L. Penning

Spine stabilization by psoas muscle during walking and running

As a continuation of the paper ‘Psoas muscle and lumbar spine stability’ [6], which deals with psoas function in standing position, I submitted a second paper to the *European Spine Journal* dealing with psoas function during walking and running. The message of this paper was that alternating flexion of the femora by the psoas muscles (PMs), as occurs during walking and running, does not interfere with the lumbar spine (LS) stabilizing function. As the reviewers were of the opinion that this second study did not fulfil the prerequisites for a full paper, because much of the work had already been presented in the first paper [6], I undertook to write a short ‘Letter to the Editor’ instead.

The experimental set-up of the cited paper [6] demonstrated that string pull, in order to enhance lordosis of a curved elastic structure without forward or backward bending, must have a very specific direction. In the sagittal plane, the PM (represented by a line connecting its upper part with the iliopubic eminence of the pelvis) interestingly has such specific direction with respect

to the LS. This supports the conclusion of the functional-anatomical investigations of Bogduk et al. [2], and of Santeguida and McGill [7], that bilateral PM action (with a fixed pelvis) draws the LS into more lordosis instead of flexing or extending the LS.

Although Bogduk et al. assumed that PM action would have a flexing effect on the flexed LS and an extending effect on the extended LS, Santeguida and McGill demonstrated that an anchoring retinaculum at the level of the lumbosacral junction keeps the PM in place alongside the LS, making PM action on the LS (increase of lumbar lordosis) independent of LS curvature (neutral, flexion and extension).

Although it is not especially mentioned in literature, the intrapelvic portion of the PM, from the retinaculum to the iliopubic eminence, has a fixed course similar to the vertebral portion. Only beyond the iliopubic eminence does the PM tendon change direction in relation to changes in the position of the femur (Fig. 1). This makes the intrapelvic PM direction independent of the femur position. As a result, action of the PM on the femur will not interfere with its LS stabilizing function in the sagittal plane (the pelvis is considered to be fixed by other muscles).

Bilateral PM action provides efficient stabilization of the LS in the frontal plane [3]. It must be empha-

Fig. 1 Effect of the contracting psoas muscle (PM) on the femur and the lumbar spine (LS): sagittal projection of the LS, pelvis, hip joint, femur and PM, showing 1 vertebral PM portion; 2 site of the retinaculum of Santeguida and McGill [7]; 3 intrapelvic PM portion; 4 PM bend at the iliopubic eminence; 5 PM tendon attachment at the minor trochanter of the extended femur (drawn lines); and 6 idem of flexed femur (interrupted lines). When flexing the femur, the PM draws the minor trochanter around the centre of the femoral head (curved arrow). At the same time, the contracting PM stabilizes the LS by drawing it into more lordosis, indicated by the vertical arrow (length arbitrarily chosen, the actual distance is expected to be quite short)

L. Penning (✉)
University Hospital Groningen AZG,
Room B 1.08 ZH, PO Box 30.001,
9700 RB Groningen, The Netherlands
e-mail: l.penning@rad.azg.nl,
Tel.: +31-50-3614789,
Fax: +31-50-3611813

sized, however, that this is possible only because the PMs have their specific direction in the sagittal plane; if they had not, bilateral PM action would bring the LS out of the upright position by flexion or extension. The same is true for the splinting effect of the vertebral portions of the PMs, brought about by the increase in cross-sectional area during contraction [5]. The PMs further contribute to stability by axial LS compression (increasing stiffness [4]) and increase of lordosis (tightening of the anterior longitudinal ligament [7]).

During walking and running the upper LS and the trunk, seen in the frontal plane, perform transverse and vertical translations, but remain in upright position [9]. This suggests that unilateral PM action on the moving leg, which will simultaneously bend the LS in an ipsilateral direction, is counteracted by contralateral psoas action from the standing leg. Indeed, intramuscular EMG from the hip flexor muscles during walking and running shows two bursts of each PM per locomotion cycle [1].

One burst is related to the onset of ipsilateral hip flexion; the other, occurring during the latter part of the ipsilateral swing phase, is assumed to be related to control and stabilization of the movements of the trunk in the frontal plane [1]. Action of other muscles like the erector spinae, which also shows two EMG bursts per locomotion cycle [8], may play a role, but has here to be left out of consideration.

Having attachments to all levels of the LS, the polyarticular PM bridges not only the hip joint, which has to be flexed, but also the five motion segments of the LS, which have to remain in stable upright position (the sacroiliac joint is left out of consideration because of its small mobility). This extraordinary achievement of the PM action during walking and running (strong flexion of the hip joint and, at the same time, active stabilization of the five intervertebral joints of the lumbosacral spine L1/S1) has to be attributed, at least in part, to the fixed specific direction of the PM with respect to the LS.

References

1. Andersson EA, Nilsson J, Thorstensson A (1997) Intramuscular EMG from the hip flexor muscles during human locomotion. *Acta Physiol Scand* 161:361–367
2. Bogduk N, Percy M, Hadfield G (1992) Anatomy and biomechanics of psoas major. *Clin Biomech* 7:109–119
3. Crisco JJ III, Panjabi MM (1991) The intersegmental and multisegmental muscles of the lumbar spine. A biomechanical model comparing lateral stabilizing potential. *Spine* 16:793–799
4. Janevic J, Ashton-Miller JA, Schultz AB (1991) Large compressive pre-loads decrease lumbar motion segment flexibility. *J Orthop Res* 9:228–236
5. Nachemson A (1966) EMG studies on the vertebral portion of the psoas muscle. *Acta Orthop Scand* 39:47–57
6. Penning L (2000) Psoas muscle and lumbar spine stability: a concept uniting existing controversies. Critical review and hypothesis. *Eur Spine J* 9:577–585
7. Santaguida PL, McGill SM (1995) The psoas major muscle: a three-dimensional geometric study. *J Biomech* 28:339–345
8. Thorstensson A, Carlson H, Zomlefer MR, Nilsson J (1982) Lumbar back muscle activity in relation to trunk movements during locomotion in man. *Acta Physiol Scand* 116:13–20
9. Thurston AJ, Harris JD (1983) Normal kinematics of the lumbar spine and pelvis. *Spine* 8:199–205