Shepard.³¹ A relationship exist between severity of motor deficit and performance of Their side of body, possibly owing to reduction in cerebral activation as a rehabilitation, education and practical skills including maintaining body balance.¹⁶ However, they did not observe any significant difference between left ($P > 0.05$) and right hemiparesis ($P > 0.05$), which contradicts the findings of Clarks et al.³² who, like Begbic JV,¹⁴ reported that performance of right sided hemiplegics was greater (muscular) than

that of left sided. But, this was again, not found consistent with Alonate et al.³³ -the finding of which may not be similar to others because of neglecting syndrome and general/muscular weakness (grade-3) and because they had osteoarthritis (in knee/other joints) and used a cane. Though a negligible negative correlation existed between age and BM (TBMS) in our patients, this was not statistically significant ($r = - 0.24$, $P > 0.05$): i.e., when age increased the balance performance diminished - which may be due to small sample size in our study. Further, balance performance may be diminished due to musculo-skeletal weakness including proprioception, visual, and vestibular inputs, though Winider et al.³⁴ did not find any significant correlation among the COP parameters, balance scale, age or post stroke duration.³⁴ However, this was not agreed by a study report.³⁵ Bohannon et al.¹⁵ reported that balance performance diminished due to decrease information-communication through visual input as age advances.¹⁵

Our findings show that height was inversely correlated with LOS (limit of stability) test in EC on foam platform ($r = -.69$, $P < 0.001$), ($r = -0.52$, $P < 0.01$): i.e., when height increased the amount of sway decreased, and so balance performance/ADL improved. This finding is consistent with Berger et al.³⁶ who found close correlation between displacement amplitude at ankle joint and patients. The sequence of this relationship as reported are: (i) compensatory reaction consisted of larger gastrocnemius responses and a stronger co activation of tibialis anterior, and, (ii) moment of increasing strength resulted in a larger increment in both ankle joint displacement and gastrocnemius-EMG responses in smaller compared to larger subjects.³⁷ Three main factors contribute to motor control of the standing balance (visual, vestibular and somatosensory input) showing greater postural sway in EC than ET or EO in which altered vestibular, somatosensory and visual inputs are needed- as our findings revealed, showing consistency with that of Dettmann et al.³⁸ Findings of BM (static and dynamic test) showed when LOS is increased the body balance performance decreased, which is consistent with that of Maki et al.³⁹ All three BM tests, in our patients, highly correlated with each other ($p<0.05$)- a finding which is consistent with others.^{37,40-43} Also, the EO LOS on foam platform correlated with TBMS ($r=-0.35$, $P<0.05$), and the EC, LOS on foam platform with TBMS ($r = - 0.34$, $P < 0.05$), though showed marginally significant. In the target sway test, only CT & TS on firm platform highly correlated with TBMS ($r = -0.48$, $P < 0.001$). These findings are consistent with Brouwer et al.⁴⁴ who evaluated the reliability of static and dynamic body balance, the maximal LOS of COG excursion and the position of the COG relative to vertical axis with a reliability from fair to good.²⁸

We observed that BM is very sensitive in terms of assessing ADLs. High correlation existed between LOS test on foam platform and CT & but BIS ($r = - 0.51$, $P < 0.001$) had marginal correlation between EO LOS on foam platform ($r = - 0.36$, $P < 0.05$). However a showed high correlation existed between BIS and EC LOS on foam platform ($r = - 0.42$, $P < 0.01$). Further BIS correlated with CT target sway on firm platform ($r = - 0.45$, $P < 0.001$), and the EC target sway with firm platform ($r = - 0.40$, $P < 0.01$). The center target of both EO and EC LOS on foam platform correlated with BIS. On the other hand, CT target sway correlated with BIS and EC and EO target sway (all on firm platform). This finding remains consistent with that of Dettman et al.³⁸ but showed marginally significance between BIS measurements of stability in stroke patients.⁴⁴ Topp et al.⁴⁵ mentioned that LOS test assesses the muscle weakness, range of motion, neural control and fear factors, related to motor control of balance.⁴⁵ The parameters reported in LOS significantly correlated with the activity of ADL (i.e. getting out of bed, stair climbing and walking) like others.^{46,47}

Limitations

Since the subjects were elderly they were hard to motivate and could not respond to all of our requests. The small sample size was small. The difference of components on BM tests such as for (EO, EC, CT Firm and Foam platform) may differ from time to time and from patient to patient which may have affected our results. Moreover, fear of falling anxiety may have confounded the accuracy of the results, at least in part.

Conclusion

The objective (quantitative) method of assessing body-balance (computerized BM) was observed to have better performance in terms of reliability and validity in all LOS parameters including TS for CT among acute stage PSH patients) than subjective methods (Qualitatively)- which should be adequate in poor socio-economic countries where facilities of such expensive computerized machines, like BM, are not available, in particular.

Recommendation

We sincerely feel that more research and/or multi-central studies in this field be conducted involving better study design and among larger samples to confirm our findings, further. Though the computerized method of body-balance assessment (BM), qualitatively, proved to be better and reliable, qualitative method of assessing of body-balance in such patients should remain adequate, particularly among poor socio-economic countries.

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Conflicts of interest

None.

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