

Sitting postural control is prerequisite for standing and stepping after stroke: A cross-sectional study

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ABSTRACT

Objective: To examine the trunk performance during static and dynamic sitting postural control, and to find an association with functional balance such as standing and stepping early after stroke., **Participants and setting:** Fifty-nine stroke patients (range 2-45 days) were evaluated once for trunk performance and functional balance by same observer in an in-patient stroke rehabilitation centre, Kasturba Medical College Hospital, Mangalore, Manipal University., **Measures:** Trunk Impairment Scale (TIS) and its subscales; Brunel Balance Assessment (BBA) and its sub-sections., **Results:** Stroke participants had a mean (SD) score of 14.5 (3.8) and 7 (3) on TIS and BBA. The Karl Pearson Correlation Coefficients was used to compare the association of TIS and its subscales, with BBA and standing, stepping measures, and found to be moderate and high correlation among the measures. The correlation was significant at the level of R value > 0.6 (P< 0.01)., **Conclusion:** Static and dynamic sitting postural control is affected in stroke patients as a result of poor selective trunk muscle control. In addition, trunk performance in sitting influences the balance performance in standing and stepping early after stroke.

Key Words: Stroke, Postural Control, Trunk Performance, Balance

INTRODUCTION

In India, the prevalence of stroke is estimated to be 203 per 100,000 populations, accounting to a total of about one million cases. It ranked as the sixth leading cause of disability in 1990 and is projected to rank fourth by 2020. Amongst the non-communicable

diseases, stroke contributes for 41 percent of deaths and 72 percent of disability adjusted life years as estimated by Indian Council of Medical Research.¹⁻³ Following stroke, patients suffer from severe postural unsteadiness, and tend to have frequent numbers of falls, as well as greater restriction of activities after fall.⁴ Reports stated that only approximately 20-66% of patients with stroke manage to walk independently in the community again.⁵ The sensory and motor impairments of upper limb, lower limb and trunk interfere with the functional performance after stroke. Trunk performance has been identified as an important early predictor of functional outcome after stroke.⁶⁻⁸ Unlike hemiplegic limb muscles, the trunk muscles are impaired on both sides of the body following an unilateral stroke as evaluated by computed tomography and motor evoked potential studies.⁹⁻¹⁰

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Studies on handheld and isokinetic dynamometer muscle strength testing found that trunk muscles are weak in patients with stroke, when compared to that of age matched healthy controls.¹¹⁻¹⁴ Movement analysis of trunk also found that selective trunk muscle control, particularly the lower trunk muscle activity was minimal in patients with stroke.¹⁵ The primary contribution of the trunk muscles is to allow the body to remain upright, adjust weight shift, and performs selective movements of the trunk against constant pull of gravity. Hence, it helps to maintain the center of mass within the base of support during static and dynamic postural adjustments in sitting, standing and stepping.^{16,17} A study on electromyography analysis found an impaired anticipatory postural trunk muscles activity in patients with stroke, which in turn essential for static postural control.¹⁸ Furthermore, studies on posturographic analysis found an impaired dynamic postural control in patients with stroke during sitting¹⁹ and standing.²⁰ Amongst the clinical measurement tools available to measure trunk performance,²¹⁻²³ the Trunk Impairment Scale (TIS) evaluates the selective movement control of the upper and the lower trunk in patients with stroke. Verheyden et al identified an impaired trunk performance in patients with non-acute and chronic stroke.²⁴ Recently, a clinical measurement tool, Brunel Balance Assessment was available to evaluate the standing and stepping in patient early after stroke.²⁵⁻²⁷ Recent cross sectional study demonstrated that trunk performance i.e. sitting postural control was related to measures of balance and mobility in patients with non-acute and chronic stroke.²⁸ To the best of our knowledge, there are no retrievable data available to evaluate the trunk performance in sitting for patients with less than 45 days post-stroke duration. In addition, this study also sought to correlate the trunk performance (static and dynamic postural control in sitting) with the measures of functional balance such as standing and stepping early after stroke.

METHODS

This study protocol was approved by the Ethics and Scientific Committee of the Institution,

Manipal University, India. The study participants were recruited from the neurological rehabilitation centre of the inpatient stroke unit, Kasturba Medical College Hospital, Mangalore, and written informed consent was obtained seeking their active participation. Acute stroke patients with medical stability; ability to understand and follow simple verbal instructions were screened for eligibility for the study. Stroke diagnosis was confirmed by the CT and MRI imaging. Patients (mean (SD) 19±10 (range 2-45) days) with the single onset of unilateral supratentorial ischemic or hemorrhagic stroke lesion; and independent static sitting ability for 30 seconds on a plinth, were included in the study. Patients were excluded if they had other neurological and/or orthopedic disorders that could influence sitting balance.

Measures

The Trunk Impairment Scale (TIS) was used to measure trunk performance in sitting. It has three subscales consisting of static sitting balance, dynamic sitting balance and coordination. It comprises of 17 items and each item of TIS is scored on a 2-, 3-, or 4-point ordinal scale. The maximum scores for static sitting balance, dynamic sitting balance and coordination are 7, 10 and 6 respectively. The total score ranges from minimum 0 to maximum 23 points, a higher score indicating a better performance. Static sitting balance subscale of TIS in fact measures the static postural control while both the dynamic sitting balance and coordination subscales of TIS measure the dynamic postural control. Dynamic sitting balance evaluates the dynamic postural control in coronal plane, measuring the trunk lateral flexor muscle control. Coordination evaluates the dynamic postural control in transverse plane, measuring the trunk rotator muscle control. In earlier studies TIS had been documented for its reliability, validity and responsiveness.^{23,24}

The Brunel Balance Assessment (BBA) was used to measure the functional balance performance of the stroke participants. It consists of a hierarchical series of functional performance tests that ranges from supported sitting balance to advanced stepping tasks. There are three sections to the

assessment: sitting, standing and stepping. The sections are divided into several levels each of which increase the demand on balance ability, ranging from assisted balance to moving within the base of support, and changes of the base of support. Standing section of BBA evaluates the static and dynamic postural control without changing the base of support. Stepping section of BBA evaluates the static and dynamic postural control while attaining new base of support. BBA combines a 12-point ordinal scale and found to be reliable, valid measure of balance disability after stroke.²⁵⁻²⁷ The study participants were evaluated once by same observer, and the coin toss method was used to prefer the sequence of the measures.

DATA ANALYSIS

Descriptive measures are summarized as mean SD or percentage, as mentioned. The Karl Pearson Correlation Coefficient was used to compare the association of TIS and its subscales, with BBA and standing, stepping measures. An R value between 0.26 and 0.49 is considered as low correlation. An R value between 0.5 and 0.69 is considered to be moderate correlation. An R value between 0.7 and 0.89 is considered to be high correlation, while value beyond 0.9 is with very high correlation.²⁹ The correlation was significant at the level of $P < 0.01$. The analysis was performed using the SPSS version 11.5.

RESULTS

Among the fifty-nine study participants, 34 were males and 25 were females. Participants' age and post-stroke duration were 57 ± 9 (range 40-75) years and 19 ± 10 (range 2-45) days, respectively. Thirty eight participants were left sided stroke and 21 were right sided stroke. Table 1 shows values of participants' measures. Table 2 shows the correlation among the measures.

There were no participants attained the

maximum score in the total TIS. Earlier study also identified that the total TIS score above 21 is considered to be the normal trunk performance in sub-acute and chronic stroke patients.²⁴ Thirty-five participants attained maximum score in dynamic standing. Sixteen participants attained dynamic standing while six participants were able to stand with support. Twenty-nine participants scored zero while six participants attained the maximum score in stepping component of BBA. Two participants were able to maintain stride stance and nine participants could transfer weight on and off the weak leg while in stride-standing position. Four participants were able to walk with walking aid, and six were able to walk without a walking aid. Three participants were able to step on a box while balancing on involved lower limb.

DISCUSSION

The aim of this study was to examine the trunk performance in sitting for patients with less than 45 days since stroke onset. Furthermore, the study intended to examine the trunk movement control and its association with standing and stepping. Our study results found that trunk performance as measured by TIS and its subscales were positively associated with functional balance performance as measured by BBA and its subscales (Figure 1 and 2).

Rationale for the selection of TIS to measure the sitting postural control is given below. Availability of objective tools to evaluate trunk function in patients with stroke is present, and documented in literature elsewhere.⁹⁻¹⁵ There are only limited clinical measurement tools available to measure trunk performance in stroke patients. Earlier studies addressed that Trunk Control Test (TCT) and trunk control items of Postural Assessment Scale are good tools in measuring trunk performance since they have high sensitivity and no flooring effect in early stage stroke.^{7,21} But, these tools usually measure the gross bed mobility such as rolling over towards affected and unaffected side in lying and static sitting postural control. The above

mentioned tools may be deficient in measuring selective trunk movement control which is essential for dynamic sitting postural control. A clinical measurement tool, Trunk Impairment Scale (TIS), found to be sensitive tool in measuring trunk performance in non-acute and late stage stroke.²⁴ This scale may be applicable to examine the trunk lateral flexor and rotator muscles control in early stage stroke patients with static sitting postural control.

Rationale for the selection of BBA to measure standing and stepping is given below. There are clinical measurement tools available to measure the postural control in standing and mobility for non-acute and chronic stage stroke patients.³⁰⁻³³ Recently, a clinical measurement tool, Brunel Balance Assessment (BBA) is available to measure postural control in sitting, standing and stepping. Standing subcomponent of BBA measures the static and dynamic postural control in standing. Stepping component of BBA measure the advance level of postural control, where the center of mass is maintained in the changing base of support.²⁵⁻²⁷ The advantage of BBA is the hierarchical series of postural control measurement, thus it may be applicable to measure the postural control in standing and stepping for the early phase stroke patients who had already attained independent sitting ability.

This study showed that static sitting postural control had moderate and high correlation with standing and stepping, respectively. In static sitting balance, the ability to maintain the trunk alignment was assessed. Anticipatory trunk muscle activity is necessary to attain the static postural stability in sitting position, and had the positive relationship with motor and functional impairments in stroke patients.¹⁸ This study also found that lateral flexor muscle control had high correlation with functional balance performance. In addition, lateral flexor muscle control had moderate and high correlation with standing and stepping, respectively (Figure 3 and 4). In dynamic sitting balance, trunk lateral flexor muscle control was evaluated in coronal plane. Study on hand-held dynamometer strength testing also identified lower scores in measuring the similar trunk

movement in stroke patients.¹¹ Trunk lateral flexor muscle control is essential for shifting the body weight within the limits of stability in coronal plane. A recent study also identified that stroke patients tend to avoid shifting their weight towards hemiplegic side in sitting¹⁹ and standing.²⁰ Weight shifting ability towards hemiplegic side requires trunk muscles control alone in sitting, but both the trunk lateral flexor and hip abductor muscles control are essential in standing. In order to attain postural control in standing and stepping, both the hemiplegic lower limb and trunk muscles control to be present. According to neuro-developmental principles, if better the trunk performance is attained, better the limb control may be anticipated.

Furthermore, the study also found that trunk rotator muscle control had high correlation with functional balance performance, and moderate and high correlation with standing and stepping components of BBA, respectively (Figure 5 and 6). For the coordination subscale of TIS, the trunk rotation movement i.e. trunk rotator muscle control was evaluated in transverse plane. Study on isokinetic dynamometer strength testing also identified lower scores in measuring the similar trunk movement in stroke patients.¹⁴ Rotation and counter-rotation between upper and lower trunk is believed to be important after stroke since all the functional movements are initiated by either upper trunk or lower trunk. Bio-mechanically, the lower trunk muscles chiefly the rotators, and hip extensors are the force couple that gets activated together during dynamic standing and stepping. For stepping component of BBA such as walking with or without a walking aid, lower trunk rotation muscles are essential to maintain the pelvis. Studies also identified that the pelvic control is unstable in stroke patients.³⁴ In this study, combination of dynamic sitting balance and coordination subscales of TIS was considered as dynamic sitting postural control since both of them evaluate the coronal and transverse planar weight shift ability of the trunk in sitting. Dynamic sitting postural control had high correlation with functional balance performance particularly of both standing and stepping (Figure 7 and 8).

Table 1: Descriptive values of 59 participants

Measures	Range	Mean (SD)	Percentage %
Trunk Impairment Scale (TIS) (0-23)	5-21	14.53 (3.79)	63 (16)
Static sitting balance(SSB) (0-7) ^a	5-7	6.28 (0.8)	90 (11)
Dynamic sitting balance (DSB) (0-10) ^b	0-9	5.8 (2.1)	58 (21)
Coordination (0-6) ^c	0-5	2.47 (1.26)	41 (21)
DSB + Coordination (0-16) ^d	0-14	8.27 (3.25)	52 (20)
Brunel Balance Assessment (BBA) (0-12)	3-12	7.08 (2.95)	59 (25)
Standing (0-3)	0-3	2.21 (1.01)	74 (34)
Stepping (0-6)	0-6	1.87 (2.17)	31 (36)

^aStatic postural control; ^bTrunk lateral flexor muscle control; ^cTrunk rotator muscle control; ^dDynamic postural control in coronal and transverse plane

Table 2: Results of Carl Pearson, Correlation Coefficients. Values are given as R (P value)

Test	TIS-total ^a	SSB ^b	DSB ^c	Coordination ^d	DSB + Coord ^e
BBA-total ^f	0.857(<0.0001)	0.712(<0.0001)	0.851(<0.0001)	0.804(<0.0001)	0.862(<0.0001)
Standing	0.721(<0.0001)	0.570(<0.001)	0.689(<0.0001)	0.674(<0.0001)	0.710(<0.0001)
Stepping	0.831(<0.0001)	0.703(<0.0001)	0.813(<0.0001)	0.797(<0.0001)	0.837(<0.0001)

TIS-total^a (Trunk Impairment Scale- total score); SSB^b (Static Sitting Balance/Static postural control); DSB^c (Dynamic Sitting Balance/Trunk lateral flexor muscle control); Coordination^d (Trunk rotator muscle control); DSB+Coord^e (Dynamic postural control in coronal and transverse plane). Correlation is significant at the 0.01 level.

Figure 1: Correlation between Trunk Impairment Scale (TIS) and Brunel Balance Assessment (BBA)

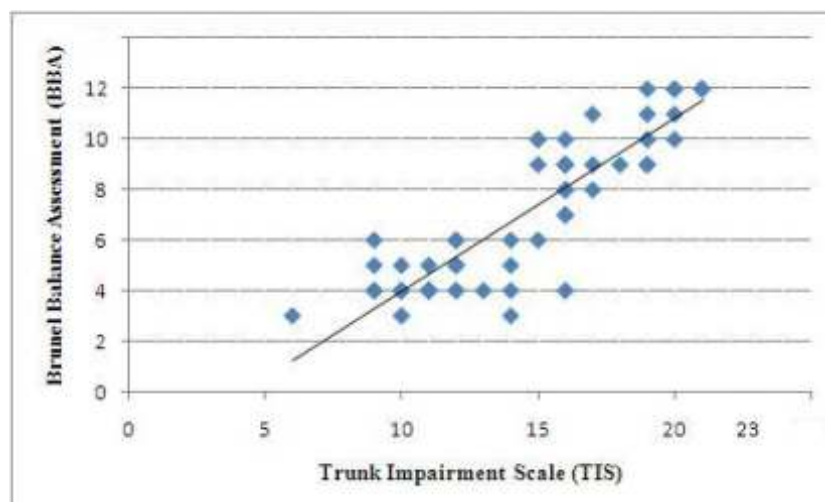


Figure 2: Correlation between Trunk Impairment Scale (TIS) and stepping component of BBA

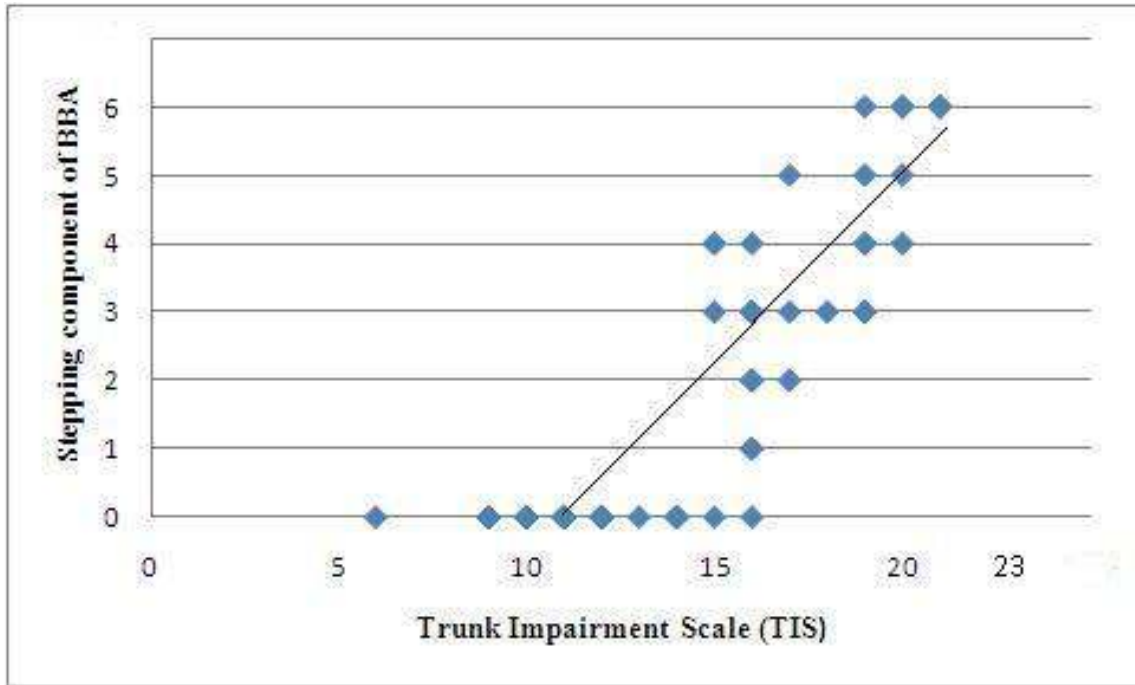
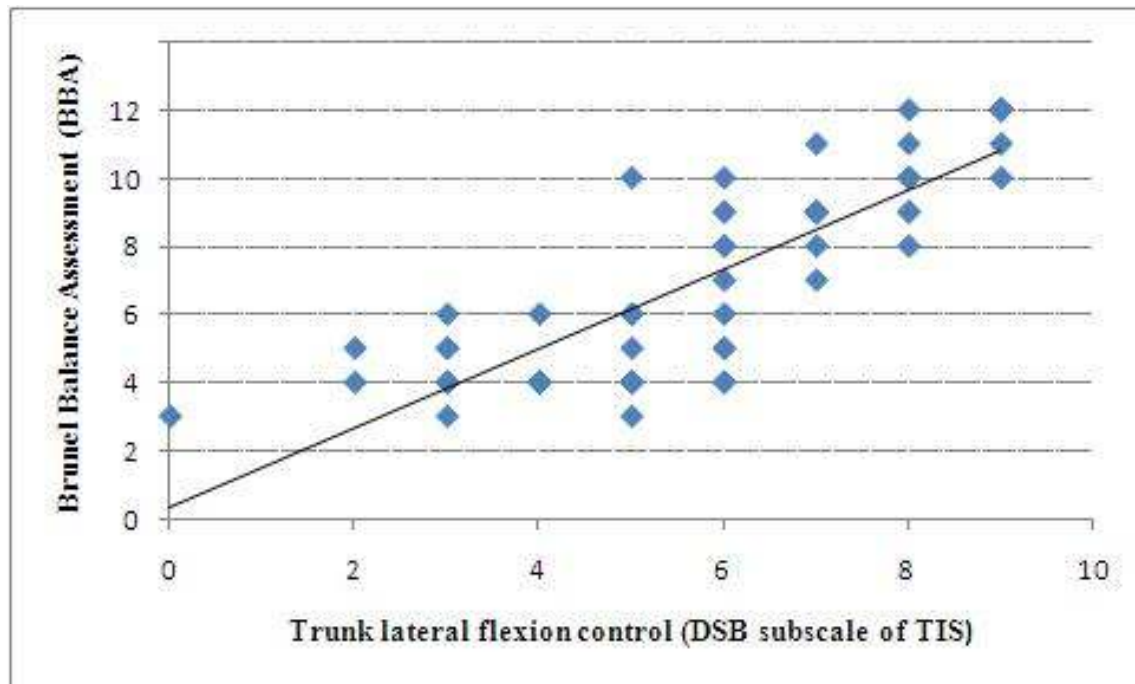


Figure 3: Correlation between trunk lateral flexion control and BBA



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Figure 4: Correlation between trunk lateral flexion control and stepping component of BBA

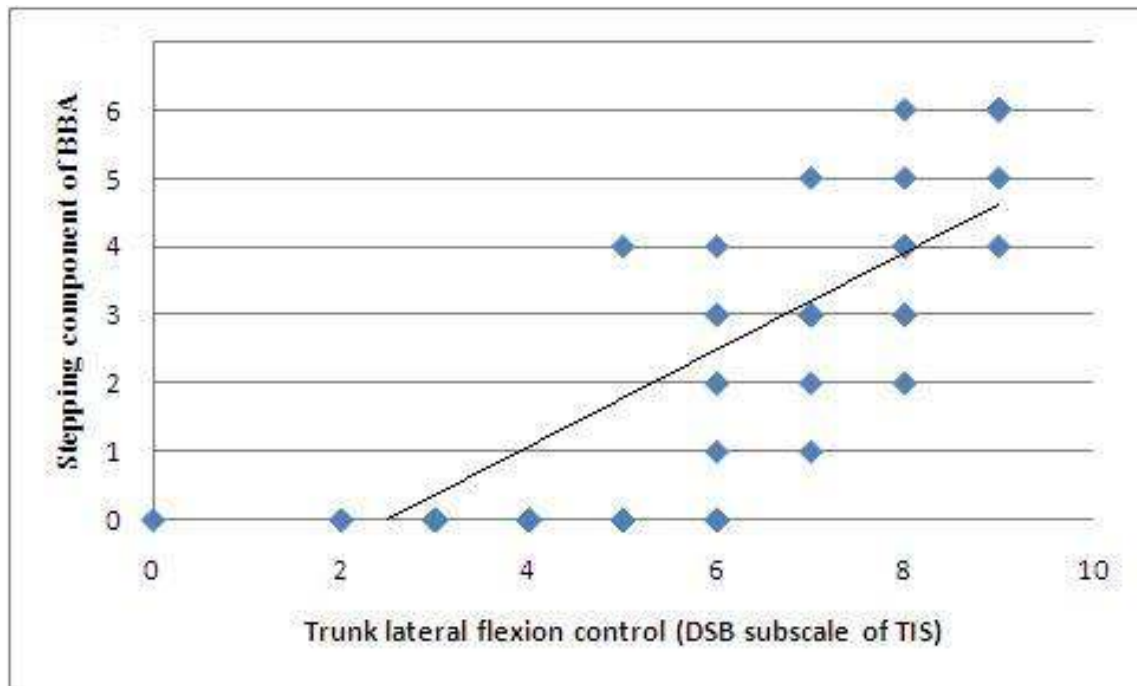


Figure 5: Correlation between trunk rotation control and BBA

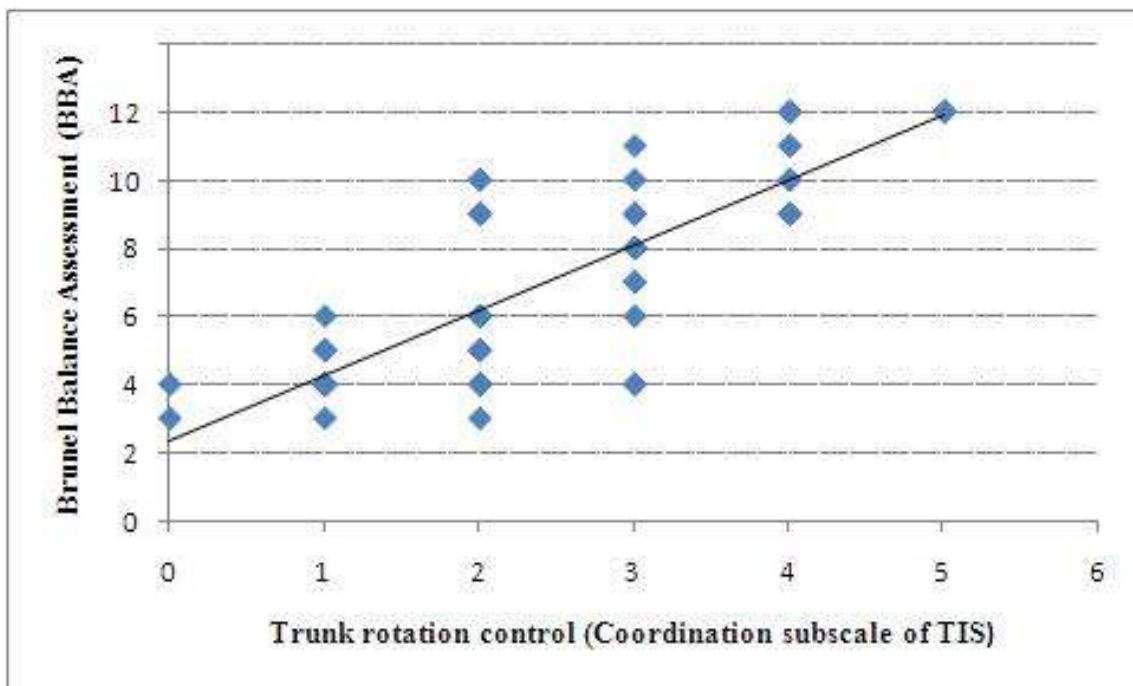


Figure 6: Correlation between trunk rotation control and stepping component of BBA

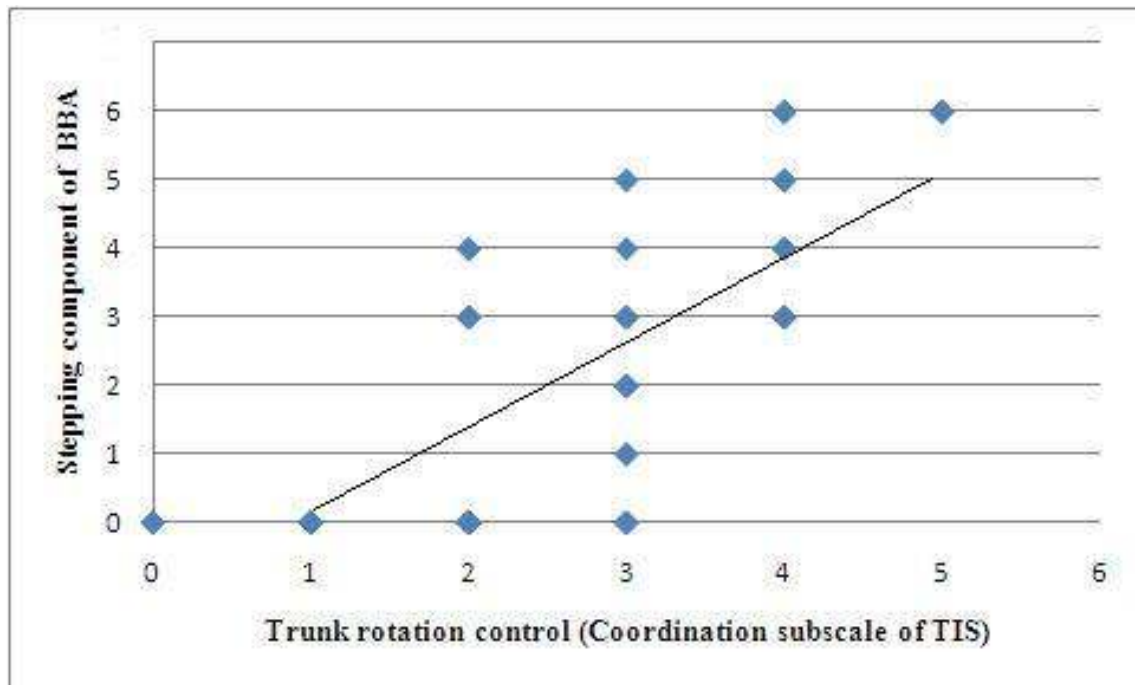


Figure 7: Correlation between dynamic sitting postural control and BBA

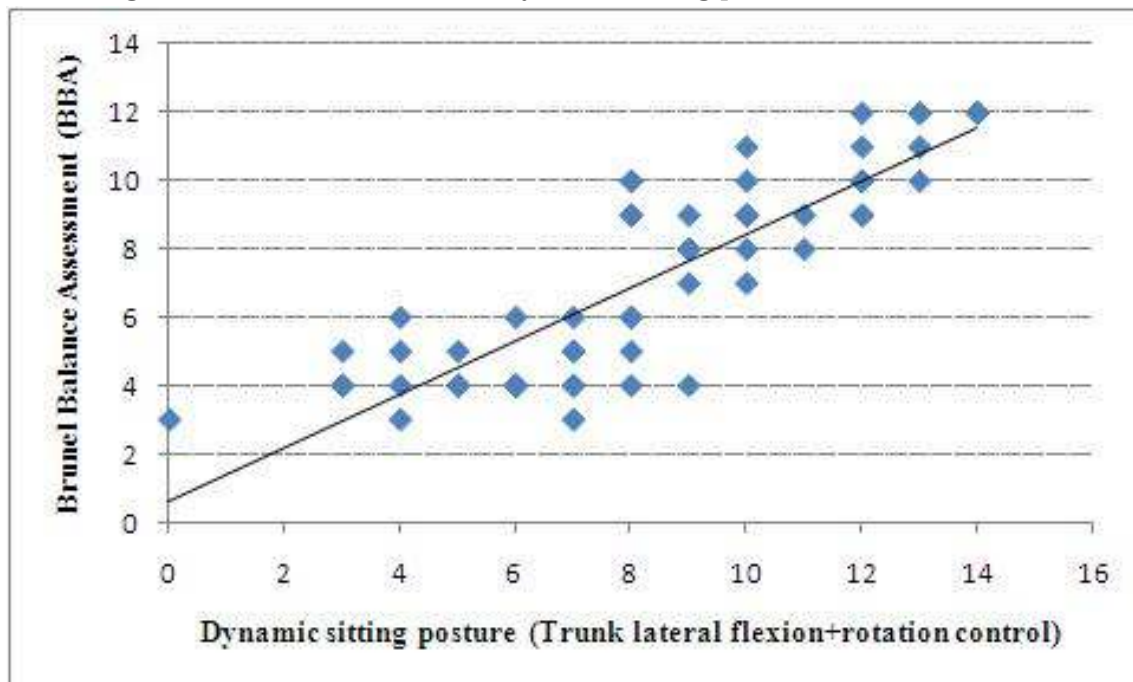
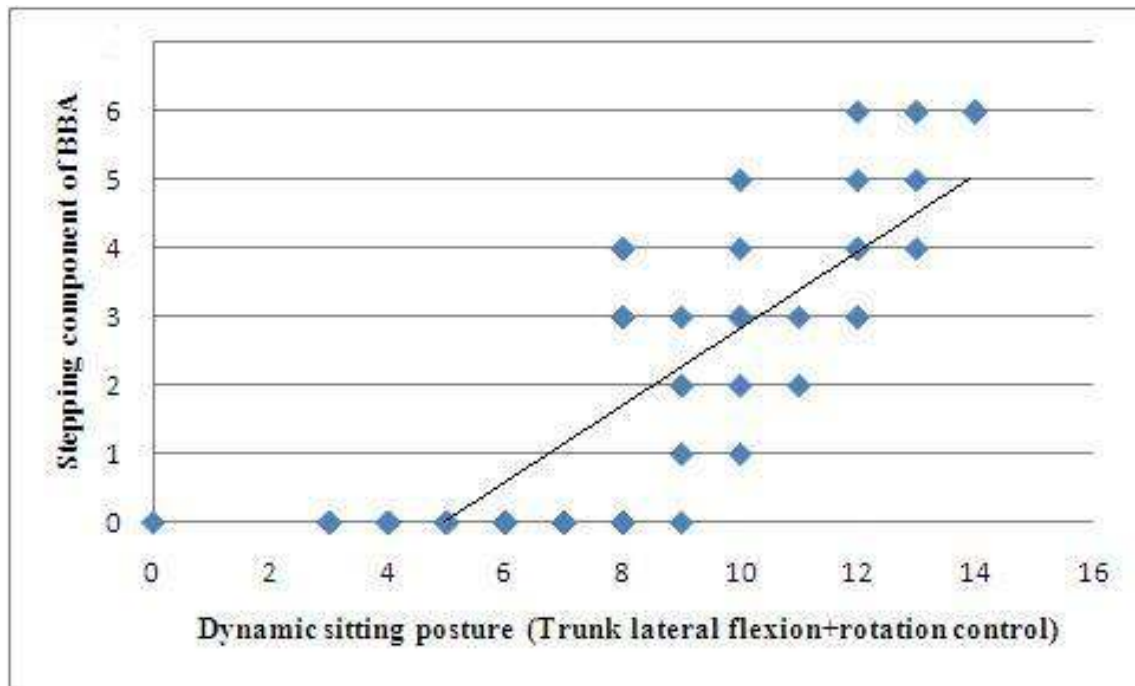


Figure 8: Correlation between dynamic sitting postural control and stepping component of BBA



Our study warrants caution when analyzing and interpreting the results due to the following limitations. Firstly, the severity of the stroke in accordance with site and extent of lesion was not considered. Secondly, the relationship between motor performance of trunk and hemiplegic limb was not assessed. Thirdly, the trunk performance and its correlation with the level of participation restriction were not examined. Fourthly, the participants were not selected in the study if they were not able to sit independently.

CONCLUSION

With the positive correlation between trunk performance during sitting and the measures of standing and stepping, we conclude that sitting postural control is prerequisite for standing and stepping postural control. Furthermore, our study

also confirmed the established statement addressing that the static postural control is prerequisite for advanced level of dynamic postural control in order to attain postural stability in non-changing and/or changing base of support. This study provides an insight to physiotherapists who are involved in trunk rehabilitation for subjects early after stroke. The goal setting at the level of body structure and function, activity limitation for early stage stroke patients who are undergoing physiotherapy rehabilitation may be evaluated by TIS and its subscales, BBA and its subcomponents, respectively.

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