Available online at www.sciencedirect.com
SCIENCE DIRECT®
Clinical Biomechanics 21 (2006) 116–121
CLINICAL BIOMECHANICS
www.elsevier.com/locate/clinbiomech

Functional aspects of cross-legged sitting with special attention to piriformis muscles and sacroiliac joints

Chris J. Snijders [a,*], Paul F.G. Hermans [a], Gerrit Jan Kleinrensink [b]

[a] Department of Biomedical Physics and Technology, Erasmus MC, University Medical Center Rotterdam, P.O. Box 1738, 3000 DR Rotterdam, The Netherlands
[b] Department of Neuroscience, Erasmus MC, University Medical Center Rotterdam, Rotterdam, P.O. Box 1738, 3000 DR Rotterdam, The Netherlands

Received 14 June 2001; accepted 6 September 2005

Abstract

Background. Transversely oriented pelvic muscles such as the internal abdominal oblique, transversus abdominis, piriformis and pelvic floor muscles may contribute to sacroiliac joint stability by pressing the sacrum between the hipbones. Surface electromyographic measurements showed that leg crossing lowers the activity of the internal oblique abdominal muscle significantly. This suggests that leg crossing is a substitute for abdominal muscle activity. No previous studies addressed piriformis muscle and related pelvic structures in cross-legged sitting.

Methods. Angles of pelvis and femur were measured in healthy subjects in standing, normal sitting and cross-legged sitting, and were used to simulate these postures on embalmed pelvises and measure piriformis muscle elongation. Deformations of pelvic ring and iliolumbar ligament caused by piriformis muscle force were measured on embalmed pelvises.

Findings. Cross-legged sitting resulted in a relative elongation of the piriformis muscle of 11.7% compared to normal sitting and even 21.4% compared to standing. Application of piriformis muscle force resulted in inward deformation of the pelvic ring and compression of the sacroiliac joints and the dorsal side of the pubic symphysis.

Interpretation. Cross-legged sitting is common. We believe that it contributes to sacroiliac joint stability. This study demonstrates the influence of the piriformis muscle on sacroiliac joint compression. The elongation of the piriformis muscle bilaterally by crossing the legs may be functional in the build-up of active or passive tension between sacrum and femur.

Keywords: Piriformis muscle; Elongation; Hip joint; Sitting; Leg crossing; Low back pain; Sacroiliac joint

1. Introduction

The piriformis muscle is the largest of the short lateral rotators of the hip. Its origin is the lateral part of the ventral surface of the second, third and fourth sacral vertebra (Fig. 1). The fibre bundles converge upon a rounded tendon that is inserted upon the medial side of the superior surface of the greater trochanter. The sciatic nerve passes under or sometimes (partially) through the piriformis muscle (Beaton and Anson, 1937; Chiba, 1992; Lee and Tsai, 1974). In contrast to the other short lateral rotators, only the piriformis muscle crosses both the hip joint and the sacroiliac joint (SIJ), consequently making movements of the femur act upon the sacrum and SIJ.

The function of the piriformis muscle in weight-bearing activities is primarily ascribed to restraining vigorous or excessive axial endorotation during gait and is related to hip load and hip position. In the non-weight-bearing limb the function of the piriformis muscle is axial exorotation of the femur with the hip

* Corresponding author.
E-mail address: c.snijders@erasmusmc.nl (C.J. Snijders).

0268-0033/$ - see front matter © 2005 Elsevier Ltd. All rights reserved.
doi:10.1016/j.clinbiomech.2005.09.002

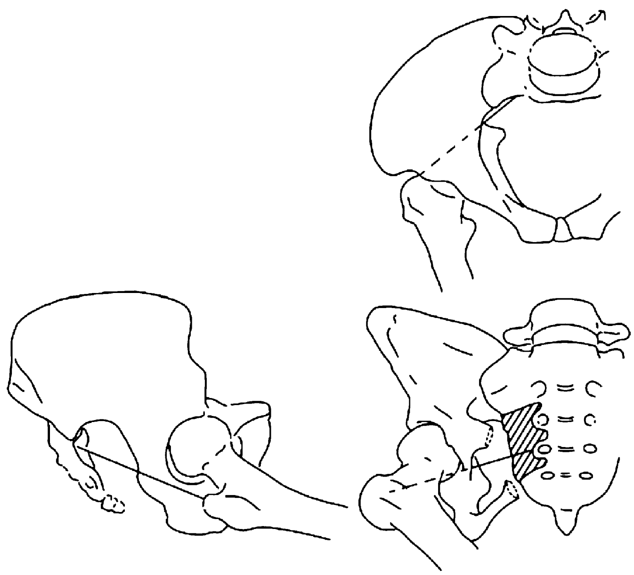

Fig. 1. Schematic representation of the right piriformis muscle in cross-legged sitting. According to Table 1 and Fig. 2A and C pelvic tilt is taken 40° and adduction of the femur is taken 20°. The shaded area indicates the origin of the piriformis at the lateral part of the ventral surface of the second, third and fourth sacral vertebra. The straight line is drawn from the third anterior sacral foramen to the superior surface of the greater trochanter.

extended, and abduction with the hip in flexion of 90° (Travell and Simons, 1992).

The piriformis muscle exerts an oblique force on the sacrum. The plane of the muscle closely approaches the frontal plane and lies at an angle of approximately 30° to the plane of the SIJ (Mitchell, 1965).

Clinically the piriformis muscle is related to compression of the sciatic nerve at the greater sciatic foramen with symptoms like buttock and posterior thigh pain (Douglas, 1997; Freiberg and Vinke, 1934; Parziale et al., 1996). Sciatica in a large number of patients can be ascribed to spasm of the piriformis muscle (Sayson et al., 1994). Pain is aggravated by sitting or activity of the lower extremities (Barton, 1991).

The function of the piriformis muscle has not yet been associated with low back pain related to lumbopelvic mechanics. It is commonly stated that low back pain is the result of spinal disorders, in particular herniated discs or lesions of the apophysial joints (Kelsey and White, 1980). We introduced an additional theory related to SIJ stability (Snijders et al., 1998, 2004). Here, we define stability as mechanical control of the joint, including muscle control, preventing injuries of ligaments and capsules. The biomechanical model describes compression of the sacrum between the innominates by means of transversely oriented muscle forces. In unconstrained sitting and standing we measured low-level tonic activity which can be described as 'forming a deep muscle corset' (Snijders et al., 1995, 1998, 2004; Richardson et al., 2002). In sitting, this activity is lowered by crossing the legs (Snijders et al., 1995). This suggests that by crossing the legs structures dorsal to the hip joints are stretched, including the piriformis muscle. Owing to its orientation to the SIJ the piriformis muscle may in this way not only have a 'leg moving function' but also a 'SIJ stabilizing function'. The latter particularly when the leg is fixed, like in stance phase or in sitting. Therefore we decided to further study leg crossing with the aim of quantification of geometric changes which may be related to compression of the pelvic joints.

2. Methods

2.1. In vivo measurement of hip angles

To determine hip joint angles in standing and sitting, in vivo measurements were performed on 10 healthy subjects (5 male, 5 female; age 22–31 yr; height 1.65–1.83 m; weight 51–89 kg; body mass index 19–27). The chair used had a horizontal and flat seat, adjustable height and adjustable backrest, so that each subject could sit upright while leaning against the backrest. Angles of pelvis and femur were recorded in 3 or, if the subject was able to, four different postures: [1] standing upright; [2] sitting upright on the chair with hips and knees flexed 90°; [3] sitting upright on the chair, cross-legged (i.e. one knee over the other) and [4], if the subject was able to sitting upright on the chair, cross-legged (one knee over the other) and with crossed ankles (i.e. one ankle behind the other).

As a reference for backward pelvic tilt (inclination) in the sagittal plane, we recorded the angle between a T-shaped plane resting on three legs on the pubic crest and both anterior superior iliac spines, and the vertical frontal plane (Fig. 2A). The legs of the T-shaped plane could be moved towards or widened from each other to match the size of the pelvis. Flexion and adduction of the femur were determined as the angle between a line from the greater trochanter to the lateral epicondyle and, respectively, the vertical frontal and sagittal plane (Fig. 2B and C). As a reference for axial femoral rotation we recorded the angle of the tibia in relation to the vertical plane coinciding with the femoral axis (Fig. 2D). All angles were measured using a digital goniometer placed on respectively the T-shaped plane and the described lines.

2.2. In vitro measurement of piriformis muscle length

The angles found in the preceding in vivo study were used to simulate the four different postures on four embalmed specimens (2 male, 2 female) and to measure piriformis muscle length in these postures. After isolation of the pelvis and proximal half of the femur, the piriformis muscle was exposed by removal of the covering