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Original Research Article

A Study of the Relationship between Trunk Impairment and Gait in Patients with a Cerebrovascular Accident

Manasi Desai[1], Samruddhi Gawde[2], Sukhada Prabhu[3]

[1]M.P.Th in Neurosciences, Department of Neuro physiotherapy, Assistant Professor, D. Y. Patil University, School of Physiotherapy, Nerul, Navi Mumbai, Maharashtra
[2]B.P.Th, D. Y. Patil University, School of Physiotherapy, Nerul, Navi Mumbai, Maharashtra
[3]M.P.Th in Cardio Vascular and Respiratory Physiotherapy, Department Of Cardio-respiratory physiotherapy, Assistant Professor, D. Y. Patil University, School of Physiotherapy, Nerul, Navi Mumbai, Maharashtra

Corresponding Author: Manasi Desai

ABSTRACT

Aim: The purpose of the study was to evaluate the relationship between trunk impairment and gait in patients with a cerebrovascular accident.
Materials and Methods: A community based cross sectional study was conducted on forty stroke patients. These patients were recruited from various OPD/IPD in and around Navi Mumbai. The subjects were evaluated for the motor trunk impairment using the Trunk Impairments Scale (TIS), whereas the coordinated components of gait in these patients were evaluated using Gait Assessment and Intervention Tool (G.A.I.T).
Results: The mean score of TIS was 15.95 with SD 3.44 whereas the mean score of G.A.I.T was 24.47 with SD 12.15. The Pearson correlation showed highly significant correlation between TIS and GAIT (r= -0.961).
Conclusion: The study reveals that trunk impairment and gait in subjects with stroke are positively correlated with each other.
Keywords- Cerebrovascular accident, stroke, trunk impairment, gait.

INTRODUCTION

Stroke [cerebrovascular accident (CVA)] is the sudden loss of neurological function caused by an interruption of the blood flow to the brain. [1] There are 2 types of stroke, A) Ischemic stroke result when a clot blocks or impairs blood flow, depriving the brain of essential oxygen. Ischemic stroke being the most common type of stroke. B) Hemorrhagic stroke occurs when blood vessels rupture causing leakage of blood in and around the brain. Transient ischemic stroke (TIA) is a type of stroke which refers to temporary interruption of blood flow to the brain. [1] India being a developing country faces a double burden of various communicable and non-communicable diseases. Out of these, stroke is one of the leading causes of death and disability in India. The estimated prevalence rate was 119-145/100000 in the year 2013. [2] Hemiplegia / hemiparesis i.e., paralysis/ weakness of one side of the body is the classic sign of neurovascular disease of brain. [3] These individuals have movement problems which lead to fundamental limitations and disabilities including problems with body posture, walking and balance. There occurs an involuntary non-purposeful movement of the affected side, atypical patterns of movement,

compensatory strategies, and loss of movements of trunk and extremities. [3]

Trunk stability is often overlooked as an essential core component for balance and coordinated extremity use for daily activities. [4] The trunk being the central key point of the body, proximal trunk control is a pre-requisite for distal limb movement control, balance and functional mobility. [5] Trunk stability is the ability of the trunk muscles to allow the body to remain upright, adjust weight shift, and perform selective movement of the trunk that maintains the center of mass within the base of support during static and dynamic postural adjustments. [6] Trunk control requires appropriate sensorimotor ability of the trunk to provide a stable foundation for balance functions in patients with stroke. [7,8] Impairment in truncal function is characterized by diminished sitting balance, decreased trunk coordination, reduced trunk control and lower muscle strength and altered trunk position. [7-11] A by S.Tanaka et al. aimed at assessing the trunk flexors-extensors and rotators muscle performance in stroke patients using isokinetic dynamometer muscle strength testing reported weakness of trunk flexors-extensors and bilateral trunk rotators. [12,13] Poor recovery of trunk muscle performance results in severe disability and reduction in activities of daily living. [14]

A systematic review was carried out to evaluate the clinical tools required to measure trunk performance after a stroke. [15] Currently available tests that specifically evaluate trunk performance after stroke are the Trunk Control Test (TCT) and Trunk Impairment Scales (TIS). The Trunk Control Test became a well-established assessment tool, but at the same time several shortcomings were reported in the literature. Probably the most limiting aspect of the Trunk Control Test is that, it does not take into account the quality of movements [14] and its ceiling effect. [15] To overcome these lacunae, the Trunk Impairment Scale was developed. The TIS uses a standardized sitting position throughout the assessment. Moreover, the movements are performed in the sagittal, frontal and horizontal plane and it also takes into account the quality of movement whether or not the task is performed with compensations. [5] Also, the Trunk Impairment Scale has no ceiling effect. [9] A study by Fujiwara T et al. on the Psychometric property of Trunk Impairment Scale concluded that, TIS was a useful adjunct in stroke outcome research with good validity and reliability. [16] Hence TIS was chosen for assessment of trunk performance of stroke patients in this study.

Stroke patients shows muscle weakness, abnormal muscle tone, and disorder in balance and posture control, which results in difficulty in locomotion. [17] A study conducted by Davies et al. showed that there is "loss of selective trunk control" which is the major functional deficit of post-stroke patients. This loss of selective trunk muscle control leads to abnormal gait parameters. [5]

Gait dysfunction is one of the most serious consequences of stroke. [18] During gait, the required functions of lower limbs are propulsion, upright stability, shock absorption and energy conservation. [19] In hemiplegic gait, these functions are reduced due to abnormal muscle tone and synergy movement pattern. [20] The motor activation pattern includes abnormal co activation of limb muscles with normal or increased activity levels in muscle groups of involved side. [21] Perry et al. observed hemiplegic gait and found that stroke patient had inadequate shock absorption at heel strike, poor control of momentum during stance, inability to generate force for push off to maintain forward propulsion and inadequate excursion of the paretic limb during swing phase. [22] The limited walking ability that follows stroke restricts the person's functional independent mobility not only at home, but also in the community. [18] Hence, assessment of gait after stroke is of great importance for therapists for the assessment of rehabilitation efficiency. [23]

There are two methods of assessment of gait, (a)- Observational gait

analysis (OGA) and (b) Computerized three-dimensional (3D) gait analysis. Computerised three-dimensional (3D) gait analysis allows objective, quantitative hemiparetic gait assessment [24] and represents the gold standard for gait assessment. [25] However, this technology is not commonly available in clinical practice as its application is complex, time consuming and not cost effective. [24] Observational gait assessment is more acceptable to clinical professionals such as physical therapists due to its convenience and low cost. Observational gait assessments can be performed using video recordings which allow slow motion and freeze-frame observations. With this kind of assessment, clinicians can assess subjects walking pattern through observation of displacement of body parts and estimate the temporo-spatial elements of gait. [23] Hence, observational gait analysis remains the most common approach to provide an estimation of gait kinematics.

A systematic review by Francesco Ferrarello, was carried out to evaluate the tools for Observational Gait Analysis in patients with stroke in 2013, and found that the Gait Assessment and Intervention Tool shows a good level of validity, inter and intra-reliability when compared with other observational gait analysis tools, and its use in stroke rehabilitation is recommended. [24] Hence this measure was chosen for assessment of gait in stroke patients in this study.

In the literature on gait, it was earlier proposed that the trunk is a passenger unit, in that it is a part of the body that is carried by the locomotor unit of the lower limbs. [19] It was believed that during normal gait, it is only necessary for the muscles of the neck and trunk to maintain the spine at a neutral position. From this perspective, trunk function appears to be a relatively unimportant requirement for satisfactory gait. [26] However, some reports have noted that trunk function influenced gait performance and activities of daily living in hemiplegic patients. [9,27] Thus, there appears to be an ambiguity (in literature and among practitioner) regarding the relationship between trunk impairment and gait in patients with stroke. Therefore the current study aims to understand the relationship between trunk impairment and gait in patients with stroke.

MATERIALS AND METHODS

The study was a community based cross sectional study. About 40 subjects were included in the study through convenience sampling within the duration of six months. Study samples were recruited from multiple centres across Navi Mumbai. Patient with ischaemic and haemorrhage type of stroke within the age group of 20-80 years who had ability to follow simple instructions with intact cognition and who were able to ambulate with or without assistive device were included in the study. Subjects with history of other progressive neurological conditions and with other co morbidities were excluded from the study.

Procedure: Ethical Approval - The study was approved by the Institutional Ethics and Research Committee at D.Y. Patil University. Written informed consent was obtained from all the subjects. Subjects were assured that the information regarding their identity obtained during the study would be strictly kept confidential. The demographic details including name, age, address, education, occupation, dominance, type of stroke and duration of stroke were obtained during the study. After a baseline neurological assessment, each patient was assessed for trunk impairment using the Trunk Impairment Scale (TIS). The TIS includes 3 components, two of which assess static and dynamic sitting balance. The third component included co-ordination. Starting position for all the item's: sitting, thighs horizontal and feet flat on support, knee 90° flexed, on back support, hand and forearm resting on the thighs. The subject gets 3 attempts for each item. The best performance is scored. Instructions given can be verbal and nonverbal (demonstration). Based on patient

performance the final score was calculated. Each patient was assessed for gait impairments using the Gait Assessment And Intervention TOOL (G.A.I.T). Each patient was instructed to walk a particular distance while the therapist video recorded the patients gait in 3 views (viz; anterior, posterior and lateral). Lastly each video was observed to measure the co-ordinated gait component using the G.A.I.T tool. The obtained data was documented and statistically analysed using the Pearson's correlation co-efficient.

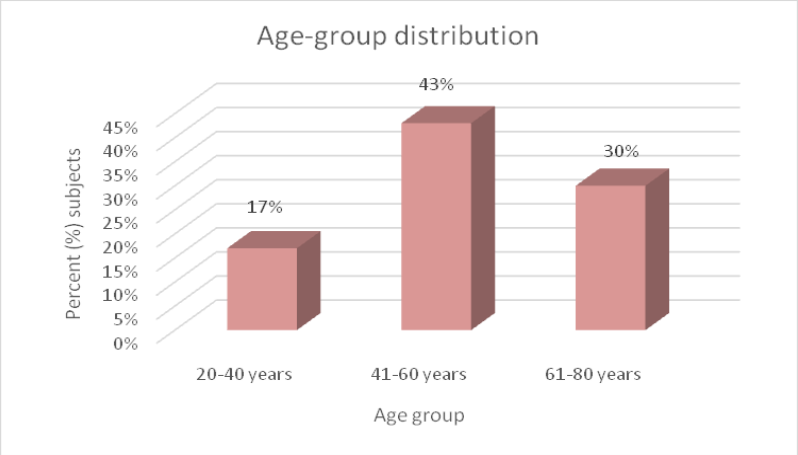
Figure 1- Trunk Impairment Scale (Dynamic sitting balance-component num:-4)

The patient is asked to touch the seat with the left elbow and return to the starting position. Movements at the trunk are noted.

Figure 2- Gait Assessment and Intervention Tool (Anterior, Lateral & Posterior view)

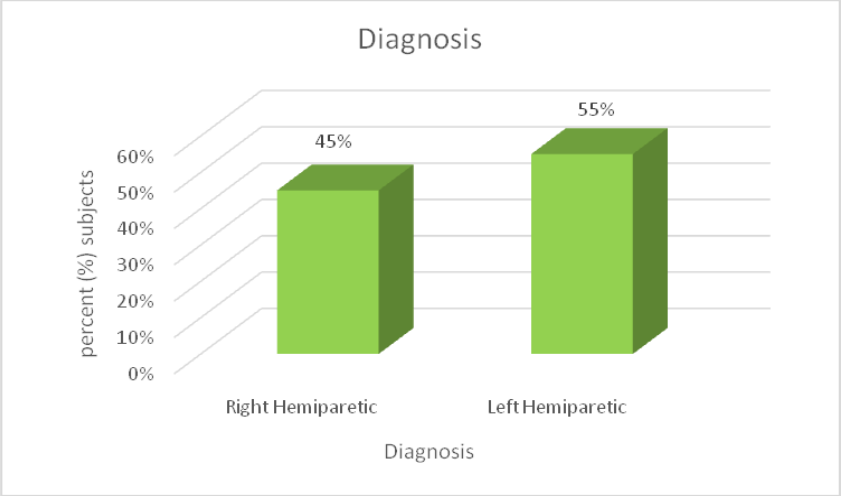
Stance Phase- Movements at trunk, hip, knee and ankle joints are noted.

Data Analysis:



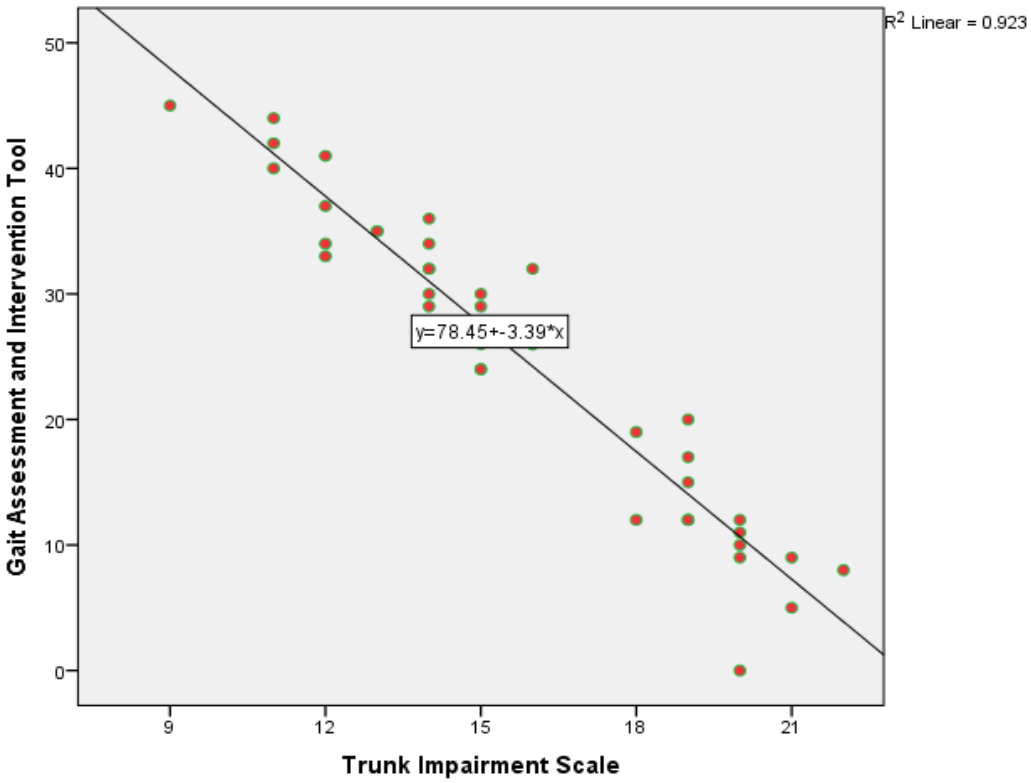
Graph 1- Age group distribution.

43% of subjects were found between the age group of 41-60years, 30% of subjects were between the age group of 61-80 years and 17% were between the age group of 20-40 years.



Graph 2- Diagnosis

55% of subjects were left hemiparetic and 45% of subjects were right hemiparetic.



Graph 3- Co-relation between TIS And G.A.I.T.

The above graphs show, Strong Negative Correlation between Trunk Impairment Scale and Gait Assessment And Intervention Tool.

The Pearson's Correlation = -0.961 and p value < 0.0001.

RESULTS & DISCUSSION

The study intended to study the relationship between trunk impairment and gait in stroke patients.

Among the 40 subjects who participated in the study, 80% (32) were male and 20% (8) were females. The mean

age of the subjects was 52.95 years with SD±11.53 years (Graph 1). 87% (35) were right handed by dominance whereas 13% (5) were left handed by dominance. About 60% (24) stroke patients were employed and 40% (16) were unemployed. About 21 subjects had left hemiparesis and 18 subjects had right hemiparesis (Graph-2). 70% (28) subjects were chronic stroke patients while 30% (12) subjects were sub-acute stroke patients. About 78% (31) subjects were able to walk without the use of assistive device while 22% (9) subject used assistive devices (i.e., walker and cane) for ambulation.

The 1st objective of our study was to assess the trunk impairment in stroke patients using TIS. The mean score of TIS was 15.95 with SD 3.44 points. The TIS has 3 components:- two of which assess the static and dynamic sitting balance and the 3rd component includes assessing co-ordination (Figure 1).

The trunk being the central key point of the body, proximal trunk control is a pre-requisite for distal limb movement control, balance and functional mobility. [5] Trunk muscles play an important role in the support of our bodies in antigravity postures such as sitting, standing and in the stabilization of proximal body parts during voluntary limb movements. [28] Counter rotation between the upper and lower trunk is mobility over stability task which is essential for all the functional movements. The rotation of the trunk muscle activity is not unilateral but requires static holding of contra-lateral muscles to stabilize the central aponeurosis, so allowing the antagonist shorten and draws one side the pelvic or thorax forwards. [5] Along with limb muscles trunk musculature is also impaired in stroke patients. [29] Contrary to limb muscles in hemiplegia, in which motor paralysis affects one side of the body; the trunk muscles are impaired on both ipsilateral and contralateral side of body to that of lesion. [30] The insufficient recruitment of high threshold motor units at high angular velocities and disuse are possible explanations for trunk muscle weakness in chronic stroke. [31]

The muscles of the trunk and pelvis are responsible for maintaining stability of the spine and pelvis [Kibler et al. 2006]. [32] The abdominals, paraspinals, the gluteals, the diaphragm, pelvic and hip girdle musculature constitutes the core musculature [Shinkle et al. 2012]. [33] The abdominal muscles need a stable origin to act efficiently, that is the pelvis, the thorax or the central aponeurosis depending upon part of trunk that is moved. [28] A study by Hodges and Richardson [30] aimed at assessing the co-contraction of the abdominal muscles during lower limb movements using surface electromyography, reported that, transversus abdominis is involved in preparation of body during contralateral weight shift. The study stated that the central nervous system initiates contraction of the trunk muscle activity, especially transverse abdominis and multifidus, which precedes the upper and the lower limb musculature activity. It is also believed that such feed-forward recruitment pattern of core musculature provides a more stable neuromuscular foundation for muscular movements and can contribute to more precise limb control during locomotion. [34]

The 2nd objective of our study was to assess gait impairment using G.A.I.T measure in stroke patients. The mean score of G.A.I.T measure was 24.47 with SD 12.15 points. The Gait Assessment and Intervention Tool (G.A.I.T.) is a 31-item measure of the coordinated movement components of gait and associated gait deficits (Figure 2). The tool is comprehensive, scored in an objectively-based manner, and capable of assessing incremental improvements in the coordinated components of gait. [35]

Gait dysfunction is one of the most serious consequences of stroke. [5] During gait, the required functions of lower limbs are propulsion, upright stability, shock ab-sorption and energy conservation. [17] In hemiplegic gait, these functions are reduced

due to abnormal muscle tone and synergy movement pattern. [18] Common deviation observed at trunk and pelvis while walking during the study were, forward flexion lean, contralateral flexion, contralateral pelvic drop and pelvic hike. Possible causes for forward flexion lean is to compensate for quadriceps weakness or may be also are used to accommodate hip or knee flexion contractures. Possible causes for contralateral trunk flexion is to assist with pelvic elevation to ensure foot clearance or may be used as a compensation for contralateral hip abduction weakness or tightness of iliotibial band. Possible causes for contralateral pelvic drop are ipsilateral hip abductor weakness, hip adductor spasticity or hip adduction contracture. Possible causes for pelvic hike is the action of quadratus lumborum to assist with limb clearance when hip flexion, knee flexion, and/or ankle dorsiflexion are inadequate for foot clearance. [1]

Ability to distribute body weight evenly (postural symmetry) and to shift weight according to the task requirements, is essential to normal balance and for locomotion (Goldie et al). [36] This ability is commonly disturbed in individuals with stroke. They frequently show an increased posture sway, a decreased static and dynamic stability, and impaired weight-shifting ability (Badke et al, [37] Dettmann [38]) onto the paretic lower limb during sitting, standing and locomotion (Hacmon et al. 2012). [39] Also, a study by Carver et al. [40] reported that the stance time on unaffected side is more than the affected side which results in weight bearing asymmetry. Hence there occurs decreased excursion and disturbed muscle control during gait cycle. Studies have shown that core training improves static and dynamic balance in stroke patients. [41] Also, core strengthening improves posterior tilt and centre of gravity transfer during swing phase. [42]

The 3rd objective of the study was to study the relationship between trunk impairment and gait in stoke patients. The study shows a strong positive correlation between the two variables with the scores being negatively correlated (Graph 3). The Pearson correlation was found to be -0.961 and $p<0.0001$

During gait, it is important to maintain the trunk in a stable upright position, which requires the activity of trunk muscles. A study conducted by P.M Davies [5] reported that, there is loss of selective activity in trunk which fails to enable the thoracic spine in extension while using lower abdominals, which is reflected in walking. Maintaining dynamic balance is an important component of walking function that is likely impaired in chronic stroke survivors, evidenced by an increased prevalence of falls. Dynamic balance control requires maintaining the centre of mass (COM) within the base of support during movement. During walking, dynamic balance control is achieved largely by modifying foot placement to adjust the base of support. However, stroke survivors have difficulty with both, precision control of foot placement, as well as reduced control of COM movement. [43] Chern et al. (2010) [44] observed that stroke subjects demonstrate larger COM movements and velocities during the task and were less likely to shift weight onto the paretic limb. They also have reduced ability to accurately sense trunk position after movement and contributed to deficits in dynamic COM control (Ryerson et al., 2008). [7] Van Criekinge et al. [45] quoted that the pelvis-thoracic coordination is affected among stroke patient. Co-ordination between the upper and lower trunk movement is important for functional movements. [45] A recent study on dynamic posturographic analysis stated that trunk movements in persons with stroke are executed by upper trunk with very minimal anterior tilt of the pelvis *i.e.* mobility over stability skill is impaired. [46] Stroke survivors have difficulty coordinating movement across body segments during normal walking (Hacmon et al. 2012 [39]) and when changing walking direction (Hollands et al. 2010 [47]),

contributing to altered COM movement during walking.

Several authors have emphasized the importance of trunk movements in human gait. [46] In the kinematic analysis of stroke patients, unstable pelvic movements and asymmetric patterns have be noted during walking (Tyson, 1999 [48]). One of the contributions of the pelvis is a forward rotation on the side of the swinging leg and an opposite rotation near the end of the stance phase. [49] Pelvic angular momentum must be counterbalanced, either directly by counter-rotating the thorax or indirectly by swinging an arm. [50,51] According to posturographic analysis from Messier et al. (2004) [49] compensatory movements using the upper trunk were frequently seen, while the movement of the lower trunk (pelvis) was rarely reported. In a practical view, the lower trunk rotation is very difficult amongst stroke patients (Verheyden et al. 2005 [52]). It is suggested that this particularly a difficult movement in stroke patients and is possibly caused by a combination of factors such as proximal hypertonia in the lower extremities or paresis of the trunk muscles and anteroposterior pelvic obliquity and rotation (Davis 2003, [5] Messier et al. 2004 [49]). Therefore, from this perspective, trunk stability seems to be an important component during locomotion.

Clinical Implication:

- The positive co-relation between trunk impairment and gait suggests that individuals with gait impairments from stroke are more likely to have deficits in trunk control and/or postural control.
- The Trunk Impairment Scale being a quick outcome measure can be used to assess trunk impairments in stroke patients and can also be used in certain outpatient clinics or home settings to evaluate the improvement in trunk performance before and after the treatment settings.
- Trunk impairment retraining emphasizes on sagittal and transverse movements and thus may prove to be an important intervention strategy to improve trunk stability for balance and for locomotion.

Limitation of the study:

- Limitations of this study warrant caution when interpreting the results.
- The relatively small and selected group of patients included in the study challenges the generalizability of the outcome of this study.
- The subjects who participated were recruited from a specific geographical location. Thus, a diverse cohort will be required to apply the finding of the study to the general population.
- Future studies to assess trunk impairment and gait abnormality need to be done with other objective measures such as posturography, electromyographic analysis and biofeedback to reduce component of human error and to obtain more accurate results.

CONCLUSION

Based on the results of the study it can be concluded that trunk impairments and gait in stroke patients are positively correlated with each other. This indicates the need for the early implementation of truncal exercises in post stroke patients in the acute stage itself which may lead to better rehabilitation outcomes.

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Conflicts of Interest:

The authors report no conflicts of interest in this work.

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