



Technical and measurement report

Assessment of the degree of pelvic tilt within a normal asymptomatic population

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ARTICLE INFO

Article history:

Received 3 December 2010

Received in revised form

4 April 2011

Accepted 12 April 2011

Keywords:

Pelvic tilt

Measurement

PALMeter

ABSTRACT

In clinical practice the degree of pelvic tilt is commonly assessed because of its reported relationship to pelvic, spinal and lower limb pathologies. There is little normative data presented within the literature establishing typical findings within an asymptomatic population from which to make comparisons in pathological populations. The aim of this study was to report typical pelvic angle in an asymptomatic populations and also the degree of side-to-side asymmetry which might exist within the pelvis. Pelvic angle was measured by finding the angle from horizontal of a line between the anterior superior and posterior superior iliac spines of the ilium using a PALM palpation meter in 120 healthy subjects (65 males, 55 females) with a mean age of 23.8(2.1) years. 85% of males and 75% of females presented with an anterior pelvic tilt, 6% of males and 7% of females with a posterior tilt and 9% of males and 18% of females presented as neutral. There was significant difference in pelvic angle between sides for males ($p = 0.002$) but a non-significant difference between sides for females ($p = 0.314$). But the difference in angle for males between sides was less than the smallest detectable difference statistic found in the reliability study, so most likely to be due to measurement error.

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1. Introduction

Faulty posture has been linked with multiple musculoskeletal pathologies and this has been related to the position of the pelvis (Sahrmann, 2002). In clinical practice standing pelvic posture is a routinely assessed to help identify possible problems with the spine and peripheral joints (Youdas et al., 1996). Asymmetry within the pelvic structures is believed to lead to a cascade of postural compensations predisposing the individual to numerous neuro-musculoskeletal dysfunctions (Juhl et al., 2004). It has been reported for example that the presence of asymmetry in pelvic alignment is indicative of sacroiliac dysfunction (Freburger and Riddle, 1999) and less specific lumbo-pelvic injuries in runners (Schache et al., 2000).

The most common technique used to assess for asymmetry in pelvic position is that of palpation, assessing the relative position of the anterior and posterior superior iliac spines (Freburger and Riddle, 1999). The reliability (Potter and Rothstein, 1985; Freburger and Riddle, 1999) and validity (Preece et al., 2008) of this technique though has been questioned. The sensitivity and specificity of the technique in relation to specific pathologies could also be called into question, with Krawiec et al. (2003) finding subjects to have

significantly more anterior pelvic tilt on the right, whereas Barakatt et al. (1996) found significantly more posterior rotation on the right in their subject group. Hagins et al. (1998) reported that more than 2° innominate rotation difference existed within their subjects between sides with 52% of their participants presenting with a more anteriorly rotated right innominate.

The use of handheld callipers has been established as an alternative method of assessment for measuring asymmetry within the innominates than direct palpation alone. This eliminates the need for visual estimates and may provide more reliable results. Several studies have used inclinometers to measure the angle of pelvic inclination. Gajdosik et al. (1985) studied the intratester reliability of measuring standing pelvic tilt, using an inclinometer they found intratester reliability for standing pelvic tilt was $r = 0.88$ overall, posterior pelvic tilt was $r = 0.88$ and $r = 0.92$ for anterior pelvic tilt. The PALM palpation meter has also been used; Hagins et al. (1998) investigated the reliability of the PALM on 24 asymptomatic subjects. Interrater reliability was reported as $r = 0.89$ in the sagittal plane with intrarater coefficients of $r = 0.98$ and standard error of measurement (SEM) of 3.66°. Krawiec et al. (2003) found intratester reliability to be excellent $r = 0.99$ with SEM ranging from 0.44° to 0.47° in their assessment of static innominate asymmetry using the PALM palpation meter.

The PALM palpation meter would appear to provide a potentially reliable measure of pelvic inclination, but what has yet to be described is typical pelvic positions and the degree of asymmetry

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which exists within an asymptomatic population using the PALM palpation meter. The aim of this study was to establish what the average pelvic inclination angle is within a normal asymptomatic population and to what degree if any is the level of asymmetry between sides in this population.

2. Method

2.1. Subjects

120 healthy subjects (65 males, 55 females) ranging in age from 18 to 44 years, with a mean age of 23.8(2.1) years, volunteered and gave informed consent to participate in this study. Subjects were excluded from the study if they had experienced any significant low back or pelvic pain (pain lasting for greater than 1–2 days), lower limb fracture or surgery, were currently pregnant or had given birth within the last 12 months. The study was approved by the university research ethics committee.

2.2. Procedure

A single experienced musculoskeletal clinician took all the measurements. Sagittal plane innominate positions were measured using the Palpation Meter (PALM) (Performance Attainment Associates, St. Paul Minnesota, USA). The PALM consists of an inclinometer and two calliper arms. The bubble inclinometer is a semi-circular arc with one degree gradations that range from 0° to 30° on either side of the midline. Each subject stood with feet positioned in the width of 30 cm platform and were told to look at a fixed point ahead of them to control for postural sway. Subjects adopted an erect posture with weight evenly distributed and arms crossed over their chest while the investigator palpated the ASIS and PSIS. Initial palpation of the ASIS was made by bringing the thumbs from inferior to superior and then on the most prominent protrusion of the ASIS, where it was marked with felt tip. 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. Once palpated the calliper tips established position over the marked landmarks and were compressed to a firm resistance as suggested by Gajdosik et al. (1985). Application of the PALM is shown in Fig. 1. The angle of inclination was directly read from the inclinometer by the investigator and recorded by an assistant. Standing pelvic tilt was determined as the angle formed by a horizontal line drawn between the ASIS and PSIS. Positive degrees were used to describe anterior innominate tilts and negative degrees were used to

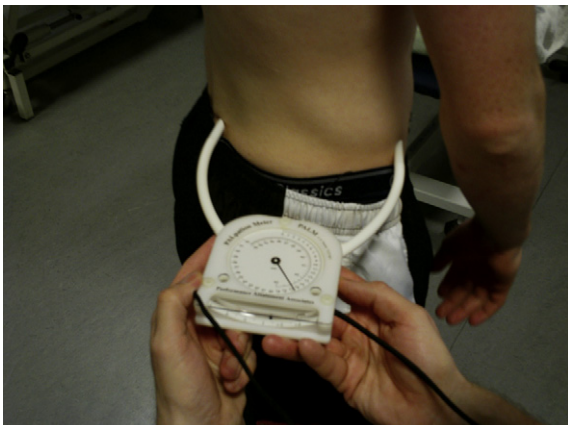


Fig. 1. The average Q angles for each position and limb for asymptomatic subjects.

describe posterior tilts in the sagittal plane. Three measurements were taken for each side to obtain an average.

2.3. Analysis

All data was analysed using SPSS Version 15 statistical software. Factorial ANOVA (Sex; male: female and side; left: right) was used to investigate if any differences between sex or side were present in pelvic angle. *t*-tests were conducted on any significant factors (subject to Bonferoni correction) to determine if any differences were apparent between left and right sides for males and females respectively. An alpha level of $\alpha = 0.05$ was set as significant.

Intratester reliability of the measurement technique was assessed on 10 subjects. These were measured on two separate occasions 1 week apart, using the procedure described above. The intratester reliability of the technique was assessed using Intra-class correlation coefficient. For purposes of this study, correlation coefficients were interpreted as follows: below 0.50 was poor, 0.50 to 0.75 was good, and above 0.75 was excellent (Portney and Watkins, 2000). The standard error of measurement (SEM) was also calculated using the formulae as follows $SEM = SD \times (\sqrt{1-ICC})$ (Portney and Watkins, 2000). The smallest detectable difference (SDD) or minimal detectable change (MDC), of the measurement of pelvic angle was also calculated from the data of the first two measurements ($SDD = MDC = 1.96 \times (\sqrt{2} \times (SEM))$) (Eliaszew et al., 1994).

3. Results

3.1. Intratester reliability

The intra-class correlation between the first and second measurement sessions was $ICC_{3k} r = 0.87$ ($p = 0.01$) showing excellent reliability, standard error of measurement (SEM) = 1.1°, and the smallest detectable difference (SDD) = 2.5°.

3.2. Pelvic angle

Out of the 65 male subjects tested 55 (85%) presented with an anterior tilt, 4 with a posterior tilt and 6 presented as neutral. Across the sample of female subjects 41 presented with an anterior tilt (75%), 4 with a posterior tilt and 10 presented as neutral. In the anterior pelvic tilt group the average degree of anterior pelvic tilt for males was 6.74° on the left and 6.23.9° on the right and for females it was 6.93.6° on the left and 6.63.3° on the right. For the individuals with posterior pelvic tilt the average degree of posterior pelvic tilt for males was 2.71° on the left and 2.21.9° on the right and for females it was 2.71.5° on the left and 2.51.2° on the right.

Factorial ANOVA revealed a side (left or right) to have a significant effect on pelvic angle ($p = 0.018$), whilst both sex and the interaction of sex and side was not significant ($p = 0.06$ and $p = 0.078$, respectively) The *t*-test revealed a significant difference in pelvic angle between sides for males ($p = 0.002$) but a non-significant difference between sides for females ($p = 0.314$).

4. Discussion

The study undertaken found the PALM palpation meter to be a reliable tool for measuring pelvic tilt in standing with this finding being in line with those previously reported (Hagins et al., 1998; Krawiec et al., 2003). The primary aim of the study was to describe typical sagittal plane pelvic angle values for a large asymptomatic population. The results of the study would indicate 85% of males and 75% of females have an anteriorly rotated pelvis as measured by the PALM palpation meter, which was on average in

the range of 6–7° for both sexes. The study also found that overall there was no significant difference in pelvic angle in standing between the sexes. The study also found that males showed significant asymmetry in pelvic angle between sides whereas females did not, though this difference on average was under 0.5°. Interestingly, though this difference between sides in males was statistically significant, the difference was less than the smallest detectable difference (SDD) value (0.5° versus 2.5°) established in the reliability arm of the study. The SDD statistic is useful in enabling a clinician to be able to distinguish real changes from meaningless fluctuation, it represents reliability in context of measurement error, with SDD being the minimal change required to be 90% confident that difference between individual measures is due to real change (Fletcher and Bandy, 2008). This would indicate that the differences between the left and right sides, are more likely to be due to measurement error (or random chance) than an actual effect of pelvic asymmetry itself.

Anterior pelvic tilt has been suggested to increase loading on the lumbar spine (Jull and Janda, 1987), but Bullock-Saxton (1993) failed to find any difference between asymptomatic and symptomatic individuals in overall range of movement. Hertel et al. (2004) found a relationship between pelvic tilt angle and anterior cruciate ligament injury, but the effect size of the study was very small (Preece et al., 2008). The failure to find significant relationships might impart prove to be due to the fact that within normal asymptomatic populations anterior tilt is common and not unique to pathology.

The presence of asymmetry is often sort as an indicator of potential pelvic and lumbar spine stress (Sahrmann, 2002), and was found by Al-Eisa et al. (2004) and Levangie (1999) to be associated with low back pain. But in both these studies the association was relatively weak. The findings of this study would appear to indicate (especially in males) that there may be apparent significant asymmetry but this may just be (random) variation within an asymptomatic population found within the realms of measurement error. Preece et al. (2008) found a mean difference of 1(=/-2)° between sides in their cadaver study and Maziar et al. (2003) found that asymmetry in ASIS height in asymptomatic individuals to rarely be greater than 5 mm. It would appear logical then that when assessing patients presenting with asymmetry of pelvic position, that this should be greater than SDD presented within this study, that is 2.5° before being regarded as potentially clinically significant.

It would appear that a degree of anterior pelvic tilt is typical within asymptomatic individuals and that asymmetry of pelvic angle is also not a unique finding confined to symptomatic

individual alone. The normative data presented in this study would indicate that care should be taken when applying cause and effect to the presence of pathology with the presence of anterior tilted and asymmetrically tilted pelvic angles especially when that difference is only a few degrees.

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