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Correlation between hamstring muscle length and pelvic tilt range during forward bending in healthy individuals: An initial evaluation

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Summary The purpose of this study was to determine if an association exists between hamstring muscle length and the angle of pelvic tilt during forward bending in a student sporting population. A bubble goniometer was used to determine angle of pelvic tilt, and the active knee extension (AKE) test used to assess hamstring muscle length in 21 asymptomatic subjects. The forward bending task was matched to the tibial length of each subject. Mean AKE was 146.5° (±9.0°) and mean angle of pelvic tilt 15.5° (±6.9°). No association was found between hamstring muscle length and total angle of pelvic tilt ($r = 0.045$) in people with extensibility of the hamstrings within normal limits.

Introduction

Pelvic tilt and posture

Changes in body alignment (static posture) and alteration of movement sequencing (dynamic posture) are considered to be common risk factors for low back pain (LBP)(McKenzie, 1981; Kendall et al., 1993; Cailliet, 1994). Alteration in movement patterns could lead to excessive loading of lumbar tissues predisposing the subject to LBP (Janda, 1993). One of the most common tasks in daily living is forward bending. Activities such as ironing, reaching into a shopping trolley, and lifting a small child for example all use forward bending within mid-range motion.

Pelvic tilt and bending

Alteration in the sequencing of hip and lumbar spine movement patterns during forward bending has been proposed as a risk factor for the development of LBP (Esola et al., 1996). Changes in lumbar motion range and motion velocity have been noted in individuals with LBP (McClure et al., 1997), and reduced hip mobility during forward bending has also been shown (Porter and Wilkinson,

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1997). LBP subjects demonstrate a decreased magnitude of hip flexion, but not other hip motions implying that an alteration in activity level of the hamstrings may be present in symptomatic subjects (Wong and Lee, 2004). Alteration in stretch tolerance rather than stiffness of the hamstrings has been shown to determine this range of motion change in nonspecific LBP subjects (Halbertsma et al., 2001).

Forward bending is a coupled movement combining lumbar flexion and pelvic rotation, the so-called lumbar–pelvic rhythm (Norris, 2000). It results from coordinated activity between the back extensor muscles (erector spinae) and the hip extensor muscles (gluteals and hamstrings).

Hamstring tightness is a common finding in the LBP patient (Nourbakhsh and Arab, 2002), and it has been argued that lengthening the hamstrings may allow greater motion to occur at the hips and therefore reduce stress on the lumbar spine (Cailliet, 1994). However, hamstring tightness is not related to pelvic tilt position during the standing static posture (Gajdosik et al., 1992). There is little data available on the relationship between hamstring length and pelvic tilt during dynamic posture. Influences on static posture are multi-factorial, with the pull of the hamstrings being balanced by both the hip flexors and the abdominal muscles (Link et al., 1990). In the dynamic movement of forward bending the picture is less clear cut.

Dynamic control of pelvic tilt

Investigation into the timing of the hip extensors and erector spinae muscle activity in forward bending has shown that the erector spinae and hamstrings are activated before the gluteus maximus in people without LBP. In those with LBP the muscle activation sequence is unchanged, but the duration of gluteus maximus contraction is shortened (Leinonen et al., 2000). Towards end range forward bending both the back extensor muscles and the hip extensors have been shown to relax, a feature termed the flexion relaxation (FR) response (Allen, 1948; Floyd and Silver, 1951; Sihvonen, 1997). As the body bends forwards, its decent is controlled by eccentric action of both the spinal extensors and hamstrings. At 90% maximum flexion, activity of the spinal extensors ceases and elastic resistance of the spinal extensors and posteriorly placed spinal soft tissues limits movement range (Kippers and Parker, 1984). Near end range (97% flexion) activity of the hamstrings also ceases and the final angle of pelvic tilt is limited by elastic resistance of these muscles and tension of other posteriorly placed soft tissues (Sihvonen, 1997). At the initiation of body lifting, little muscle contraction is seen, the trunk being raised by elastic resistance of the posterior tissues. The point at which this occurs (critical point) varies, and the FR response itself may be altered or obliterated in subjects with chronic LBP (Golding, 1952).

Movement of the lumbar spine, relative to that of the pelvis, has been shown to change during the forward bending movement (Rose et al., 1988; Esola et al., 1996). Lumbar spine to hip flexion (L/H) ratios for early (0–30°), middle (30–60°), and late (60–90°) forward bending have been given as 2:1, 1:1, and 1:2, respectively (Esola et al., 1996), showing an increase in the contribution by the pelvis as forward bending proceeds. Subjects with a history of LBP tend to have a changed pattern of forward bending compared to normal subjects although the total range of motion for both groups is generally the same. In LBP subjects hamstring flexibility is reduced (Esola et al., 1996; Rose et al., 1988) and greater electrical activity in the hamstring muscles is seen (Mooney and Robertson, 1976). Earlier lumbar motion in the activities of daily living (ADL) will increase the repetitive stress imposed on the low back tissues and could be an important factor in the re-occurrence of LBP, particularly as ADL requires only partial forward bending.

Purpose of this study

The purpose of this study was to establish if an association exists between hamstring muscle length and the range of motion of pelvic tilt during forward bending. Determining if an association exists between these two variables will allow clinicians and sports coaches to more accurately prescribe lumbo-pelvic exercise to this group. Furthermore, the study will draw attention to an additional method of subject assessment using currently available measuring apparatus.

Method

Subjects

Twenty-one University sport studies students (12 female, 9 male) with no history of knee or back pain volunteered to participate in this study (see Table 1 for their physical characteristics). No participant had any history of low back or hip pathology. The testing procedure was explained to

Table 1 Means (*M*) and standard deviations (SD) for physical characteristics of participants.

	M	SD
Age (years)	20.5	2.5
Height (cm)	172.8	11.3
Mass (kg)	69.7	15.9

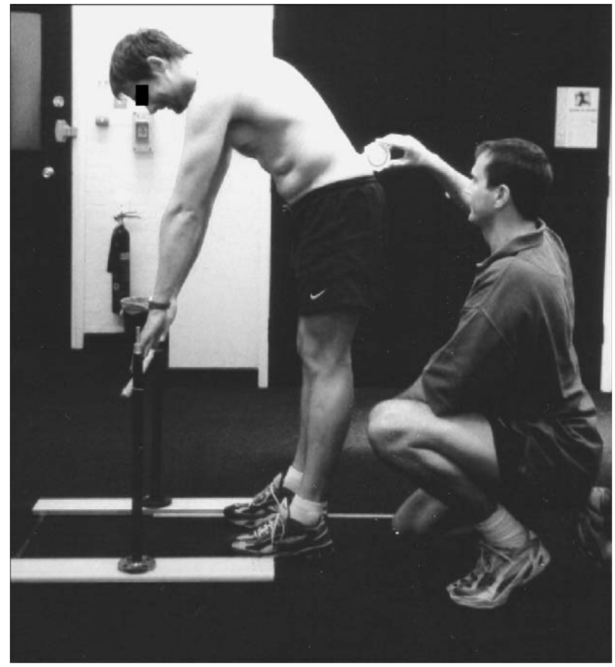

Figure 1

the subjects and each signed an informed consent form.

Design

This was a correlation study conducted on 1 day. All subjects were measured in a clinical laboratory, by a qualified physiotherapist. The assessment included the collection of descriptive data of age, height, and weight. Hamstring muscle length and pelvic tilt angle were determined using the following protocols.

Procedures

Hamstring muscle length was measured using the self-monitored active knee extension (AKE) test described previously (Norris and Mathews, 2005). The subject lay supine on a couch and flexed their right knee and hip to 90°. They monitored the position of the femur with their right hand, and were instructed not to allow the femur to move away from the hand at any point during the test. The participant was instructed to extend their right leg as far as possible, keeping their foot relaxed. The end position was held for 5 s, and the angle of knee extension was measured using a standard Perspex goniometer (Physiomed, Manchester, UK). The centre of the goniometer was positioned over the lateral knee joint line, and the goniometer arms were positioned along the femur and fibula.

Before testing the forward bending action, tibial length of the right-hand side was measured for each subject from the lateral joint line of the knee to the inferior border of the lateral malleolus. This length was designated *T*. A horizontal line was drawn joining the posterior superior iliac spines and this line was designated L. A line was drawn on the ground and subjects stood in bare feet with their feet shoulder width apart, and the backs of the heals placed on the line. A bar was positioned at distance *T* from the ground line and at a height *T* from the ground, and held in place on a frame (Fig. 1). A bubble goniometer (Physiomed, Manchester, UK) was placed over the subjects sacrum with its upper edge aligned with the previously drawn line L joining the subjects posterior superior iliac spines. The goniometer was pressed firmly against the body to make and maintain contact with the spines of the sacral vertebra through the skin. The goniometer was zeroed in the starting position and subjects were instructed to bend forward to touch the bar in a single smooth action, without allowing any change in their knee joint angle. The goniometer reading was taken immediately, and recorded as the angle of anterior pelvic tilt.

Results

Mean AKE was measured as 146.5° (range 131.0–163.5, SD = 9.0). Results for the angle of pelvis revealed a mean angle of tilt of 15.5° (range 3.0–30.0, SD = 6.9).

Correlation analysis of the AKE and pelvic tilt data revealed a correlation coefficient of $r = 0.045$ indicating that no association exists between the two variables.

Discussion

Mean value of AKE obtained compared well with other studies using similar subjects (Rolls and George, 2004). This reflects a relatively young and active population. Results may have been different using inactive subjects or those with a history of LBP. The subjects for the study were university students on a sport-based course. The active nature of these students compared to the normal population may have meant that their proprioceptive control of the bending action was better than normal. Subjects with LBP have been shown to have poorer proprioceptive control of the lumbar spine (O'Sullivan et al., 2003; Lehman, 2004). Results from this study should therefore be used with caution when inferring changes in the LBP patient.

Only the total range of motion of the pelvis was measured during this study, and not the timing of pelvic tilt relative to that of lumbar flexion. It has been postulated that when two body segments move, the segment which is more mobile will move first. This phenomenon has been termed relative flexibility (Sahrmann, 2002). Both alteration in lumbar to hip flexion motion ratio and changes in hamstring flexibility have been shown in LBP patients (Esola et al., 1996). It may be that a correlation exists between hamstring tightness and pelvic motion, not in terms of total motion range, but rather motion ratio or temporal pattern.

Total range of pelvic motion was measured in the upright stance, with the goniometer zeroed before measurement. Individuals with tighter hamstrings may have begun the movement from a position of reduced anterior tilt. If so, the study was not able to show if differences existed between anteriorly tilted subjects and those with neutral lumbo-pelvic alignment.

This study assessed people without LBP and found no correlation between hamstring length and pelvic tilt. However, reduced hamstring flexibility, and greater electrical activity of these muscles has been shown in symptomatic subjects (Rose et al., 1988; Mooney and Robertson, 1976). In addition, although the order of hip extensor (hamstrings/gluteus maximus) activity is unchanged in symptomatic individuals the duration of gluteus maximus activation is shortened (Leinonen et al., 2000). It may be that hamstring length and pelvic tilt are correlated in symptomatic subjects but not in asymptomatic individuals.

Motion of the pelvis could have been more accurately assessed using video analysis. However, the bubble goniometer is a tool readily available to practitioners in the clinical environment, and has been shown to have high intertester reliability (Petherick et al., 1988). This method of assessment has been shown to be valid when compared to video analysis for single joint motion of the lower limb (Bartholomy et al., 2002), but not for the pelvic tilt action used in this study. A subsidiary aim of the study was to draw attention to this method of assessment as a baseline for lumbo-pelvic exercise prescription. In the UK currently, video analysis equipment is rarely found in rehabilitation departments.

Clinicians often assume that tighter hamstring muscles will limit anterior tilt of the pelvis. It has been argued that anterior tilt of the pelvis will be reduced because the hamstrings attach to the ischial tuberosity, and this structure moves superiorly as the pelvis tilts, increasing the distance between the attachments of the hamstrings. However, the line of action of the hamstrings is almost vertical, and the attachment to the ishial tuberosity is only slightly posterior to the femoral head. This minimal posterior force tending to posteriorly rotate the pelvis is likely to be outweighed by activity of the hip flexors tending to anteriorly rotate the pelvis. Therefore, any change in the length of the hamstrings may not alter the total range of pelvic tilt.

The measurement obtained in this study only represents the total range of motion of the pelvis during forward bending. Further studies are required using more subtle measuring devices to determine if there is an association between hamstring muscle length and alteration in the L/H ratio.

Conclusion

This study has shown that no association exists between hamstring muscle length and total range of pelvic motion during forward bending in asymptomatic subjects.

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