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 Yardi²
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 intratester and intertester 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 ICCs 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).
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). 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. 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.
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 (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.
(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° (24). Gajdosik et al reported a total range of motion of 10.9 1 to 2 1.74° for pelvic tilt (25). Precision is critical to measure asymmetrically inclined innominate bones which may differ, in position only from 1 to 11° (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.
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.

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 MEASUREMENT

As per the method defined by Walker, 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.
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>
<thead>
<tr>
<th>Group I– 21-30 years (n=30)</th>
<th>Pelvic inclination X-ray Rt</th>
<th>Pelvic inclination X-ray Lt</th>
<th>Pelvic inclination angle clinical Rt.</th>
<th>Pelvic inclination angle clinical Lt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st tester</td>
<td>8.6</td>
<td>8.79</td>
<td>8.56</td>
<td>9.03</td>
</tr>
<tr>
<td>2nd tester</td>
<td>8.55</td>
<td>8.79</td>
<td>8.6</td>
<td>9.03</td>
</tr>
</tbody>
</table>

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

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

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

<table>
<thead>
<tr>
<th>Group II- 31-50 (n=30)</th>
<th>Pelvic inclination Xray Rt</th>
<th>Pelvic inclination Xray Lt</th>
<th>Pelvic inclination angle clinical Rt.</th>
<th>Pelvic inclination angle clinical Lt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st tester</td>
<td>9.49</td>
<td>9.73</td>
<td>9.33</td>
<td>9.67</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Group III- 51-65 (n=30)</th>
<th>Pelvic inclination Xray Rt</th>
<th>Pelvic inclination Xray Lt</th>
<th>Pelvic inclination angle clinical Rt.</th>
<th>Pelvic inclination angle clinical Lt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st tester</td>
<td>9.46</td>
<td>8.83</td>
<td>10</td>
<td>9.9</td>
</tr>
<tr>
<td>2nd tester</td>
<td>9.45</td>
<td>8.84</td>
<td>10.17</td>
<td>9.87</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Measures</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>pinclin1R</td>
<td>9.3</td>
<td>2.24084</td>
<td>90</td>
</tr>
<tr>
<td>pinclin2R</td>
<td>9.3444</td>
<td>2.21923</td>
<td>90</td>
</tr>
<tr>
<td>pinclin1L</td>
<td>9.5333</td>
<td>2.29411</td>
<td>90</td>
</tr>
<tr>
<td>pinclin2L</td>
<td>9.5111</td>
<td>2.30897</td>
<td>90</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th></th>
<th>Intraclass Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pelvic inclination angles Rt.</td>
<td>Pelvic inclination angles Lt.</td>
</tr>
<tr>
<td>Single Measures</td>
<td>0.982</td>
</tr>
<tr>
<td>Average Measures</td>
<td>0.991</td>
</tr>
</tbody>
</table>

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

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

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

<table>
<thead>
<tr>
<th>Paired Samples Test</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>99% Confidence Interval</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1</td>
<td>Pinxray1R - pinclin1R</td>
<td>-0.11778</td>
<td>1.60383</td>
<td></td>
</tr>
<tr>
<td>Pair 2</td>
<td>pinXray1L - pinclin1L</td>
<td>-0.41556</td>
<td>2.01522</td>
<td></td>
</tr>
<tr>
<td>Pair 3</td>
<td>Pinxray2R - pinclin2R</td>
<td>-0.19111</td>
<td>1.54328</td>
<td></td>
</tr>
<tr>
<td>Pair 4</td>
<td>pinXray2L - pinclin2L</td>
<td>-0.38222</td>
<td>1.96689</td>
<td></td>
</tr>
</tbody>
</table>

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™ which is indigenously designed pelvic inclinometer is highly reliable and valid to use clinically.

REFERENCES


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DOI:10.15680/IJRSET.2015.0407006