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Original article

Intra-rater and inter-rater reliability of measuring pelvic tilt using the palpation meter (PALM™) device in stroke

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ABSTRACT

Introduction: Palpation meter (PALM™) device was tested for its reliability to measure the pelvic tilt in musculoskeletal related dysfunctions, but not in stroke. The aim of this study is to find the intra and inter rater reliabilities of the PALM™ device and quantify the pelvic tilt in patients with stroke. Sixty four patients post stroke and age matched 64 healthy individuals participated in the study. **Materials and Methods:** Sagittal and coronal planar pelvic positions were measured in standing using PALM™ device by two raters blinded for the values at different time point on same day. **Results:** The mean anterior pelvic tilt (APT) was 5.5 degrees on the most affected side and 5.4 degrees on the least affected side and lateral pelvic tilt (LPT) was 3.03 degrees towards most affected side. The intra-rater reliability (r value) of LPT and APT towards the most and least affected sides was 0.76, 0.91 and 0.90, respectively. The inter-rater reliability was ranging between 0.47-0.80 for the LPT and 0.80-0.92 for the APT. **Conclusion:** PALM™ device provided excellent inter and intra-rater reliability for sagittal planar pelvic tilt and good intra and inter-rater reliability for coronal planar pelvic tilt in stroke. Clinicians can use PALM™ device to find the treatment efficacy of pelvic control training for patients post stroke.

KEYWORDS: Intra-rater and inter-rater reliability, pelvic tilt, palpation meter (PALM™), stroke.

INTRODUCTION

The primary role of the pelvis is to support the weight of the upper body and transfer it onto the lower extremities. Lower trunk and hip muscular control provide the dynamic stability and allow the three dimensional pelvic movement for lower extremity functional tasks.[1-4] Weakness of the abdominal muscles and the gluteal maximus muscle leads to an anterior tilt of the pelvis which might cause the knee to hyperextend during gait.[5] Weakness of the hip abductors causes a lateral pelvic drop to the contralateral side while in standing and walking.[6] In patients post stroke, the trunk movements during a forward reach task in sitting are executed by the upper trunk and very little anterior pelvic tilt occurs due to poor lower trunk control.[7] Poor co-activation of the trunk limits the pelvis to dissociate from the trunk and lower extremities in standing and walking.[8] Tyson had shown that the lateral displacement of the pelvis during gait in patients post stroke was large and orientated more over the sound side due to poor control of the hip abductors. Vertical displacement and increased anterior pelvic tilt on the most affected side could possibly due to weak hip extensor and poor lower trunk control respectively.[9]

In patients post stroke, an asymmetry is observed in standing and walking as they find it difficult to accept weight bearing on the most involved leg.[10] Inactivity of the hip abductors to work as pelvic stabilizers might be the possible explanation for this.[11] They also present with greater excursion of the pelvis compared to healthy subjects at similar walking speeds.[12] This atypical muscle activation specifically at the pelvis is a characteristic feature of walking post stroke and is a prominent and underappreciated feature.[13] Lennon[14] identified that pelvic reeducation resulted in decreased anterior pelvic tilt with better knee extension during stance and a more normal ankle pattern during swing phase emphasizing the importance of pelvic control and weight shift capacity towards the most affected side. So, it becomes necessary to measure this pelvic asymmetry accurately.

Various methods to measure pelvic tilt such as depth or bowleg calipers [15,16] and Iowa Anatomical Position System (IAPS)[17] were used in the past. The limitations are that they are difficult to perform and required trigonometric calculations. Radiographs can be used but the potential harm, cost and inaccessibility of this method to clinicians are few of the drawbacks.[15] Visual observation of assessing the pelvic tilt was previously suggested.[18]

The pelvic sensors used in most recent studies were neither cost effective nor portable.[19,20] The PALM^{TM} device is a portable, convenient to use device which combines the features of a caliper and an inclinometer. It was earlier tested for its reliability to measure the pelvic tilt in musculoskeletal related dysfunctions.[21] In asymptomatic individuals, the inter-rater and the intra-rater reliability (r value) of PALM^{TM} were 0.65 and 0.84 points in the frontal plane and 0.89 and 0.98 points in the sagittal plane.[22] Although the PALM^{TM} device appears to provide a potentially reliable measure of pelvic inclination in pelvic dysfunction, the degree of pelvic malalignment is yet to be described in patients post stroke. This study attempted to test the intra and inter-rater reliability of the PALM^{TM} device and to quantify the pelvic tilt in patients with stroke.

MATERIALS AND METHODS

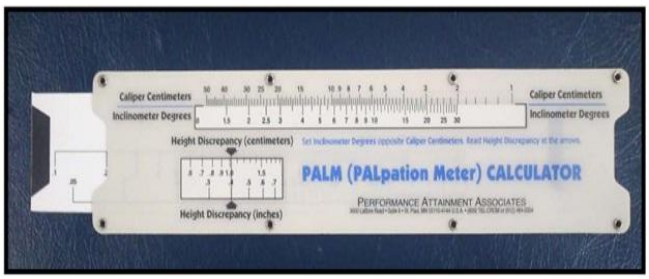
The study protocol was approved by the ethics and research committees of the SOAHS, Manipal University, India. The purpose of the study was explained to the participants and they were screened for the inclusion criteria. Inclusion criteria are as follows: Patients with ischemic or hemorrhagic stroke; both gender aged between 25 and 85 years; MMSE score of at least 25 out of a possible 30 points; standing ability without any assistive device; score 21 or less out of 23 on Trunk Impairment Scale (TIS); Brunnstrom recovery stage above 3; and more than 20% body weight asymmetry. The body weight asymmetry i.e. the ration of weight borne on the most and least affected limbs was calculated using two weighing scales.

Patients were excluded from the study if they had a history of associated balance dysfunction resulting from Parkinson's disease, Vertigo or Cerebellar disease; recent lower limb fractures, surgeries within 6 months of duration and restricted hip, knee and ankle terminal range of motion due to contractures. A written informed consent was obtained from them stating that their participation in the study was voluntary. Two qualified physiotherapists took the measures to test the intra rater reliability and the inter rater reliability.

All patients were measured for the pelvic tilt with PALM^{TM} device. It is a pelvic leveling device that combines the features of a caliper and an inclinometer. It combines the ease and proprioceptive advantages of palpation with the objectivity and reliability of caliper and inclinometer measurements. The caliper determines the distance in centimeters between the two palpating fingers. The bubble inclinometer determines the inclination in degree between the two palpating fingers. The gradations ranged from 0 degree to 30 degree on either side of the midline. PALM^{TM} calculator gives the height discrepancy between the two landmarks palpated in centimeters (Figure-1& 2).

Figure 1: Palmation meter (PALM^{TM}) device

Figure 2: PALM^{TM} Calculator



Prior to the patient's arrival, two pieces of tape spaced 30 cm apart were placed on the floor. The tape strips marked the location on the floor where they positioned their feet for measurements with the PALM^{TM} device. They were given instructions to stand as erect as possible without bending the ankles, knees, hips, or spine and were told to look at a fixed point ahead of them. They were asked to support the weak arm by using the strong arm. For measuring the anterior – posterior tilt, the anterior superior iliac spine (ASIS) and posterior superior iliac spine (PSIS) were palpated directly on the skin.

The ASIS was palpated by bringing the thumbs from inferior to superior and then on the most prominent protrusion of the ASIS and was marked using a marker. The PSIS was then palpated and marked by tracing the iliac crest posteriorly and then moving the thumbs superiorly and laterally from the sacrum edge to the most prominent protrusion and was marked as well. Once palpated, the caliper tips established position over the marked landmarks with the physiotherapist standing at the side of the patient and were compressed to a firm resistance as suggested. The patient was asked to take a deep breath, exhale and to wait to inhale again until after the measurement is taken. This gave the degree of an anterior or posterior pelvic tilt (Figure-3).

Figure 3: Measurement of anterior pelvic tilt using PALM™ device

Figure 4: Measurement of lateral pelvic tilt using PALM™ device

Standing behind the patient, the most superior aspect of the iliac crests was palpated and marked to measure lateral pelvic drop. The PALM™ calipers were placed over the marked area and the patient was instructed to take a deep breath, exhale, and to wait to inhale again until after the measurement is taken. The distance between caliper heads were read to the nearest centimeter, while the angle of inclination was read to the nearest degree. It was used to convert the inclinometer and caliper values to a corresponding pelvic obliquity value in centimeters. The markings of the skin were cleaned before the next measurement was taken. A log book was given to read in between measurements which consisted of various pelvic tilt readings of other subjects, and was asked to read aloud to prevent immediate memory recall of the readings which could have led to bias while measuring the second reading.

For the inter-rater reliability, readings taken by two independent raters were considered. The first rater took a single measurement of the tilt in degree and centimeter followed by the second rater. A second reading was taken again by the first and second raters respectively who were masked to each other's readings. Similarly, for intra-rater reliability, a single rater took two readings at different time points and readings were measured in degree and centimeter.

Statistical Analysis: Data was analyzed using SPSS version 16.0. Normality of the data was tested using Kolmogorov - Smirnov test. Mean (standard deviation) and standard error of mean were analyzed to report the demographic data. The intra-rater and inter-rater reliability were reported through the intra-class correlation coefficient (ICC).

RESULTS

This study enrolled 64 patients post stroke with a mean age of 54.9 years and mean post stroke duration of 29.2 months. Among them, 37 were men and 27 were women. Sixty nine percent of the patients had an ischemic stroke and 31% had a hemorrhagic stroke. Twenty five patients had most weakness on the right side and 39 patients had paresis on the left side. They showed 38.6% mean body weight on the most affected side. The demographic data of them are shown in Table-1. The intra-rater reliability was analyzed for the anterior pelvic tilt on most and least affected sides along with that of the lateral pelvic tilt. The ICC values for the anterior pelvic tilting on the most and least affected sides of the first rater were 0.9 and 0.9 and that of the lateral tilt was 0.8. Second investigator rated the same with ICCs of 0.9, 0.9 and 0.7 respectively. The correlation coefficients were interpreted as follows: below 0.50 was poor, 0.50 to 0.75 was good, and above 0.75 was excellent (Table-2).

Table 1: Demographic characteristics of patients post stroke (N=64)

Measures	Mean ± SD	SEM
Age (months)	54.6±14.5	1.85
BMI (kg/m^2)	24.4±3.5	0.44
Weight asymmetry(%)	38.6±8.1	1.01
Trunk Impairment Scale (Max score 23)	16.8±2.4	0.30
Tinetti balance(max score16)	12.1±3.1	0.39
Tinetti gait (max score 12)	6.9±2.1	0.25

Mean ±SD= Mean ± Standard deviation; SEM=Standard error of measurement

Table 2: Intra-raterandinter-rater reliability of PALM™ device

Pelvic tilt	Intra-rater reliability		Pelvic tilt	Inter-rater reliability	
	ICC r value	95% CI (lower-upper)		ICC r value	95% CI (lower-upper)
APT-MAS R1	0.91	0.85 - 0.94	APT-MAS R1&2*	0.90	0.83 - 0.94
APT-MAS R2	0.90	0.84 - 0.94	APT-MAS R1&2^	0.88	0.80 - 0.92
APT-LAS R1	0.90	0.84 - 0.94	APT-LAS R1&2*	0.92	0.88 - 0.95
APT-LAS R2	0.90	0.83 - 0.94	APT-LAS R1&2^	0.91	0.85 - 0.94
LPT-MAS R1	0.80	0.68 - 0.88	LPT-MAS R1&2*	0.64	0.30 - 0.80
LPT-MAS R2	0.76	0.61 - 0.85	LPT-MAS R1&2^	0.67	0.47 - 0.80

Pelvic obliquity values in centimeter measured by the PALM ™ device were considered. APT-MAS=Anterior pelvic tilt on most affected side; APT-LAS=Anterior pelvic tilt on least affected side; LPT-MAS: Lateral pelvic tilt on most affected Side; R1=1st rater; R2=2nd rater; *1st readings; ^2nd readings; ICC=Interclass Correlation Coefficient; CI=Confident Interval; Range considered below 0.50 was poor, 0.50 to 0.75 was good and above 0.75 was excellent.

DISCUSSION

The aim of the study was to test the intra-rater and inter-rater reliability of measuring pelvic tilt using PALM™ device in stroke. The intra class correlation coefficient suggests that the intra rater and inter-rater reliability were excellent for sagittal and frontal plane measures i.e. anterior pelvic tilt and lateral pelvic tilt except moderate inter-rater reliability for lateral pelvic tilt. The methodology was adapted from Petrone et al [21]and Herrington et al [23] who performed the limb length discrepancy. In this study, we performed in a way that is suitable to the patients post stroke. As it was difficult to stand with a narrow base of support after stroke, a distance of 30 centimeter was kept between the feet. Hagins et al[22] reported the inter-rater reliability (ICC) of 0.65 in the frontal plane and 0.89 in the sagittal plane, and intra-rater reliability coefficients of 0.84 in the frontal plane and 0.98 in the sagittal plane in asymptomatic subjects. These values were similar to the readings obtained in this study. Thus the PALM™ device was a reliable tool in measuring the pelvic tilt in stroke.

All the patients presented with an anterior pelvic tilt on the most and least affected sides. We found that the mean anterior pelvic tilt on the most and least affected sides was 5.5 and 5.4 degree. This was probably because of the weakness of the bilateral abdominal muscles resulting excessive anterior pelvic tilt.[5] Tanaka et al[24] identified that the weakness of trunk flexion-extension muscles and trunk rotators in stroke might be accounted for the bilateral innervations from the motor cortex, the insufficient use of high threshold motor units and disuse atrophy. Weakness of gluteus maximus could result in excessive anterior pelvic tilt on the most affected side which further leads to an anterior rotation of the pelvis on the least affected side since the pelvis moves as a single unit.[25] In this study, the pelvic tilt was measured in 64 aged matched asymptomatic individuals to find out how much the pelvic tilt differs in patients post stroke. The mean pelvic tilt on the dominant side was 3.0 degree and on the non-dominant side was 2.9 degrees and a mean lateral tilt was 0.8 degree.

Lateral pelvic tilt of 3.03 degree on the most affected side could be due to the tendency of bearing more weight towards the least affected side and allowing a pelvic drop on the most affected side. One of the major causes of asymmetric weight shifting during gait is the lack of activation of hip abductors to work as pelvic stabilizers.[11] The weight bearing asymmetry showed 38% and 62% mean body weight on the most and least affected sides. This is in agreement with Genthonet al[10] who estimated 63% body weight borne on the least affected foot in patients with stroke using force platform. The insufficient co-activation of the abdominal muscles and the gluteus maximus muscle shall allow the more lateral pelvic drop. In addition, lateral reaching towards least affected side showed a different pelvis-trunk-head pattern in stroke compared to normal individuals and they had a limited reach with slower speed.[26]

In clinical assessment, we not only observe a poor co-activation of proximal musculature, the distal muscular spasticity and tightness may also alter pelvic orientation in standing and walking. Patients with severe plantar flexor tightness and poor intra-limb dissociation shall hike the pelvis and circumduct the lower extremity while in walking. These factors were not considered separately for analysis. Additionally, not measuring the pelvic tilt during dynamic sitting and standing movements might be accounted as a limitation of the study and can be considered for future research. Furthermore, the validity is yet to be established and future studies are recommended to validate this tool with radiographic findings.

CONCLUSION

The PALM™ device showed excellent inter and intra-rater reliability for sagittal planar pelvic tilt and good intra and inter-rater reliability for coronal planar pelvic tilt in stroke.

Clinical implications: Clinicians can use PALM™ device in future to find the treatment efficacy of pelvic control training for individuals post stroke.

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