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Relationship between postural alignment in sitting by photogrammetry and seated postural control in post-stroke subjects

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Abstract.
BACKGROUND & OBJECTIVE: This study was executed to find out correlation between postural alignment in sitting measured through photogrammetry and postural control in sitting following stroke.
METHODS: A cross-sectional study with convenient sampling consisting of 45 subjects with acute and sub-acute stroke. Postural alignment in sitting was measured through photogrammetry and relevant angles were obtained through software MB Ruler (version 5.0). Seated postural control was measured through Function in Sitting Test (FIST). Correlation was obtained using Spearman's Rank Correlation co-efficient in SPSS software (version 17.0).
RESULTS: Moderate positive correlation ($r = 0.385$; $p < 0.01$) was found between angle of lordosis and angle between acromion, lateral epicondyle and point between radius and ulna. Strong negative correlation ($r = -0.435$; $p < 0.01$) was found between cranio-vertebral angle and kyphosis. FIST showed moderate positive correlation ($r = 0.3446$; $p < 0.05$) with cranio-vertebral angle and strong positive correlation ($r = 0.4336$; $p < 0.01$) with Brunnstrom's stage of recovery in upper extremity.
CONCLUSION: Degree of forward head posture in sitting correlates directly with seated postural control and inversely with degree of kyphosis in sitting post-stroke. Postural control in sitting post-stroke is directly related with Brunnstrom's stage of recovery in affected upper extremity in sitting.

Keywords: Sitting, posture, postural alignment, postural control, photogrammetry

1. Introduction

Re-establishment of postural control in sitting is an important early goal in stroke rehabilitation as it is critical to independent functioning. Postural control in undisturbed sitting is necessary for building more complex tasks such as reaching, standing or walking. Stroke affects static as well as dynamic component of postural control in sitting (Hamzat, 2000; Dean, 1997).

The static postural control is measured in terms of postural alignment and postural tone (Horak, 2006). Following stroke, the postural alignment is disturbed due to impaired motor control, altered pattern of motor-unit recruitment, muscle imbalance and changes in the length-tension relationship (Eng, 2004). Ability to maintain postural alignment is a vital component of postural control system (Benda, 1994). There are various methods by which postural alignment can be measured. These include plumb line (Norris, 1988), palpation meter (Flynn, 2003), posturometer (Brown, 2001), postural alignment grid (Sepúlveda, 2007) as well as by photogrammetric analysis (Ferreira, 2010). Quantitative data of postural alignment obtained

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through photogrammetric analysis is more reliable than through visual observation alone (Fortin, 2011). Photogrammetry allows the recording of subtle changes and the inter-relations between different parts of the human body that are difficult to measure or record through any other means. Further, it is reliable, irrespective of the software used to assess the photograph (Sacco, 2007). Postural alignment of head, shoulder, trunk, lower limbs in the standing posture has been studied with the help of photogrammetric analysis in the asymptomatic subjects (Ferreira, 2010; Fortin, 2011; Sacco 2007).

Photogrammetry in standing position was utilised as an outcome measure in a case study, which was done to determine the efficacy of Postural Re-education technique on posture of a chronic stroke patient (Gomes, 2006) The feasibility of using photogrammetry through SAPo (Postural Assessment Software) was analysed in four subjects with stroke, evaluated in standing position (Farias, 2009). They found that photogrammetry is an effective way to assess and monitor the stroke patients.

Location of the centre of gravity is altered by changes in the postural alignment which may alter the postural control (Riley, 1987; Danis, 1998). Posture control in sitting is analysed quantitatively with the help of clinical measures like Trunk Control Test, Trunk Impairment Scale, sitting components of Berg Balance Scale (Nieuwboer, 2007), and the recently developed Function in Sitting Test (FIST) (Gorman, 2011). FIST is a sitting-specific balance test to analyse the seated postural control following acute stroke (Gorman, 2010).

However, there is dearth of retrievable literature available to address the photogrammetric analysis of postural alignment in sitting and its relationship with seated postural control in stroke population. Hence, the aim of this study was to explore the relationship between the postural alignment in sitting measured through photogrammetric analysis and seated postural control in subjects with stroke. A secondary aim was to find the correlation between the Brunnstorm's stage of recovery for the upper extremity in sitting and seated postural control post-stroke.

2. Methods

This cross-sectional study was approved by the Scientific Research Committee and the Institutional Ethical Committee of Kasturba Medical College, Mangalore, Manipal University and was conducted at Kasturba Medical College Hospitals, Mangalore. Medically stable acute and sub-acute supra-tentorial stroke subjects who were referred by neurologist for neuro-rehabilitation were selected on convenience basis. The purpose and brief methodology of the study was explained to the subjects. On their consent, a signed information annexure seeking their active participation and co-operation was obtained from the interested subjects. Subjects were then screened as per the inclusion and exclusion criteria. Subjects were included if they were able to sit on a stable surface for at least 10 minutes without support (Gorman, 2010), and had a Mini Mental Status Examination Score of more than 23 (Dick, 1984), Subjects were excluded if they had any complaints of pain (Visual Analogue Scale >6) which was aggravated on sitting or hindered the ability to sit. The only other exclusion criteria was a history of any known disease other than stroke that could influence sitting balance which included Benign Postural Paroxysmal Vertigo and other vestibular diseases. In the subjects who were selected, the demographic data, including Brunnstrom's stage of recovery for the upper extremity, was taken in sitting.

Prior to the study, a pilot study was carried out in 5 stroke patients for familiarisation with the test procedure of photogrammetry and Function in Sitting Test. For photogrammetry, a plumb-line was fixed for reference with respect to vertical alignment before the placement of the camera. The principal investigator used the same camera (Sony cyber-shot: model DSC-W35), with in-built grid system, throughout the study. The camera was fixed on a tripod (Benro^{TM}) at a distance of 200 cm from the subject for the lateral, anterior and posterior views (Ferreira, 2010). To avoid positional errors, the level of the camera was standardised with respect to the horizontal, with the help of spirit level. The camera was focussed at the xiphi-sternum for anterior view, at the lateral epicondyle for lateral view, and at the T7 spinous process level for posterior view. The subject was asked to sit in high sitting, as straight as possible, on the rotatable stool in which the supporting surface had a diameter of 32 cm. The proximal thighs (half of the femur length) were supported well within the stool with the hips in neutral abduction-adduction and rotations. The hips and knees were maintained at 90° flexion with the feet unsupported (Ferreira, 2010). In order to isolate postural control of the trunk musculature and avoid lower limb contribution, foot rest was not provided (Perlmutter, 2010). Subjects were advised to maintain their both upper extremities in the anatomical position (shoulders in 20–30° abduction, mild lateral rotation, neither flexed nor extended, elbows completely extended, forearms supinated, wrist in neutral flexion-extension; neutral ulnar and radial deviation, fingers extended at proximal and distal interphalangeal joints and thumb extended and pointing outwards) as much as possible.

Markers were placed on the pre-defined relevant anatomical points, as discussed in the study done by Ferreira et al.

The anatomical points included were ear lobe, glabella, menton, acromion, lateral epicondyle, midpoint between the radial styloid process and head of the ulna, anterior-superior iliac spine (ASIS) and posterior-superior iliac spine (PSIS), inferior angle of the scapula, transition point between the medial border and scapula spine and the spinous processes of C7, T1, T3, T9, T12 and S1 (Ferreira, 2010).

The photographs were taken in three different views: anterior, posterior and lateral. The lateral view photograph of the dominant as well as the non-dominant side was taken. For each view, three photographs were taken and the best of the three photographs was chosen for further analysis. For each view, the position of the camera was kept constant and the subjects who were seated on the rotating chair were carefully manoeuvred to capture the pictures for the three views. The procedure for photogrammetry took approximately fifteen minutes for each subject. After the photographs were taken, the markers were removed. The photographs with the marker points were loaded onto the desktop and photogrammetric analysis was performed using software MB-Ruler version 5.0. All the photogrammetric data were measured in terms of angles (degrees) except the distance between the spine of scapula and the T3 spinous process which was measured in terms of centimetres. Following the photogrammetry, the stroke patients were allowed a rest period of 5 minutes. Later they were evaluated with Function in Sitting Test by the principal investigator and the standard procedure was used as per the manual on FIST.

The mean and the standard deviation of the data obtained from photogrammetry were calculated for the stroke patients. As the photogrammetric data for few variables was skewed, the correlation between the measures of postural alignment through photogrammetry was done using Spearman's correlation coefficient. Each measure of the photogrammetric analysis was correlated with the Function in Sitting Test using the Spearman's correlation co-efficient. Correlation with p value less than 0.05 was considered to be statistically significant. Statistical analysis was done using SPSS Software 17.0.

3. Results

Forty five subjects were included in the study. As per the demographic data (Insert Table-1 here), seventy percent of the subjects included in the study were in the acute stage. All the included subjects were right-handed dominant and seventeen percent subjects had young onset stroke with age less than fifty years. Sixty two per cent (Table 1) subjects were in stage three and four of Brunnstorm's stage of recovery in the upper extremity.

The data obtained from photogrammetry is summarised in Tables 2 and 3.

In the anterior view, the values for lateral tilt of the head indicated a predominance of tilting towards the normal side as indicated by the negative values. The values of horizontal alignment of the acromion indicated that there was tendency of the acromion of the hemiparetic side to be depressed, as shown by the negative values. The lateral view consisted of spinal alignments in terms of cranio-vertebral angle, kyphosis, lordosis and pelvic tilt. There was a predominance of posterior pelvic tilt than anterior pelvic tilt, which was indicated by the negative values. The amount of elbow flexion on the affected side was more than that in the normal side. In the posterior view, the values of horizontal alignment of the scapula indicated that there was tendency of the scapula of the hemiparetic side to be depressed or displaced downward as shown by the negative values. The values of difference between the angles formed between the medial border of the scapula and the horizontal on both the sides indicated that there was tendency of the scapula of the hemiparetic side to be rotated in the downward direction as shown by the negative values. The values of difference in the distance of the spine of the scapula from the T3 spinous process indicated that there was tendency of the scapula of the hemiparetic side to be retracted as shown by the positive values.

The results also included the correlation between the photogrammetric data, correlation between FIST and photogrammetric data (Insert Table 4 here). A significant very strong positive correlation ($r = 0.706$; $p < 0.001$) was found between the pelvic asymmetry measured with respect to ASIS (anterior view) and the pelvic asymmetry measured with respect to PSIS (posterior view). A moderate positive correlation ($r = 0.385$; $p < 0.01$) was found between the angle of lordosis and angle between the acromion, the lateral epicondyle, and the point between the radius and the ulna. A strong negative correlation ($r = -0.435$; $p < 0.01$) was found

Table 1
Demographic data of the subjects

Variables		No.	%	Mean ± SD
Gender	Male	32	71	
	Female	13	29	
Dominance	Right	45	100	
	Left	0	0	
Hemiparetic side	Right (dominant)	18	40	
	Left (non-dominant)	27	60	
Type of lesion	Ischaemic	28	62	
	Haemorrhagic	17	38	
Age (years)	40–50 years	8	18	61.57 ± 10.86
	51–60 years	8	18	
	61–70 years	21	46	
	Above 70 years	8	18	
Time since onset of stroke (days)	Acute (0–4 wks)	33	73	10.12 ± 5.08
	Sub-acute (1–3 months)	12	27	58.54 ± 27.51
Brunnstrom stage of Upper Limb recovery	1	0	0	
	2	7	16	
	3	11	24	
	4	17	38	
	5	6	13	
	6	4	9	

Table 2
Characteristics of the photogrammetric data of postural alignment in static sitting and FIST

	N	Mean	Standard deviation	Minimum range	Maximum range
Anterior View					
HTV	45	0.266	4.001	−6.23	8.07
HTH	45	−0.088	5.648	−9.71	9.33
AH	45	−1.298	4.684	−14.76	8.26
H-ASIS	45	183.009	3.775	174.43	189.36
Lateral View					
CVA	45	41.959	6.553	32.12	55.95
Kyp	45	51.115	11.046	23.79	76.83
Lor	45	25.568	6.998	15.32	42.76
PTH	45	19.81	13.279	−6.23	48.56
Aff UL	45	135.677	17.607	105.96	174.85
Nor UL	45	141.64	22.036	100.69	165.76
Posterior View					
H-PSIS	45	180.261	5.302	170.37	190.56
SAH	45	−1.014	4.809	−9.9	8.75
Diff MBS	45	−3.94	10.923	−29.7	22.97
Aff-T3	45	0.049	0.371	−1.61	0.46
Diff-T3	45	2.76	1.326	1.01	5.68
Tool for postural control in sitting					
FIST	45	38.43	9.532	15	54

HTV: inclination of the head with respect to vertical axis; HTH: inclination of the head with respect to horizontal axis; AH: Horizontal alignment of the acromions; H-ASIS: Horizontal Alignment of the Anterior Superior Iliac Spines; CVA: Cranio-Vertebral Angle; Kyp: Angle of the Thoracic Kyphosis; Lor: Angle of the Lumbar Lordosis; PTH: Horizontal Alignment of the Pelvis; Aff UL; Nor UL: Alignment of the Affected and Normal Upper Limbs; H-PSIS: Horizontal Alignment of the Posterior Superior Iliac Spines SAH: Horizontal Alignment of the Scapula; Diff-MBS: Scapular alignment with respect to the medial border of Scapula; Aff-T3: Alignment of the Scapula related to T3; Diff-T3: Difference in the Alignment of the Scapulae related to T3 on affected side; FIST: Function In Sitting Test.

between the cranio-vertebral angle and the angle of kyphosis. FIST showed a moderate positive correlation ($r = 0.3446$; $p < 0.05$) with the cranio-vertebral angle and a strong positive correlation ($r = 0.4336$; $p < 0.01$) with the Brunnstrom's stage of recovery in the upper extremity.

4. Discussion

Postural control is a complex sensorimotor skill that is designed to support postural orientation and equilibrium (Woollacott, 2002). Hemiparetic stroke patients frequently present with altered postural control.

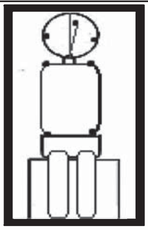
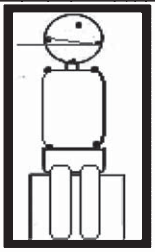
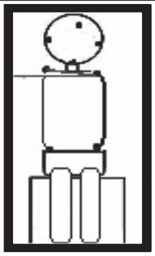
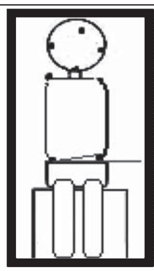
Vertical inclination of head	Angle between glabella, menton, and a horizontal line	
Horizontal alignment of head	Angle between the 2 ear-lobes and a horizontal line, taken with the fulcrum on the normal side	
Horizontal alignment of acromion	Angle between the 2 acromions and a horizontal line, taken with the fulcrum on the normal side	
Horizontal alignment of PSIS	Angle between the ASIS and the horizontal line, taken with the fulcrum on the normal side	

Fig. 1. Angles and measures used in anterior view of photogrammetry.

Altered postural control can be caused in patients with stroke due to impairments in sensory afferents, movement strategies, biomechanical constraints, cognitive processing and perception of verticality (De Oliveira, 2008) Ability to maintain postural alignment is a vital component of postural control system (Jaraczewska, 2006). The aim of the present study was to find the relationship between postural alignment in sitting and seated postural control in acute and sub-acute stroke subjects. Subjects with chronic stroke were excluded to avoid the later onset impairments due to non-neural mechanical changes like shortening and increased stiffness of muscles, which may contribute towards abnormal postures (Turk, 2011).

The photogrammetric data measured in this study were correlated with each other in order to understand the association between the photogrammetric data for postural alignment in static sitting. A significant

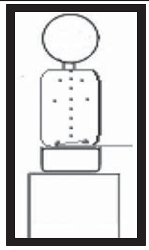
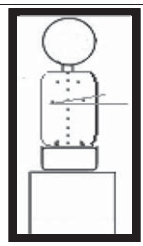
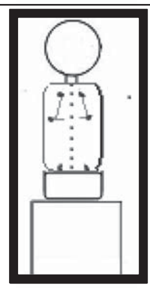
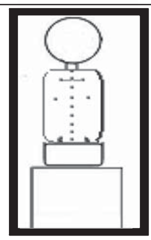
Posterior Superior Iliac Spine (PSIS) level	Angle between the PSIS and the horizontal line, taken with the fulcrum on the normal side	
Horizontal alignment of scapula	Angle between the inferior angles of the scapulae and a horizontal line, taken with the fulcrum on the normal side	
Frontal plane alignment of scapula	Angle between the point of intersection of the spine of the scapula and the medial margin, the inferior angle of the scapula, and a horizontal line. Difference between the angle of both sides is taken as diff MBS whereas, the angle on the affected side is taken as aff MBS	
Distance of inferior angle of scapula from T3 spinous process	Difference of the distances of the scapulae to the T3 spinous process is taken as diff T3, whereas; the distance on the affected side is taken as aff T3	

Fig. 2. Angles and measures used in posterior view of photogrammetry.

positive correlation ($r = 0.706$, $p = 0.009$) was found between the pelvic asymmetry measured with respect to ASIS in the anterior view and PSIS in the posterior view. This pelvic asymmetry could have been due to sacro-iliac upslope, intorsion as well as retraction (Neumann, 2002). Although pelvic asymmetry was studied with respect to both ASIS and PSIS; the pelvic retraction in the transverse plane, which is a common finding on the hemiparetic side, could not be studied due to methodological limitations. A weak positive correlation ($r = 0.385$, $p = 0.009$) was found between the angle of lumbar lordosis and angle between acromion, lateral epicondyle, and point between the radius and the ulna (elbow flexion) on the paretic side. These findings

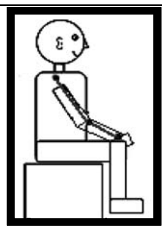
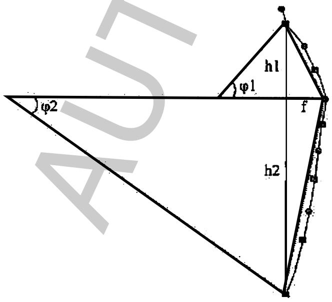
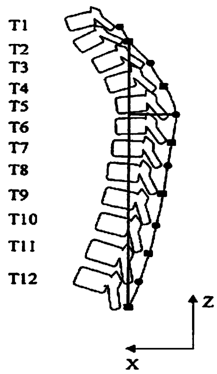
Horizontal alignment of head	Angle between C7 spinal process, ear-lobe, horizontal line	
Horizontal alignment of pelvis	Angle between the ASIS, the PSIS, horizontal line	
Alignment of superior extremity	Angle between acromion, lateral epicondyle, point between radius and ulna	
Kyphosis $K = \Phi1 + \Phi2$ $\Phi1 = 180^{\circ} - 2 \times [\arctan(h1/f)]$ $\Phi2 = 180^{\circ} - 2 \times [\arctan(h2/f)]$ Lordosis		

Fig. 3. Angles and measures used in lateral view of photogrammetry.

were consistent with the findings of Gandavadi et al, suggesting that exaggerated lumbar lordosis is associated with the better functioning and recovery of the paretic upper limb post-stroke (Gandavadi, 2005). A weak negative correlation ($r = -0.435$, $p = 0.003$) was found between the cranio-vertebral angle and the angle of kyphosis. Cranio-vertebral angle is related inversely with the degree of forward head posture (Quek, 2012). Thus, the present finding implies that angle of kyphosis positively correlates with degree of forward head

Table 3
Correlation within the photogrammetric data for postural alignment in static sitting with $p < 0.05$

	r value	*p* value
HTV with HTH	0.948	0.000
H-ASIS with H-PSIS	0.706	0.000
Aff UL with Lor	0.385	0.009
CVA with Kyp	−0.435	0.003

HTV: inclination of the head with respect to vertical axis; HTH: inclination of the head with respect to horizontal axis; H-ASIS: Horizontal Alignment of the Anterior Superior Iliac Spines; H-PSIS: Horizontal Alignment of the Posterior Superior Iliac Spines; Aff UL: Alignment of the Affected Upper Limbs; Lor: Angle of the Lumbar Lordosis; CVA: Cranio-Vertebral Angle; Kyp: Angle of the Thoracic Kyphosis.

Table 4
Correlation of FIST with photogrammetric data and stage of upper limb recovery

	r value	*p* value
Anterior view		
HTV	−0.0908	0.5516
HTH	−0.1258	0.4111
AH	−0.1031	0.5001
H-ASIS	−0.0107	0.9445
Lateral view		
CVA	0.3446*	0.0203
Lor	0.0478	0.758
Kyp	−0.0332	0.8269
PTH	−0.0712	0.6407
Aff UL	−0.0885	0.5649
Nor UL	0.0461	0.7621
Posterior view		
H-PSIS	0.1655	0.2774
SAH	0.1745	0.2524
Diff MBS	0.1876	0.218
Aff-T3	0.1575	0.2995
Diff-T3	0.0773	0.6126
Brunnstrom's stage of recovery		
Upper extremity	0.4366**	0.0027

HTV: inclination of the head with respect to vertical axis; HTH: inclination of the head with respect to horizontal axis; AH: Horizontal alignment of the acromions; H-ASIS: Horizontal Alignment of the Anterior Superior Iliac Spines; CVA: Cranio-Vertebral Angle; Kyp: Angle of the Thoracic Kyphosis; Lor: Angle of the Lumbar Lordosis; PTH: Horizontal Alignment of the Pelvis; Aff UL; Nor UL: Alignment of the Affected and Normal Upper Limbs; H-PSIS: Horizontal Alignment of the Posterior Superior Iliac Spines SAH: Horizontal Alignment of the Scapula; Diff-MBS: Scapular alignment with respect to the medial border of Scapula; Aff-T3: Alignment of the Scapula related to T3; Diff-T3: Difference in the Alignment of the Scapulae related to T3 on affected side; FIST: Function In Sitting Test; *Highly significant; **Very highly significant.

posture. These findings were consistent with the study by Quek et al. and Lau et al. which had concluded that kyphosis was significantly associated with lesser cranio-vertebral angle (Quek, 2012; Lau, 2010).

Maintaining postural alignment in a static state of equilibrium is an active process. It entails mechanical constraint of the body segment configuration thus ensuring stability when the centre of gravity is situated within the base of support. Further, locally, each body part must also be balanced with respect to each other (Bouisset, 2008). In patients with stroke, the Centre of Pressure velocity is increased. This signifies that as the instability in sitting posture increases, the postural control required to maintain the postural alignment increases manifold in them (Farias, 2009). Postural stability may occur due to muscular forces occurring from equilbrium reactions (Bouisset, 2008), mechanical factors in the form of multiple kinetic linkages (Jaraczewska, 2006) anticipatory and reactive postural control mechanisms, both of which are modulated by sensory inputs and influenced by learning and experience (Graham, 2009). In the present study, postural alignment in sitting was measured through photogrammetry and its relationship with seated postural control was studied with FIST. FIST showed a weak positive correlation with high level of significance ($r = 0.3446$; $p < 0.05$) with the cranio-vertebral angle. These findings are similar to the study by Salehi et al who concluded that forward head posture can affect postural control and lead to impaired motor control (Salehi, 2012). This may be due to the altered length tension relationship of the cervical stabiliser muscles (Kapandji, 1998; Grant, 2002) and impaired sensory reweighting (Kang, 2012) in forward head posture. This is consistent with the findings by Marigold et al. (2004) which concluded that impairments in re-weighting/integrating afferent information as well as muscle weakness may contribute to impaired postural control in stroke.

The postural control involved in the sitting presents similar characteristics to those observed in upright standing, with some differences which include larger base of support and reduced height of centre of gravity (Genthon, 2006). In our study, as the subject's feet were not in contact with the ground during photogrammetry. Further the diameter of the supporting surface of the stool was 32 cm and it was kept same irrespective of the anthropometric characteristics of the subjects. Hence, we expected that the quality of base of support to reduce. Further, the quality and size of the base of support are considered to be one of the most important biomechanical constraints to postural control (Genthon, 2006). Hence, we expected that postural malalignment would be exaggerated leading to reduced postural control. However, apart from cranio-vertebral angle, there was no significant correlation between the other photogrammetric variables and postural control. The present findings were similar to the findings in the study by Danis et al. (1998) in subjects with vestibular hypofunction and normal individuals in which posture and stability were not correlated in either of the groups. He concluded that larger postural deviations may have shown better correlation with postural stability than minute postural deviation as analysed from the photogrammetric study.

Postural control in sitting plays an important role in functional recovery of the affected upper extremity post-stroke (Raine, 2009). In stroke subjects, there is lack of selective trunk activity and poor stability of the ribs due to weak abdominals which results in scapular instability. Further, the shoulder girdle has no direct articulation with the vertebral column and is dependent on complex muscle activity in the upper trunk muscles to provide the necessary support for the functional arm (Jaraczewska, 2006). This present study found a significant ($r = 0.4366$, $p = 0.0027$) correlation between Brunnstrom's stage of recovery for upper limbs in sitting and FIST. Thus, adding to the literature, that the movements between the upper trunk and lower trunk are a key to postural control and as the basis for limb function.

Perceptual disorders may contribute to altered postural alignment post-stroke (Snowdon, 2005). Perceptual abilities of the subjects with stroke was not studied as a part of the present research work, hence it remains as one of the confounding factors of the study. Twenty-seven percent of the stroke subjects had sub-acute stroke (Table 1). As the duration after the onset of stroke increases, the likelihood of developing secondary non-neural factors increases which might have had an impact on the postural alignment as well as postural control post-stroke (Turk, 2011; Gandavadi, 2005). Pelvic retractions in the transverse plane could not be measured due to technical difficulty in positioning the camera for that view. Although the stroke subjects were instructed to maintain the position of their upper extremities as close to the anatomical position, there was a tendency to place the hemiparetic upper extremity on the lap or touching the lap. This would have interfered with the photogrammetric analysis of the scapular variables. Further, as photogrammetry is 2-dimensional measure; minor amounts of associated rotational components could have been present, impacting the reliability of the readings. However, according to the study by Ferreira et al. (2010) the measurement of angles can be considered reliable even for when the points analysed were not on the same plane.

Photogrammetry can be used an effective tool measure postural alignment in sitting post-stroke. Postural alignment should be incorporated as an important part of evaluation as well as rehabilitation of acute and sub-acute stroke patients. Further studies can be carried on postural alignment of lower limbs using photogrammetry and its impact on standing balance and ambulation post-stroke. Further, the postural alignment and its impact on postural control in sitting and standing can be compared in acute, sub-acute and chronic stroke subjects.

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None declared.

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