ISSN(Online) : 2319-8753
ISSN (Print) : 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

Intertester and Intratester Reliability and Validity of Measures of Innominate Bone Inclination in Standing Using PELVIN®TM

Dr.Shivani Chowdhury Salian (PT) [1], Dr. Sujata Yardi[2]

Professor and Head, Department of Electrotherapy and Electrodiagnosis, School of Physiotherapy, D.Y.Patil University, Nerul, Navi Mumbai, India.

Professor & Ex- Director, Department of Physiotherapy, Pad.Dr.D.Y.Patil University Nerul, Navi Mumbai, India.

ABSTRACT: Determination of innominate bone inclination in standing is frequently assessed in postural analysis of subjects. Currently, no goniometer for objective assessment of innominate bone inclination in standing is commercially available in India. The purpose of this study is to determine the intra-tester and inter-tester reliability and validity of measures taken with a pelvic inclinometer designed indigenously. This study was conducted to determine the intra-tester and inter-tester reliability and validity of measures taken with a pelvic inclinometer designed indigenously. Pelvic Inclination Angle was measured bilaterally using X-ray and Clinical methods. The intraclass correlation coefficient (KC) for repeated measures of the pelvic inclinometer fixed to a mechanical stand was 0.99. The intertester reliability of using the pelvic inclinometer to determine inclination was ICC = 0.99. In measures of 90 subjects by two testers, the Cronbach's Alpha for intertester reliability was 0.99 and the lCCs for intratester measures was 0.99.

Measures by the inclinometer had a high degree of reliability compared with the criterion x-ray measure, ICC= 0.99. Pelvic inclination angle recorded by Pelvin®TM which is indigenously designed pelvic inclinometer is highly reliable and valid to use clinically. Measurement of the inclination of both left and right innominate bones of a subject required only 2 minutes, indicating clinical applicability.

KEYWORDS: Physiotherapists, PELVIN®TM, Pelvic inclination angle, X-ray, reliability, validity.

I. INTRODUCTION

Physical therapists routinely assess relaxed standing posture to help identify possible problems with the spine or peripheral joints. For example, if a patient stood with an exaggerated lumbar lordosis, various authors (1– 4) suggested that the patient's abdominal muscles were weak and elongated, whereas the erector muscles of the spine and the hip flexor muscles were supposed to be shortened. An assumption is often made by physiotherapists and others is the degree of pelvic inclination in a standing position while examination of patients presenting with lumbar spine problems. The angle of pelvic tilt in quiet standing describes the orientation of the pelvis in the sagittal plane. It is determined by the muscular and ligamentous forces that act between the pelvis and adjacent segments. A forward rotation of the pelvis, referred to as anterior pelvic tilt, is accompanied by an increase in lumbar lordosis (5) and is believed to be associated with a number of common musculoskeletal conditions, including low back pain 6 and anterior cruciate ligament deficiency (7,8) . In addition, anterior pelvic tilt has been associated with a loss of core stability, and therefore the degree of pelvic tilt has been used to assess core strength (9).

ISSN(Online) : 2319-8753
ISSN (Print) : 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

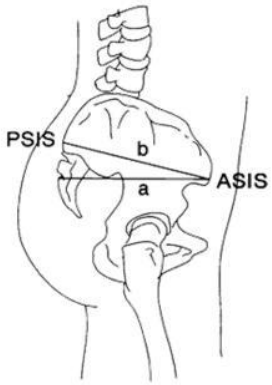


FIGURE 1: Schematic diagram of the pelvis. The pelvic inclination angle is defined as the angle between the horizontal and a line drawn between the ASIS and the PSIS.

A standard method of assessing the angle of pelvic tilt is depicted in Figure 1, which illustrates the angle between the horizontal and a line drawn from the anterior superior iliac spine (ASIS) to the posterior superior iliac spine (PSIS) 10. Although this angle is dependent on the muscular and ligamentous forces that act between the pelvis and adjacent segments, it is also dependent on the relative position of the two bony landmarks (ASIS and PSIS) on the innominate bone.

Using valid, reliable, safe, portable and low price measurement tools is necessary in clinical evaluation. Use of registered medical equipments not only ensures safety but also efficiency of the examination tool to be used as diagnostic equipments in physiotherapy clinics. Use of a pelvic inclinometer clinically to measure pelvic inclination angles is a non-invasive, quick, user-friendly and harmless method. This tool was used in various studies done in different countries by several researchers. However, the unavailability of indigenously designed equipment in our country restricted the Indian physiotherapist in complete clinical evaluation of patients.

For the last 50 years, standing full spine frontal and lateral roentgenograms (X-rays) have been used by many clinicians for not only evaluation of posture, but also for demonstration of mal-positions of joints and pathological information 11,12. There is some controversy in literature as to the reliability of these practices. The problems reported till date are associated to distortional factors, amount of exposure required and reliability of detecting pathologic problems on a large X-ray.

Roentgenometrics is an accepted part of medical radiology expertise. However, because Physiotherapists deal with biomechanical faults, the object of roentgenometric analysis is to create is to correlate millimetre differences with clinical findings. Physiotherapists rae justified in arguing that due to the distortion inherent in such a large X-ray, the standard deviation of error is greater than the measured degree of asymmetry observed clinically. Also referring patients for X-ray analysis demands the patient consent and ethical clearance for a physiotherapist to do so on first hand practice

Mane et al in an unpublished study accepted as valid the conclusions of Schram, Hosek and Silverman and devised an experiment to assess the relationship between roentgenographic measurement of sagittal plane mal-alignments and bilateral clinical, physical measurement of pelvic tilt using an inclinometer. Their result indicated 85% correlation between X-ray and clinical measurements. Hence we designed an indigenous Pelvic inclinometer and subjected it to reliability and validity test.

ISSN(Online) : 2319-8753
ISSN (Print) : 2347-6710

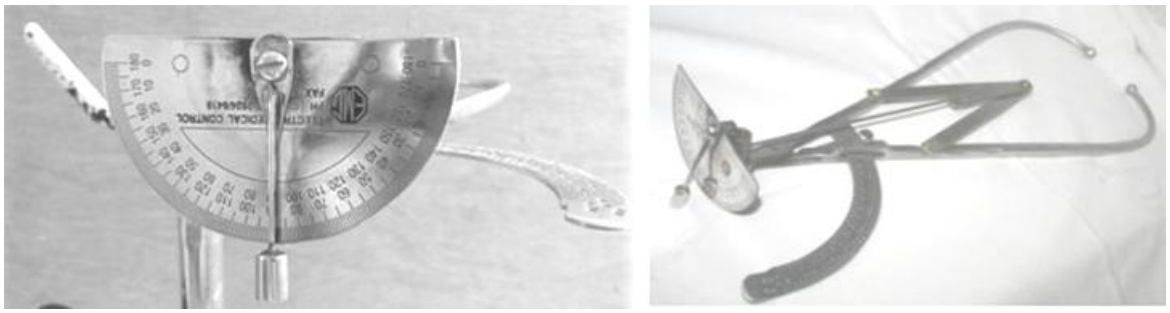
International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

Figure 2: Martin's Pelvimeter used to measure fundus height in Obstetrics

In the present study we have devised a similar method of measuring pelvic tilts by means of an inclinometer designed indigenously. This instrument (Figs. 2 and 3) is made using a Sklar Martin Pelvimeter. Pelvimetry used to be performed routinely to discern if spontaneous labour was medically advisable. Women whose pelvises were deemed too small received caesarean sections instead of birthing naturally. To the pelvimeter ball points, a small pendulum, and a stainless steel protractor measuring from 0 degree to 180 degrees. The rod, upon which the protractor and pendulum are mounted, slides through the friction post and continually bisects the space between the arms of the calipers. Thus, the plane of the surface of the protractor always is parallel to a line that connects the tips of the calipers. Pelvic tilt is defined as the angle between the horizontal plane and line passing through the midpoint of the posterior superior iliac spine and midpoint of anterior superior iliac spine. It is usually measured using pelvic inclinometer. Such inclinometer was designed in our lab at the School of Physiotherapy, D.Y.Patil University, Nerul, Navi Mumbai. We registered the design with the Patents office of India



(a) (b)

Figure 2: Design of the Pelvin (a) protractor and the pendulum recording the angles. (b) Pelvimeter.

(Design Reg no: 234648) and trademarked the name PELVIN (Trademark no: 2102140) for the same.

II. METHOD OF CLINICAL MEASUREMENT OF PELVIC INCLINATION ANGLE

The examiner applies one tip of the calipers to the antenor-superior iliac spine (ASIS) of one of the subject's ilia; he applies the other tip to the posterior-superior spine (PSIS) of the same ilium; and, finally, he brings the closed end of the calipers to a position such that the pendulum hangs free over the protractor. In this position, the plane of the protractor is perpendicular to the floor and the therapist can thus measure the angle of inclination of that ilium from the protractor scale.

Pelvic symmetry is often evaluated as part of the examination for postural deviations and leg length discrepancies (13,14,15,16,17). The credibility of postural assessments has been hampered by the fact that many clinical tests/measures for assessing pelvic asymmetry have been shown to lack precision, or the methods are unreliable

ISSN(Online) : 2319-8753
ISSN (Print) : 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

(18,19). Given these facts, an instrument and method that yields precise and reliable measures of innominate bone inclination would enhance credibility for physical therapists as they evaluate and treat problems involving pelvic tilt angle or asymmetrical innominate bone inclination. Such a method would yield a determination of pelvic asymmetry by comparing measures of inclination of both innominate bones.

Since 1936, clinicians have attempted to measure inclination of the pelvis by developing instruments that are sufficiently precise and methods that are sufficiently reliable to meet their need to document clinical theories (20,21,22,23). Precision of instruments to measure innominate bone inclination is important because of the relatively small amount of excursion of the pelvis as a whole and the even smaller movement available between the two innominate bones. Alviso et al reported ranges of total pelvic tilt between 10.9 and 17.1^{o} (24). Gajdosik et al reported a total range of motion of 10.9 1 to 2 1.74^{o} for pelvic tilt (25). Precision is critical to measure asymmetrically inclined innominate bones which may differ, in position only from 1 to 11^{o} (22, 26) or a few mm (19, 27, 28, 29,30). This excursion becomes even smaller after the third decade of life (31,32). It is clear, therefore, that clinical measures must achieve very small ranges of variability to detect changes in innominate bone inclination associated with dysfunction or in response to treatment.

Radiographic studies are generally accepted as providing the most accurate data on innominate bone inclination, but this method is generally regarded as "expensive and potentially harmful" (25). Repeated radiographic studies are not feasible for ongoing clinical assessments of treatment effects.

Most visual and palpatory assessment methods, although widely used by physical therapists, are supported by little objective and verifiable data (15). Visual assessment of ASIS, PSIS and crest height used in combination were found acceptable to detect qualitative but not quantitative pelvic asymmetry (19). Potter and Rothstein demonstrated that testers agreed on ASIS and PSIS levels only 3.538% of the time (18).

A goniometric device for measuring innominate bone inclination was first introduced in 1936 (22) and variations have since been reported (33,34, 35).

The purpose of this study was to determine whether a method of measurement including an indigenously designed inclinometer would provide valid and reliable measures of innominate inclination with a clinically acceptable degree of precision. To achieve this, we had to minimize sources of variation in measurement due to differences between subjects and changes in position of the subject between measures. Specifically, we determined the intratester and intertester reliability and concurrent validity for our method of measurement of pelvic inclination using PELVIN

III. OBJECTIVES

To determine the intra-tester and inter-tester reliability and validity of measures taken with a pelvic inclinometer designed indigenously.

IV. MATERIALS & METHODOLOGY

(Figure 4) An indigenously designed Pelvic inclinometer named Pelvin, fixed to stand, and marker pens. All the subjects were explained the purpose of the study through an information sheet which delineated both the benefits and the risks involved in the experimental study. A signed consent form was also procured prior to enrolling the subjects in the experiment. The Ethics Committee of D.Y.Patil University granted the permission to carry out the research subject in collaboration with the Department of Radiology of D.Y.Patil Hospital and Research Centre, Nerul, Navi Mumbai. For radiological measurements: digital images (soft copy) of lateral view of pelvis in weight bearing position. Computer based Autocad software for measuring pelvic inclination angle on the X-ray. 90 asymptomatic subjects (30 in each group) were selected randomly and grouped in three homogeneous groups, viz; Group I: 21-35 years of age, Group II: 36-50 years of age, Group III: 51-65 years of age.

ISSN(Online) : 2319-8753
ISSN (Print) : 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

All the subjects underwent X-ray to measure pelvic inclination angles of Rt. and Lt. innominate bones in the standing posture. Pelvic inclination angle of Rt. And Lt. innominate bone was also measured clinically using the indigenously designed Pelvic inclinometer.

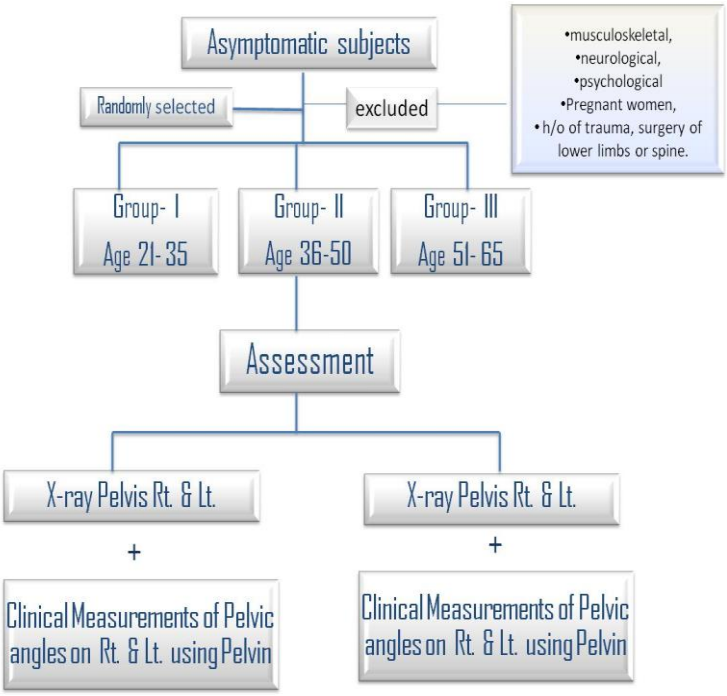


Figure 4: Flowchart showing the methodology of the experiment

The pelvic inclinometer was clamped to a stand. The angle was recorded three times for each of the subjects. Reliability of measures with the inclinometer was established by two therapists in outpatient orthopaedic practice. A recording assistant was used for blind data collection. The next testers followed the above procedure.

V. OUTCOME MEASURES

Pelvic Inclination Angle measured bilaterally via X-ray and Clinically using Pelvic inclinometer

VI. METHOD OF MEAUSUREMENT

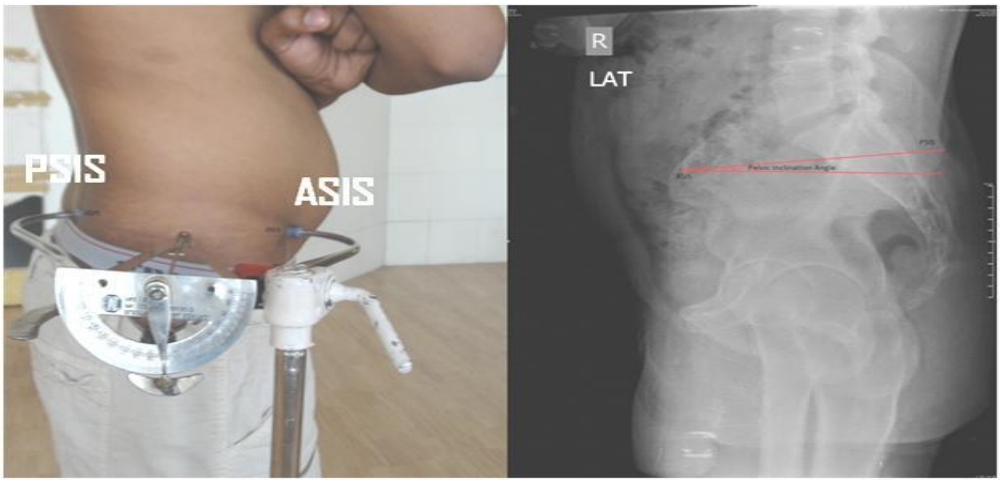
As per the method defined by Walker [10] X-ray measurements were on the soft copy film showing lateral view of the pelvis using Autocad software as shown in Figure 5. Hence Pelvic inclination angle as measured on the X-ray was the angle is formed by a line joining ASIS and PSIS and a line drawn horizontal from ASIS.

ISSN(Online) : 2319-8753
ISSN (Print) : 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015



(a) (b)

Figure 5: (a). Method of measuring pelvic inclination angle using PELVIN, (b). Pelvic inclination angle as measured on the X-ray

VII. DATA ANALYSIS

We used the intraclass correlation coefficients (ICC) to determine the reliability of measures for the inclinometer. The ICC model was used to determine intratester and intertester reliability because it was assumed that the testers were fixed determinants; that is, trained in using this device and not representative of individuals who are unfamiliar with the pelvic inclinometer (36). The ICC was calculated to determine the concurrent validity of the inclinometer measures vs. X-ray measures of pelvic inclination angles. In addition, the means and standard deviations for all of the measurements were computed, and agreement among testers was determined.

VIII. RESULTS

The mean values of Pelvic inclination angles in Group I, i.e. in the age group of 21-30 years of subjects, measured by two testers on the Right pelvis and Left pelvis is as depicted in Table 1.

Table 1: Mean measurements of Pelvic Inclination angles in Group I subjects measured by two testers

Group I-- 21-30 years (n=30)

	Pelvic inclination X-ray Rt	Pelvic inclination Xray Lt	Pelvic inclination angle clinical Rt.	Pelvic inclination angle clinical Lt.
1st tester	8.6	8.79	8.56	9.03
2nd tester	8.55	8.79	8.6	9

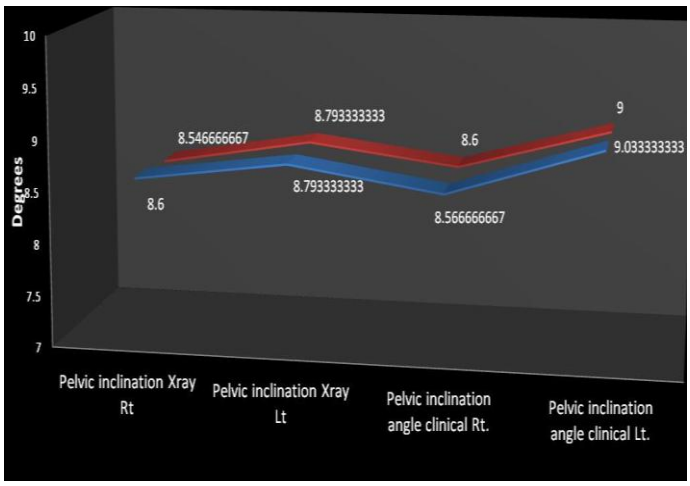


Figure 6: Mean measurements of Pelvic Inclination angles in Group I subjects measured by two testers

ISSN(Online) : 2319-8753
ISSN (Print) : 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

Figure 6 shows the graphical representation of measurements of pelvic inclination angles in Group I as measured by two testers. The mean values of Pelvic inclination angles in Group II, i.e. in the age group of 31-50 years of subjects, measured by two testers on the Right pelvis and Left pelvis is as depicted in Table 2.

Table 2: Mean measurements of Pelvic Inclination angles in Group II subjects measured by two testers

Group II- 31-50 (n=30)

	Pelvic inclination Xray Rt	Pelvic inclination Xray Lt	Pelvic inclination angle clinical Rt.	Pelvic inclination angle clinical Lt.
1st tester	9.49	9.73	9.33	9.67
2nd tester	9.46	9.75	9.367	9.67

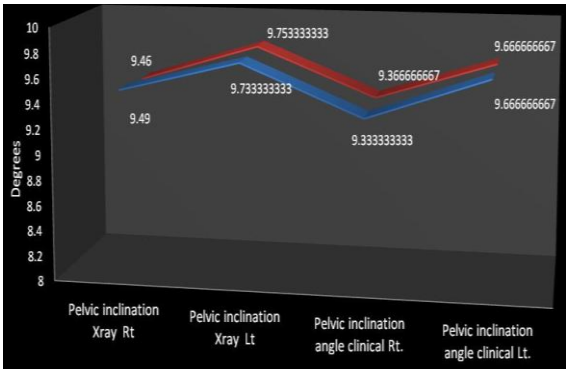


Figure 7: Mean measurements of Pelvic Inclination angles in Group II subjects measured

Figure 7 shows the graphical representation of measurements of pelvic inclination angles in Group II as measured by two testers

The mean values of Pelvic inclination angles in Group II, i.e. in the age group of 51-65 years of subjects, measured by two testers on the Right pelvis and Left pelvis is as depicted in Table 3. Figure 8 shows the graphical representation of measurements of pelvic inclination angles in Group III as measured by two testers

Table 3: Mean measurements of Pelvic Inclination angles in Group III subjects measured by two testers

Group III-- 51-65 (n=30)

	Pelvic inclination Xray Rt	Pelvic inclination Xray Lt	Pelvic inclination angle clinical Rt.	Pelvic inclination angle clinical Lt.
1st tester	9.46	8.83	10	9.9
2nd tester	9.45	8.84	10.17	9.87

.

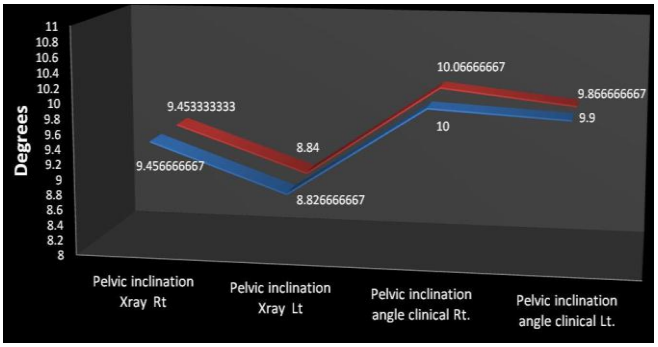


Figure 8: Mean measurements of Pelvic Inclination angles in Group III subjects measured by two testers

Mean and Standard deviation of Pelvic inclination angles measured clinically by two testers for Rt.and Lt. Innominates is depicted in Table 4.

ISSN(Online) : 2319-8753
ISSN (Print) : 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

Table 4

	Mean	Std. Deviation	N
pinclin1R	9.3	2.24084	90
pinclin2R	9.3444	2.21923	90
pinclin1L	9.5333	2.29411	90
pinclin2L	9.5111	2.30897	90

The intraclass correlation coefficient ICC for repeated measures of the pelvic inclinometer fixed to a mechanical stand was 0.99. Refer Table 5

Table 5

	Intraclass Correlation	
	Pelvic inclination angles Rt.	Pelvic inclination angles Lt.
Single Measures	0.982	0.983
Average Measures	0.991	0.991

Measures by the inclinometer had a high degree of reliability compared with the criterion x-ray measure, ICC - 0.99. Mean & standard deviation estimates for repeated measures of pelvic inclination angles using Pelvin is as shown in Table 6

Table 6

Testers	Measures	Mean	N	Std. Deviation
Pair 1 1st tester	Pinxray1R	9.1822	90	2.39708
	pinclin1R	9.3	90	2.24084
Pair 2 1st tester	pinXray1L	9.1178	90	2.54561
	pinclin1L	9.5333	90	2.29411
Pair 3 2nd tester	Pinxray2R	9.1533	90	2.34962
	pinclin2R	9.3444	90	2.21923
Pair 4 2nd tester	pinXray2L	9.1289	90	2.53418
	pinclin2L	9.5111	90	2.30897

Validity of pelvic inclinometer is evident from the t-tests resulting in no significant difference between clinical radiological measurements of pelvic inclination angles. The values of t test are as shown in Table 7

ISSN(Online) : 2319-8753
ISSN (Print) : 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

Table 7: Comparison between Clinical measurements of pelvic inclination angles and pelvic angles measured radiologically using Paired t test.

Paired Samples Test		Mean	Std. Deviation	99% Confidence Interval Sig. (2-tailed)
Pair 1	Pinxray1R - pinclin1R	-0.11778	1.60383	0.488
Pair 2	pinXray1L - pinclin1L	-0.41556	2.01522	0.054
Pair 3	Pinxray2R - pinclin2R	-0.19111	1.54328	0.243
Pair 4	pinXray2L - pinclin2L	-0.38222	1.96689	0.069

IX. CLINICAL IMPLICATION

The results of this study clearly indicate that an experienced physical therapist can make reliable measurements of innominate bone inclination with the inclinometer. The PELVIN offers promise as a useful measurement device for the clinician who treats postural problems related to pelvic tilt angle and pelvic asymmetry. The precision of the instrument and procedure will allow for normative data collection. Our study suggests that clinicians can learn to use the device with a few hours of practice and can achieve sufficient precision in measures to detect the small changes that we expect in pelvic position or innominate inclination. Testers familiar with the pelvic inclinometer were able to determine the inclination of both left and right innominate bones of a subject in less than 2 minutes. It is proposed that this type of inclinometer and procedure is applicable to the patient population with low back pain. Standardization of objectively assessing pelvic tilt, i.e., innominate bone inclination, should be accepted practice and be an integral part of goniometric measurements of the musculoskeletal system.

X. CONCLUSION

Pelvic inclination angle recorded by Pelvin$^{®TM}$ which is indigenously designed pelvic inclinometer is highly reliable and valid to use clinically.

REFERENCES

1. Kendall FP, McCreary EK, Provance P. Muscles, Testing and Function:With Posture and Pain. 4th ed. Baltimore, Md: Williams & Wilkins; 1993.
2. Cailliet R. Low Back Pain Syndrome. 5th ed. Philadelphia, Pa: FA DavisCo; 1995.
3. Kisner C, Colby LA. Therapeutic Exercise: Foundations and Techniques. 3rd ed. Philadelphia, Pa: FA Davis Co; 1996.
4. Jull GA, Janda V. Muscles and motor control in low-back pain: assessment and management. In: Twomey LT, Taylor JR, eds. Physical Therapy of the Low Back. New York, NY: Churchill Livingstone Inc; 1987:253–278.
5. Levine D, Whittle MW. Th e effects of pelvic movement on lumbar lordosis in the standing position. J Orthop Sports Phys Ther 1996;24:130–135.
6. Jull GA, Janda V. Muscles and motor control in lower back pain: Assessment and management. In: Twomey LT, Talyor JR.Physical Th erapy of the Lower Back. 1st ed. New York: Churchill Livingstone, 1987.
7. Hertel J, Dorfman JH, Brahman RA. Lower extremity malalignments and anterior cruciate ligament injury history. J Sport Sci Med 2004;3:220–225.
8. Loudon JK, Jenkins W, Loudon KL. Th e relationship between static posture and ACL injury in female athletes. J Orthop Sports Phys Ther1996;24:91–97.
9. Willson JD, Dougherty CP, Ireland ML, Davis IM. Core stability and its relationship to lower extremity function and injury. J Am Acad Orthop Surg2005;13:316–325.
10. Walker et al .Relationship between lumbar lordosis,pelvic inclination and abdominal muscle performances.Physical Therapy.April 1987 ; vol 67:no 4:512-516
11. Field, T.J. and Buehler M.T. Improvements in chiropractic full spine radiology. Journal of manipulative and physiological therapeutics, 4(1): 21-25, March 1981
12. Hilderbrandt R.W.Chiropractic spinography and postural roentgenology- Part I: history of development. Journal of manipulative and physiological therapeutics, 3(2): 87-92, June 1980

ISSN(Online) : 2319-8753
ISSN (Print) : 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

13. Cibulka MT, Koldehoff RM: Leg length disparity and its effect on sacroiliac joint dysfunction. Clin Management Phys Ther 6(5):10-11, 1986
14. DonTigny RL: Anterior dysfunction of the sacroiliac joint as a major factor in the etiology of idiopathic low back pain. Phys Ther 70:250-262, 1990
14. DonTigny RL: Anterior dysfunction of the sacroiliac joint as a major factor in the etiology of idiopathic low back pain. Phys Ther 70:250-262, 1990
15. DonTigny RL: Dysfunction of the sacroiliac joint and its treatment. / Orthop Sports Phys Ther 1:23-35, 1979
16. Grieve CP: The sacro-iliac joint. Physiother 62:384-400, 1976
17. Subotnick 51: Limb length discrepancies of the lower extremity: The short leg syndrome. / Orthop Sports Phys Ther 3: 1 1 - 16, 1985
18. Potter NA, Rothstein /M: Intertester reliability for selected clinical tests of the sacroiliac joint. Phys Ther 65: 1671 - 1674, 1985
19. US Department of Health and Human Services: NlOSH Low Back Atlas of Standardized Tests Measures, Springfield, VA: National Technical Information Services, 1988
20. Day lW, Smidt CL, Lehamann T: Effect of pelvic tilt on standing posture. Phys Ther 64:5 10-5 16, 1984
21. Loebl WY: Measurement of spinal postures and range of spinal movements. Ann Phys Med 9: 103- 1 10, 1967
22. Pitkins HC, Pheasant HC: Sacrarthrogenetic telalgia. 11. A study of sacral mobility. 1 Bone loint Surg 28A:365- 374, 1936
23. Sanders C, Stavrakas P: A technique for measuring pelvic tilt. Phys Ther 6 1 :49-50, 198 1
24. Alviso Dl, Dong CT, Lentell CL: Intertester reliability for measuring pelvic tilt in standing. Phys Ther 68:1347- 1351, 1988
25. Gajdosik R, Simpson R, Smith R, DonTigny RL: Pelvic tilt intratester reliability of measuring the standing position and range of motion. Phys Ther 65: 169- 174, 1985
26. DonTigny RL: Function and pathomechanics of the sacroiliac joint: A review. Phys Ther 65:35-44, 1985
27. Cibulka MT, Delitto A, Koldehoff RM: Changes in innominate tilt after manipulation of the sacroiliac joint in patients with low back pain. An experimental study. Phys Ther 68:1359-1363, 1988
28. Egund N, Olsson TH, Schmid H, Selvik C: Movements in the sacroiliac joints demonstrated with roentgen sterophoto-grammetry. Acta Radio1 53:833- 846, 1978
29. Frigerio NA, Stowe RR, Howe /W: Movement of the sacroiliac joint. Clin Orthop 1 OO:370-377, 1974
30. Weisl H: The movements of the 511. Acta Anat 23:80-9 1, 1955
31. Stewart TD: Pathologic changes in aging sacroiliac joint: A study of dissecting room skeletons. Clin Orthop 183: 188- 196, 1984
32. Walker /M: Age-related differences in the human sacroiliac joint: A histological study; implications for therapy. Orthop Sports Phys Ther 7:325-334, I986
33. Loebl WY: Measurement of spinal postures and range of spinal movements. Ann Phys Med 9: 103- 1 10, 1967
34. Smidt CL, Day /W, Cerleman DC: Iowa anatomical position system: A method of assessing posture. Eur Appl Physiol52:407-4 13, 1984
35. Walker ML, Rothstein /M, Finucane SD, Lamb RL: Relationship between lumbar lordosis, pelvic tilt, and abdominal muscle performance. Phys Ther 67:5 12-5 16, 1987
36. Shrout PE, Fleiss /L: lntraclass correlations: Using rater reliability. Psychol Bull 86:420-428, 1979