International Journal of Research in Medical Sciences
Pathak S et al. Int J Res Med Sci. 2014 Nov;2(4):1483-1487
www.msjonline.org
pISSN 2320-6071 | eISSN 2320-6012
DOI: 10.5455/2320-6012.ijrms20141144

Research Article

The relationship between pelvic alignment and trunk control in stroke subjects: a cross-sectional study

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Received: 22 August 2014
Accepted: 6 September 2014

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ABSTRACT

Background: Following stroke static as well as dynamic components of postural control were affected. Ability to maintain postural alignment is also a vital component of the postural control system. Pelvic asymmetry is commonly observed in stroke subjects which can influence trunk control. However, there is a paucity of literature that determines the relationship between pelvic alignment and trunk control in subjects with stroke.
Aim: To analyze the relationship between pelvic alignments using PALM and trunk control as measured by the Trunk Impairment Scale (TIS).
Setting: Inpatient rehabilitation unit, Tertiary Care Hospitals, Mangalore.
Design: A cross-sectional study.
Subjects: 38 supra-tentorial stroke subjects with more than 3 weeks duration and who can be able to sit independently were recruited.
Methods: The medio-lateral pelvic alignment of the stroke subjects was measured in sitting using the PALM™. The deviation in the pelvic tilt on the paretic side in comparison to the non-paretic side was measured in degrees. Following which the trunk control was evaluated using the Trunk Impairment Scale.
Results: The correlation between the pelvic tilt and the trunk control in the stroke subjects showed a negative correlation which indicates that a change in the pelvic alignment which affects the trunk control. Pelvic tilt values negatively correlated with all the sub-items of trunk impairment scores ($p < 0.00$). The pelvic tilt and the items of TIS scores. Brunnstrom's stage of lower extremity Motor Recovery demonstrated a significant association ($p < 0.05$), except for the coordination sub score of the TIS.
Conclusion: Pelvic alignment influences the trunk control and is also available to be associated significantly with the acute phase of stroke (3 weeks to 3 months). Brunnstrom's Stage of lower extremity motor recovery is also associated significantly with the static and dynamic sub scores of the TIS, hence trunk control may influence extremity motor recovery.

Keywords: Stroke, Trunk control, Pelvic Alignment, Sitting balance

INTRODUCTION

Stroke is the third major cause of mortality in the world, usually seen in the elderly population.[1] In India, the prevalence of strokes is estimated to be 203 per 100,000 people, and it was ranked as the sixth leading cause of disability in the year 1990 and is projected to rank fourth by the year 2020.[2] The trunk being the center of the body plays a major role in maintaining the body posture for functional movements by preparing the body, for the movement of the extremities against gravity.[3] Impairment in trunk performance following stroke is considered to be associated with changes in the measures of balance, gait and functional ability seen with stroke.[4] Trunk controls

have also been identified as a crucial predictor of activities of daily living following stroke..[5]

The trunk muscle strength in patients with a stroke is found to be impaired in the sagittal, coronal and transverse plane in stroke patients, when assessed using an isokinetic dynamometer and hand held dynamometer.[6-8] It is also suggested that these deficits in muscle strength and trunk amplitude observed in subjects with hemiparesis, result in reduced mobility of the pelvis.[9] Kinematic and kinetic studies of upper-body motion in the frontal plane have shown that the trunk is precisely controlled and highly dependent upon the motion of the pelvis which provides a basis of support for trunk mobility. [10, 11] Various methods have been used to assess the normal and pathologic pelvic alignment including radiography, videography, posturography, PALMTM and 3D motion analysis system.[12] PALMTM has the advantage of palpation along with the objectivity and reliability of the caliper and an inclinometer, their psychometric properties has good validity and intra-rater reliability (ICC = 0.97 and 0.98) and inter-rater reliability (ICC = 0.88 and 0.89) is found to be excellent.[13, 14]

Biomechanical mal-alignment due to pelvic asymmetry in stroke patients places the trunk muscles in a disadvantageous length tension relationship resulting in impaired trunk muscle activation and mobility.[15] Trunk control has been clinically measured using tools such as the Trunk Control Test, the Trunk Impairment Scale (TIS) described by Verheyden et al and the Trunk Impairment Scale described by Fujiwara et al.[16] Trunk Impairment Scale by Verheyden et al is found to have good psychometric properties for stroke subjects.[17] However, the relationship between pelvic asymmetry and trunk control in stroke patients has been scarcely studied. Hence the aim of the present study to investigate the relationship between pelvic alignment using PALM and trunk control (TIS) in subjects with stroke.

METHODS

This cross-sectional study was approved by the Institutional Research Ethics Committee, KMC, Mangalore, Manipal University, Karnataka, India. Stroke subjects referred by a neurologist to the physiotherapy department for rehabilitation from March 2013-March 2014 were recruited for the study. The aim and procedures of the study were explained to the volunteering subject, following that a written informed consent was obtained from those who were interested to participate in the study. Subjects were selected for inclusion and exclusion criteria. The inclusion criteria were (1) stroke subjects with supra tentorial lesions for more than 3 weeks post stroke duration (2) Trunk Control Test score=100 (3) MMSE score >23 and (4) Subjects who can sit without support for a minimum of 15 minutes. Exclusion criteria are (1) musculoskeletal complaints in the back which limit their performance (2) other neurological diseases that can affect their sitting balance (3) lateropulsion or pushers syndrome following stroke.

55 subjects were screened and 38 subjects met our study criteria. Before commencing of the study demographic data of the subjects and standardized instructions to sit as upright as possible to the treatment plinth with hips and knees flexed at 90 degrees and ankles at the neutral position. The medio-lateral pelvic alignment was measured with the lever arms of the PALMTM placed on the Anterior Superior Iliac Spine (ASIS) on either side. The deviation in the pelvic tilt on the paretic side in comparison to the non-paretic side was measured in degrees. In three test trials of pelvic tilt readings were taken, the mean of which was taken into account in analysis. The subjects were then permitted to rest for five minutes following which the trunk control was measured using the Trunk Impairment Scale.

Data Analysis

Descriptive analysis included mean, standard deviations and frequency distribution for the demographic variables. Correlation between pelvic alignment and trunk control was calculated using Karl Pearson's correlation coefficient. Associations between clinical assessments were made using chi square tests. Results were interpreted based on the confidence interval set at 95% and were reported along with statistical significance ($p<0.05$).All statistical analysis was performed using SPSS version 17 for Windows.

RESULTS

Table 1: Demographic data of the stroke subjects.

	Variable	n	Percentage
Sex	Male	29	76.3
	Female	9	23.7
Side	Left	26	68.4
	Right	12	31.6
Duration	Acute	20	52.6
	Sub-Acute	8	21.1
	Chronic	10	26.3
Diagnosis	Ischemic	31	81.6
	Hemorrhagic	7	18.4
BSRLL	Stage 2	1	2.6
	Stage 3	10	26.3
	Stage 4	8	21.1
	Stage 5	10	26.3
	Stage 6	9	23.7

Table 1 summarizes the demographic variables of the study.38 stroke subjects (29 males, 9 females) were recruited in the study with mean age 59.52± 11.16 years. With respect to type of stroke 31 subjects had ischemic lesions and 7 hemorrhagic and with duration of stroke, there were 20 subjects with an acute stroke, 8 with sub-

acute stroke and 10 with a chronic stroke. Brunnstrom's Stage of Recovery for the lower limb was more or less equally distributed among the subjects from stage 3 to stage 6, except for one subject who was in stage 2 of recovery.

Table 2 summarizes the measurement of Pelvic Tilt and TIS mean scores of the stroke subjects. The mean score for Pelvic tilt using PALM was 2.68 ± 1.06 and mean total TIS score was 15.52 ± 4.02.

Table 2: Mean Scores of Pelvic Tilt measure and TIS.

	Minimum	Maximum	Mean ± SD
Pelvic tilt	.00	5.00	2.68 ± 1.06
TIS (static)	1.00	7.00	5.23 ± 1.30
TIS (dynamic)	1.00	7.00	5.23 ± 1.30
TIS (coordination)	1.00	7.00	5.05 ± 1.55
TIS (total)	3.00	21.00	15.52 ± 4.02

Table 3 summarizes the correlation between pelvic tilt and trunk control of the stroke subjects. The correlation between the pelvic tilt and trunk control in the stroke subjects showed a negative correlation which indicates that a change in the pelvic alignment which affects the trunk control. Pelvic tilt values negatively correlated with all the individual trunk impairment scores with p value = 0.00.

Table 3: Correlation between pelvic tilt (P T) and trunk control (TIS).

P T vs TIS sub scores	Pearson's Correlation	*p* value
Static	-.605**	.00
Dynamic	-.605**	.00
Coordination	-.542**	.00
Total	-.602**	.00

** = correlation is highly statistically significant, $p<0.00$

Table 4: Associations between the individual TIS sub scores with Brunnstrom's Stage of Recovery of the Lower Limb (BSRLL).

Variables	Chi Square	*p*-value
Pelvic tilt vs BSR LL	33.461*	0.030
TIS static vs BSR LL	35.752*	0.016
TIS dynamic vs BSR LL	35.752*	0.016
TIS coordination vs BSR LL	34.568-	0.075

*significant $p<0.05$

Table 4 summarizes associations between the individual TIS sub scores of Brunnstrom's Stage of recovery of the Lower Limb which demonstrated significant association, except for the coordination sub score of the TIS.

Table 5: Correlation between the Pelvic Tilt and TIS in different durations post stroke.

Duration	Variables	n	*r*	*p*
Acute	PT vs TIS	20	-.741**	.000
Sub-Acute	PT vs TIS	8	-.183	.664
Chronic	PT vs TIS	10	-.269	.452

** = correlation is highly statistically significant, $p<0.001$

Table 5 summarizes the correlation between the Pelvic Tilt and TIS in different durations post stroke which showed a significant correlation in the acute stage of stroke with the p value<0.00.

DISCUSSION

The primary aim of this study was to examine the relationship between pelvic alignment and trunk control and the secondary aim was to determine the association between the Pelvic Tilt, sub scores of TIS with the Brunnstrom's Stage of Recovery of the Lower Limb as well as the relationship between pelvic tilt and trunk control in the different stages of stroke.

A stroke results in bilateral weakness of the abdominal muscles. Furthermore, this weakness is found to be more pronounced on the affected side[6-9] In the sitting position, this abdominal weakness accounts for the of line of gravity being placed relatively posterior to the centre of gravity, leading to an increased tendency to fall backwards. As a result, stroke subjects usually compensate by sitting with a flexed thoracic spine, to place the line of gravity comparatively anterior to the centre of gravity. When the spine is flexed with an exaggerated thoracic kyphosis, the pelvis will passively move into a posterior pelvic tilt leading to an approximation of the origin and insertion of abdominal muscles, especially the oblique muscles which further leads to their asymmetric weakness.[18-20]

Ideal sitting includes a neutral lumbar lordosis, increased anterior pelvic tilt, with the ASIS of both sides being at the same level.[21] This requires an efficient stabilizing system of the spine, which is divided into three subsystems: a passive (osteo-ligamentous system), an active (musculo-tendinous system), and a neural control system. A stroke causes an impairment of the latter two systems which leads to an altered alignment resulting in disturbed postural symmetry.[22] majority of stroke subjects sit with more weight bearing on the unaffected side, and thus causes a compensatory lateral flexion with convexity towards the affected side. Thereby elevating the pelvis on the unaffected side.[23] A recent posturographic analysis also reported that stroke patients tend not to move the

center of the body to the paretic side while in the sitting position.[24]

In previous studies it has been stated that the weakness of the trunk muscles leads to impaired trunk control in stroke subjects.[15, 22] Electromyographic analysis of the trunk muscles has shown that the external oblique muscle is responsible for fixing the position of the pelvis during dynamic activities.[25] Hence it can be assumed that an abnormal trunk control could lead to a deviation in the pelvic alignment from the neutral position which is one of the findings of the present study. This is consistent with the finding of the present study in which a significant negative correlation existed between the pelvic tilt and trunk control, i.e. when pelvic asymmetry increases trunk control decreases (r= - 0.62, p = 0.00).

When the pelvic tilt is correlated with the Brunnstrom's Stage of recovery of the lower limb it also shows a significant association ($p<0.05$).According to a previous study, patients with the most impaired legs presented with the greatest amount of lateral displacement and asymmetry of the pelvis.[26] Trunk control when associated with the Brunnstrom's Stage of Recovery of the Lower Limb showed significant associations with the static and dynamic sub-scores of the Trunk Impairment Scale except with the coordination sub score ($p<0.05$).Lower extremity movement is dependent on the proximal stability of the trunk. Therefore, in order to achieve the recovery of the skilled functional tasks of the lower extremity, it is paramount to addressing trunk stability. Hence the trunk forms a central key point in the rehabilitation of the stroke patients.[15, 26, 27]

When the pelvic tilt is correlated with trunk control across the various stages of stroke, a significant correlation is observed in the acute stage of stroke(r =-.741, p=0.00).Previously carried out study emphasizes that the time course required by the trunk for recovery is the same as the arms and legs. The most striking improvement in motor recovery was from one week to one month and also a significant improvement was observed in one month to three months following stroke.[28] this may attribute to our findings that significant association between the pelvic tilt and trunk impairment score was found in the acute stage post stroke.

This study has several limitations which includes stratification of subjects according to the duration and motor recovery of the lower limb might have increased the sample size and power of the study, sagittal and transverse pelvic alignments with respect to trunk control and also correlating pelvic tilt with sitting, standing balance and measures assessing gait were not analyzed in this study.

Clinical Implications

The result of the current study indicates that the assessment of the pelvic alignment should be incorporated as a part of routine clinical examination of trunk control following stroke.

CONCLUSION

The trunk along with the pelvis when optimally aligned is responsible for appropriate activation of the trunk muscles and this translates into the maintenance of a good trunk control. Thus pelvic alignment influences the trunk control and is also available to be associated significantly with the acute phase of stroke. The lower limb Brunnstrom's stage of motor recovery is associated significantly with the static and dynamic sub scores of the TIS.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Mishra NK, Khadilkar SV. Stroke Programme of India. Ann Indian Acad Neurol 2010; 13: 28–32.
2. Banerjee T, Kumar S. Epidemiology of stroke in India. Neurology Asia 2006; 11:1-4.
3. Ryerson S, Byl NN, Brown DA, Brown D, Wong R and Hidler J. Altered trunk position sense and its relation to balance functions in people post-stroke. J Neurol PhysTher 2008; 32: 14–20.
4. Verheyden G, Niewbouer A, Vereeck L ,Steven T, Mark T, Herregodts,et al. Trunk Performance After Stroke And Its Relationship With Balance, Gait And Functional Activity. Clin Rehabil 2006; 20:451-8.
5. Hsieh CL, Sheu CF, Hsueh IP, Wang CH. Trunk control as an early predictor of comprehensive activities of daily living function in stroke patients. Stroke 2002; 33: 2626-30.
6. Bohannon RW. Lateral trunk flexion strength: impairment, measurement reliability and implications following unilateral brain lesion. Int J Rehabil Res 1992; 15: 249-51.
7. Tanaka S, Hachisuka K, Ogata H. Trunk rotatory muscle performance in post-stroke hemiplegic patients. Am J Phys Med Rehabil 1997; 76:366-9.
8. Tanaka S, Hachisuka K, Ogata H. Muscle strength of trunk flexion-extension in post-stroke hemiplegic patients. Am J Phys Med Rehabil 1998; 77:288-90.
9. Messier S, Bourbonnains D, Desrosiers J, Roy Y. Dynamic Analysis of Trunk Flexion after Stroke. Arch Phys Med Rehabil 2004; 85(10):1619-24.
10. Ryerson Sd. Movement Dysfunction Associated with Hemiplegia. Umphred's Neurological Rehabilitation 6th edition USA, Mosby Elsevier; 2007 p.626-27.
11. Tyson SF. Trunk kinematics in hemiparetic gait and the effect of walking aids. Clin Rehabil 1999; 13:295-300.
12. Vrtovec T, Janssen MMA, Likar B, Castelein R, Viergever M and Pernus F. A review of methods for

evaluating the quantitative parameters of sagittal pelvic alignment. The Spine 2012; 12(5):433-46.
13. Petrone MR, Guinn J, et al. The Accuracy Of The Palpation Meter(PALM) For Measuring Pelvic Crest Height Difference And Leg Length Discrepancy. J Orthop Sports Phys Ther 2003; 33:319-25.
14. Hagins, Marshall Brown, Martha Cook, Clare Gstalder, Karen Kam, Michael Kominer, Gene Strimbeck, Katesel.Intratester and Intratester Reliability of The Palpation Meter (PALM) In Measuring Pelvic Position. J. Man Manip Ther 1998; 6 (3):130-36.
15. Davies PM. Right in the Middle. Selective Trunk Activity in the treatment of Adult Hemiplegia, India: Springer (India) Private Limited; 2003 p34-35.
16. Verheyden G., Niewbouer A., Ann Van De Winckel, Willy De Weerdt. Clinical Tools to Measure Trunk Performance after Stroke: A Systematic Review of Literature. Clin Rehabil 2007; 21:387-94.
17. Verheyden G., Niewbouer A., Mertin J. ,Peger E, Kiekens C. TheTrunk Impairment Scale: A New Tool To Measure Motor Impairment Of The Trunk After Stroke. Clin Rehabil 2004; 18:326-34.
18. Yahia Zakaria, Usama Rashad. Assessment of Malalignment of Trunk and Pelvis in Stroke Patients.Egypt J Neurol Psychiat Neurosurg 2010; 47 (4): 599-604.
19. Verheyden G, Van Duijuhoven, Burnett M, Littlewood J, Kunkel D, Ashburn AM. Kinematic Analysis of Head, Trunk and Pelvis Movement With People Early After Stroke Reach Sideways. Neuro rehabil Neural Repair 2011; 7: 656-63.
20. Lee D. The Pelvic Girdle. Edinburgh: Churchill Livingstone; 1989.p86-90.
21. Preuss RA, Grenier SG, McGill SM. Postural control of the lumbar spine in unstable sitting. Arch Phys Med Rehabil. 2005; 86: 2309-15.
22. Hun SY, Doo SP. The effects of core stability strength exercise on muscle activity and trunk impairment scale in stroke patients. J Exerc Rehabil 2013; 9(3):362-67.
23. Feigin L, Sharon B, Czaczkes B, Rosin AJ. Sitting equilibrium 2 weeks after a stroke can predict the walking ability after 6 months. Gerontology 1996; 42:348-53.
24. Isle JW, Nienhus B, Latour H, Geurts A. Posturographic assessment of sitting balance recovery in sub-acute phase of stroke. Gait Posture 2008; 28: 507-12.
25. Bujanda DE., Sylvie N., Daniel B., Dickstein Ruth. Associations between lower limb impairments, locomotor capacities and kinematic variables in the frontal plane during walking in adults with chronic stroke. J Rehabil Med 2003; 35: 259–64.
26. Karthikbabu S., Nayak Akshatha., K Vijayakumar., Misri Z K., BV Suresh., Ganesan Sailaxmi., Joshua Abraham M. Comparison of physio ball and plinth trunk exercises regimens on trunk control and functional balance in patients with acute stroke: a pilot randomized controlled trial. Clin Rehabil 2011; 25(8): 709–719.
27. Ryerson S and Levit K. Functional movement: A practical model for treatment. Functional movement reeducation: a contemporary model for stroke rehabilitation.Edinburgh: Churchill Livingstone, 1997, pp.1–14.
28. Verheyden G, Nieuwboer A.,Wit L, Thijs V, Dobbelaere J., Devos H., Severijns D. Time Course of Trunk, Arm, Leg, and Functional Recovery After Ischemic Stroke. Neurorehabil Neural Repair 2008; 22:173-9.

DOI: 10.5455/2320-6012.ijrms20141144
Cite this article as: Pathak S, Vijaya Kumar K, Nayak A, Kedambadi RC. The relationship between pelvic alignment and trunk control in stroke subjects: a cross-sectional study. Int J Res Med Sci 2014;2:1483-7.