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A review on assessment and treatment of the trunk in stroke

A need or luxury●

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Abstract
Trunk function has been identified as an important early predictor of functional outcome after stroke and the same deteriorates on both contralateral and ipsilateral sides of the body following stroke. The primary contribution of the trunk muscles is to allow the body to remain upright, adjust weight shifts, and control movements against constant pull of gravity and is considered central key point of the body. Proximal stability of the trunk is a pre-requisite for distal limb mobility, balance, gait and functional activities and its positive correlation in hemiplegia has been demonstrated in a cross-sectional study. Both isokinetic and handheld dynamometer muscle strength testing demonstrated the weakness of bilateral trunk flexors, extensors and rotator muscles in both acute and chronic hemiplegic patients. This was confirmed by electromyography analysis which identified poor bilateral trunk muscles activity in patients with stroke. Trunk impairment scale is sensitive to evaluate the selective muscle control of upper and lower trunk, and it has been reported that lateral flexion of the trunk is easier than rotation of the trunk and the clinical observation concurs to the difficulty in lower trunk rotation of stroke patients. However, trunk exercises given early after stroke could produce enhanced balance performance post- stroke. This review attempts to report the evidence supporting the involvement of the trunk and its influence on balance and functional performance in post-stroke hemiplegia.

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Key Words
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Research highlights
(1) Trunk-functional assessment post-stroke is important as a requirement in predicting the probable clinical outcome of the patient with stroke and designing an effective rehabilitation protocol.
(2) Authors recommend researchers to lay focus on the effects of trunk rehabilitation on the outcome of stroke in further investigation.

Abbreviations
TIS, trunk impairment scale; EMG, electromyography

INTRODUCTION

Stroke is a clinical syndrome characterized by rapidly developing signs of focal or global disturbance of cerebral functions, lasting for more than 24 hours or leading to death, with no apparent causes other than vascular origin[1]. This results in muscle weakness which is recognized as a limiting factor in the motor recovery after stroke. Contrary to the extremities, trunk is involved bilaterally in stroke whose identification plays a crucial role in planning treatment strategies in rehabilitation. As recruitment of trunk precedes recruitment of the limb joints, it begins to move earlier and continues moving even after the limbs have stopped at the target. Involvement of trunk in turn has an impact on balance and functional ability of subjects which is assessed clinically using tools like trunk control test, and two trunk impairment scales (TIS) proposed by Verheyden and Fujiwara. Hand held dynamometers, isokinetic dynamometers, posturography and surface electromyography (EMG) are of choice to quantify the involvement of trunk. This literature review intends to throw light on the various tools used for trunk assessment post-stroke emphasizing its importance in trunk rehabilitation.

TRUNK MUSCLES IN PATIENTS WITH POST-STROKE HEMIPLEGIA

Trunk is the central key point of the body with its primary contribution to stabilize spine and trunk[1]. Trunk control is the ability of the trunk muscles to allow the body to remain upright, adjust weight shifts and perform selective movements of the trunk that maintains the base of support during static and dynamic postural adjustments. Although hemiplegia affects unilateral limb activity, it has a potential to deteriorate the function of trunk muscles on both sides of the body affecting the proximal control. The lack of proximal stabilization influences the limbs profoundly in that the arm and leg can only be moved in spastic synergy patterns. In an attempt to move upright against gravity, this loss of fixation is compensated by increased distal spasticity. Loss of selective activity in these muscle groups of trunk fails to enable the patient to stabilize his/her thoracic spine in extension while using lower abdominals in isolation, which is reflected in walking[2-3].

A cross-sectional study on transcranial magnetic stimulation among stroke patients had shown that the recovery of trunk function after stroke is associated with increased ipsilateral motor evoked potentials in external oblique muscle upon stimulation of unaffected hemisphere. This suggested a role of compensatory activation of uncrossed pathways in recovery of trunk function[4]. Computed tomography of trunk muscles demonstrated an increase in paravertebral muscle cross section area bilaterally by 3–4% after 3 months of a conventional rehabilitation program. However, the contralateral paravertebral muscle cross section area was larger than ipsilateral side. This was related to degree of impairment (stroke impairment assessment set, trunk control test) and functional limitation (functional independence measure) of the subjects[5].

TRUNK MUSCLE WEAKNESS IN PATIENTS WITH HEMIPLEGIA

Trunk muscle strength is impaired multidirectionally in hemiplegic patients. Isokinetic dynamometric testing reported weakness of trunk flexors and extensors and peak torques of these muscles were significantly smaller in chronic hemiplegic patients than in healthy controls except for flexors at angular velocity of 0° per second. The tested isometrically flexor and extensor strength was determined as 88% and 64%, respectively compared to those in control subjects. However, extensor muscle strength was determined as 88% and 64% was weaker than that of flexors. The insufficient recruitment of high threshold motor units at high angular velocities and disuse are possible explanations for trunk muscle weakness in chronic stroke[6]. Isokinetic testing also found that trunk rotatory muscle strength is smaller in chronic hemiplegic patients than that of controls; however, there was no difference in the performance of trunk rotators to right and left directions[7]. In addition, trunk lateral flexor muscle weakness of the paretic side was more compared to non-paretic side measured using hand held dynamometer[8-10].

EMG studies reporting the characteristics of anticipatory postural adjustment in axial-lateral and posterior-anterior trunk muscles during the performance of upper and lower limb flexion tasks after stroke showed major impairments in the activity of the trunk muscles. The impairments manifested as reduced activity of the lateral muscles, delayed onset, and reduction in synchronized activation of pertinent muscle pairs. This reduction in electromyographic anticipatory postural activation was also noted in lattismus dorsi and external oblique muscles of the affected side. Motor (motor assessment scale and trunk control test) and functional (Bartel Index) deficits were found associated to it[11]. It was considered that the altered EMG activity of trunk muscles, particularly rectus abdominus may be one of the reasons for the occurrence of compensatory strategies in patients with hemiplegia[12]. Furthermore, trunk flexion when analyzed dynamically though did not alter the amplitude of flexion, a decreased displacement of center of pressure with limited weight bearing on feet was observed. This is suggestive of a smaller displacement of the body mass compared to healthy subjects in sub-acute stroke. Trunk movements are executed involving upper trunk and a very little anterior pelvic tilt was noted in hemiparesis patients[13]. Analysis of trunk kinematics found that pelvic movements in stroke patients were unstable and asymmetrical during walking[14].

TRUNK CONTROL AND ITS INFLUENCE ON BALANCE AND FUNCTION IN STROKE

Alteration of trunk position sense[15] and weakness[16] of trunk muscles in stroke has a significant influence on balance difficulty in these patients. Anticipatory postural adjustments of trunk muscles play a major role in maintaining antigravity postures like sitting and standing when a reaching task is executed[17]. Sitting balance recovery when correlated in a posturographic assessment reported that lateral balance was more affected than antero-posterior balance. In addition, lateral balance control showed the strongest association with the berg balance scale as a clinical measure of balance capacity. This suggests that leg muscles may assist in stabilizing the trunk in the antero-posterior direction whereas lateral sitting balance almost completely depends on trunk muscles[18]. Increased risk of falls due to poor balancing in stroke subjects after discharge in turn leads to poor functional performance[19]. Recent evidence supports that the ability of balance and walking in stroke subjects depends on the performance of trunk function as measured by trunk control test and TIS[20]. It is the important functional predictor at discharge after stroke[21-24]. Hemiparetic patients with poor trunk function (trunk control) at admission stayed longer in a rehabilitation ward compared to patients who had better initial trunk function and could walk longer distances with speed at discharge[21]. Monaco *et al* [25] demonstrated that not only trunk performance in sitting position but also postural balance in lying, sitting and standing post-stroke predicted functional ability and destination at discharge from inpatient rehabilitation. Ability to ambulate independently at discharge had a significant relationship to early unsupported sitting balance and also found that this ability could predict independent ambulatory status in the later stage of stroke recovery[26]. A multi center trial had shown the total TIS and its static sitting balance subscale at admission and functional ability measured at discharge from the rehabilitation center (median days post-stroke, 20) are the most important predictors of Barthel Index score at 6 months after stroke. With an explained variance of 50% and more, the TIS total and static sitting balance subscale were even more important predictors than Barthel index itself on admission to the rehabilitation center[24].

TRUNK REHABILITATION

Despite the trunk performance is considered to be the important predictor for balance and functional performance, the evidence supporting the effectiveness of trunk rehabilitation is scarce. Mudie *et al* [27] found that training the stroke patients in the awareness of trunk position enhanced weight symmetry. Trueblood *et al* [28] reported that propioceptive neuromuscular facilitation-based resisted anterior elevation and posterior depression of pelvic movements for lower trunk muscles resulted in an improvement in walking in early phase stroke patients. Additional trunk exercises to regular physiotherapy improved trunk lateral flexion performance in sub-acute stroke patients[29]. A recent randomized controlled trial of truncal exercises early after stroke reported an improved balance ability and mobility[30]. Trunk exercises performed on a physio ball not only produced better trunk rotator control compared to similar exercises performed on a plinth but also its effect was carried over to the stepping balance performance in subjects with acute-stroke[31]. Recent pre-post design trial showed that administration of trunk rehabilitation in chronic stroke patients improved their balance performance and gait parameters[32].

INFERENCE

Further to this literature review, the authors believe that trunk functional assessment post stroke is important as a requirement in predicting the probable clinical outcome of the patient with stroke and in designing an effective rehabilitation protocol. We recommend researchers to lay focus on the effects of trunk rehabilitation on the outcome of stroke in further investigation.

Author contributions: Suruliraj Karthikbabu participated in the study concept and design, specifying the question, identifying relevant references and writing the manuscript. Chakrapani Mahabala, Sailakshmi Ganeshan and Kedambadi C Rakshith supervised the review process. Syed Nafeez and Venkatesan Prem participated in reading and checking the manuscript.
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