The Influence of hamstring extensibility on spinal and pelvic postures in highly trained paddlers

Pedro A. López-Miñarro, José M. Muyor**, Fernando Alacid**

*University of Murcia (Spain)

**University of Almería (Spain)

Abstract

Objectives. To determine whether the degree of hamstring muscle extensibility influences the sagittal spinal curvatures in standing and maximal trunk flexion on young athletes. Methods. Forty-two young elite kayakers (mean age: 15.09 ± 0.63 years) were recruited. Thoracic and lumbar curvatures and pelvic position were evaluated with a Spinal Mouse system in standing position and maximal trunk flexion with knees extended (toe-touch test) and flexed. Hamstring muscle extensibility was determined by passive straight leg raise test (PSLR). The sample was divided into two groups with regard to straight leg raise angle (PSLR < 80º, n=20, and PSLR ≥ 80º, n=20). Results. Subjects with lower extensibility presented higher thoracic angle and a more posterior pelvic tilt in maximal trunk flexion. However, no significant differences were found between both groups when standing. The lumbar curve was not affected by hamstring extensibility. Conclusions. Lower hamstring extensibility is related to increased thoracic curve and more posterior pelvic tilt when maximal trunk flexion is performed, which can overload the spine. A systematic stretching programme to improve hamstring extensibility should be incorporated into training activities.

Key words: *thoracic, lumbar, pelvic, spine, straight leg raise.*

Introduction

Sagittal spinal curvatures are geometric parameters, which influence mechanical properties [9, 18]. Sagittal alignment influences postural loading and load balance of the intervertebral disc in healthy male and female subjects [9, 22, 32]. Abnormal spinal curvatures cause increased forces to act upon the intervertebral discs. Alterations in spinal curvatures may potentially influence the development of lower back pain [7, 30].

The sagittal spinal curvatures are influenced by several factors. Hamstring muscle extensibility has been associated with changes in lumbopelvic rhythm [4] and spinal posture [13-17, 26]. Earlier studies found that hamstring muscle extensibility influences pelvic and spinal postures in maximal trunk flexion with knees extended. Lower hamstring muscle extensibility has been associated with decreased flexion range of motion of the hip and lumbar spine and increased thoracic flexion [5,6]. Other researches [10,27] have reported an association between greater lumbar spinal flexion and reduced hamstring extensibility when the sit-and-reach test is performed.

Some studies have compared the spinal and pelvic postures between subjects in relation to hamstring extensibility. Tully and Stillman [31] found differences in the spinal posture between successful and unsuccessful toe-touchers. Gajdosik et al. [6] found differences in hip (pelvis) flexion between men with or without reduced hamstring extensibility. Carregaro and Coury [1] found that the subjects with decreased hamstring extensibility adopted higher spinal angles and a limitation on pelvic movements during handling tasks. López-Miñarro and Rodríguez [15] found that hamstring criterion-related validity of the sit-and-reach and toe-touch tests is related to hamstring muscle extensibility. These tests were not valid as measures of hamstring extensibility for subjects with reduced hamstring muscle extensibility. Other studies [2, 3] found differences in pelvic movement between short and long hamstring subjects when active straight leg raise was performed.

However, all these studies analyzed non-athlete population. In paddlers, López-Miñarro and Alacid [13] found that the hamstring muscle extensibility influences the thoracic and pelvic postures when the sit-and-reach test was performed.

The relation of hamstring muscle extensibility and spinal posture in several positions should be analyzed. For this reason, the objective of this study was to compare the spinal and pelvic postures between paddlers in relation to their hamstring muscle extensibility.

Materials and methods

Forty-two young kayakers were recruited for the study (mean ± SD, age: 15.09 ± 0.63 years; height: 172.16 ± 8.70 cm; body mass: 64.01 ± 9.21 kg). The inclusion criteria were more than 4 years' paddling experience and training at least six times per week. Paddlers were excluded if they presented pain induced or exacerbated by the test procedures, injury preventing participation in paddling training before testing, or known structural spinal pathology.

Procedures

An Institutional Ethical Committee approved the study and all subjects and parents or guardians signed an informed consent form before participation. The Spinal Mouse system, a hand-held, computer-assisted electromechanical-based device, was used to measure sagittal spinal curvatures and pelvic inclination in relaxed standing, and maximal trunk flexion with knees extended (toe-touch test) and flexed. Hamstring muscle extensibility was determined in both legs by passive straight leg raise test. The measurements were made in a randomized order. No warm-up or stretching exercises were performed by the subjects prior to the test measurements. The subjects were allowed to rest briefly standing up for 5 minutes between measures. All measurements were made during the same testing session and were administered under the same environmental conditions. Participants were instructed not to undertake a weight-training session or strenuous exercise the day before testing to ensure consistent test conditions.

Prior to measurements, the principal researcher determined by palpation and marked on the skin surface with a pencil the spinous process of C7 (starting point) and the top of the anal crease (end point). The Spinal Mouse was guided along the midline of the spine (or slightly paravertebrally in particularly thin individuals with prominent processus spinous) starting at the processus spinous of C7 and finishing at the top of the anal crease (approximately S3). For each testing position, the thoracic (T1-2 to T11-12) and lumbar (T12-L1 to the sacrum) spine and the position of the sacrum and the hips (difference between the sacral angle and the vertical) were recorded. In the lumbar curve, negative values corresponded to lumbar lordosis (posterior concavity). With respect to the pelvic position, a value of 0º represented the vertical position. Thus, a greater angle reflected an anterior pelvic tilt while a lower angle (negative values) reflected a posterior pelvic tilt.

Standing

The subject assumed a relaxed position, with the head looking forward, the arms hanging by the side, the knees normally extended, and the feet shoulder-width apart (Figure 1).

Figure 1. Standing position.

Maximal trunk flexion with knees extended

Spinal and pelvic angles were measured when the subjects reached the maximal trunk flexion in standing with knees extended (toe-touch test) (Figure 2). The toe-touch test was measured as described in a previous study [19]. The subjects were required to stand with knees straight, legs together so that the soles of the feet were flat against the end of a constructed box (ACUFLEX I Flexibility tester, height = 32 cm). With palms down, placing one hand on top of the other, the subjects slowly reached forward as far as possible sliding the hands along the box with the knees as straight as possible and held the position for approximately five seconds while the spinal curvatures were measured.

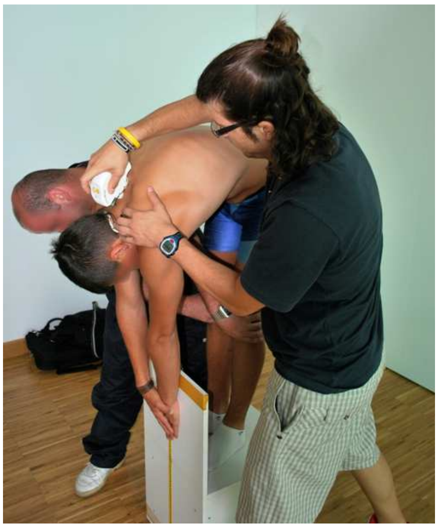

Figure 2. Toe-touch test.

Maximal trunk flexion with knees flexed in sitting

Figure 3. Maximal trunk flexion in sitting.

Spinal and pelvic angles were measured when the subjects reached the maximal trunk flexion with knees flexed in sitting position (Figure 3). The subjects sitting with knees flexed (90º) were asked to bend maximally forward. When maximal trunk flexion was achieved the spinal posture was measured.

Hamstring muscle extensibility

The criterion measure of hamstring extensibility was determined by performing a passive straight leg raise (PSLR) on each limb in counterbalanced order. While the participant was in the supine position, a Uni-level inclinometer (ISOMED, Inc., Portland, OR) was placed over the distal tibia. The participant's leg was lifted passively by the tester into hip flexion. The knee remained straight during the leg raise. The ankle of the tested leg was restrained in plantar flexion. Moreover, the pelvis was fixed to avoid the posterior pelvic tilt and an auxiliary tester kept the contralateral leg straight to avoid external rotation [28]. The criterion score of hamstring extensibility was the maximum angle (degree) read from the inclinometer at the point of maximum hip flexion. Angles were recorded to the nearest degree for each leg. Two trials were given for each leg and the average of the two trials on each side was used for subsequent analysis.

Only subjects with PSLR difference between right and left sides lower or equal to 5 degrees were included in the analysis. Two participants were excluded. The left and right PSLR measurements were then averaged. After this, the sample was divided into two groups in relation to the median value: lower hamstring extensibility group (PSLR < 80º, n = 20), and greater hamstring extensibility group (PSLR ≥ 80º, n = 20).

Statistical Analysis

The hypotheses of normality and homogeneity of the variance were analyzed via Shapiro-Wilk and Levene tests, respectively. Descriptive statistics including means and standard error of the mean were calculated. An independent t-test was conducted to examine differences between both groups for all dependent variables. The data were analyzed using the SPSS 15.0. The level of significance was set at $p \leq 0.05$.

Results

The mean values (± standard error of the mean) of PSLR angle were was 74.57 ± 1.85º for lower hamstring extensibility group and 87.35 ± 2.06º for greater hamstring extensibility group ($p < 0.001$). No significant differences were found between right and leg PSLR angle in any group.

The mean values of thoracic curve, lumbar curve and pelvic tilt for both groups are presented in figures 4, 5 and 6, respectively. No significant differences were found in standing between both groups. The thoracic curve and pelvic tilt showed the higher differences between lower and greater hamstring extensibility groups. No differences were found in lumbar curve in any position.

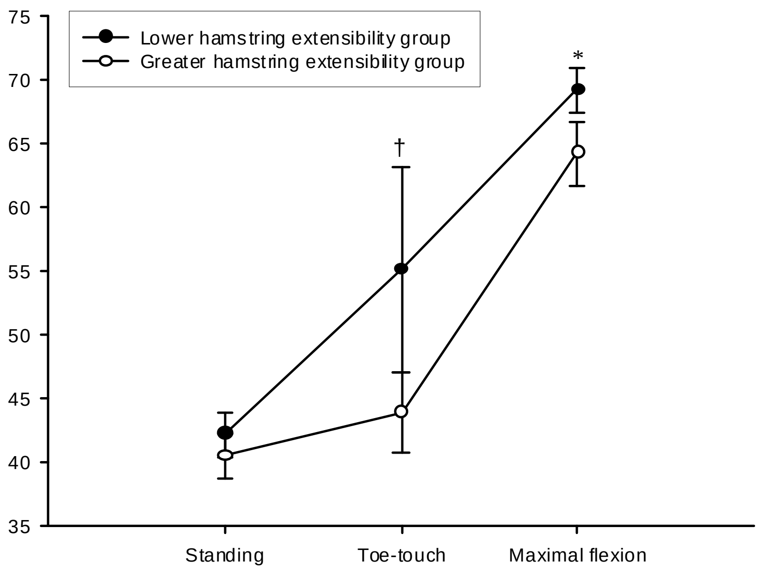

Figure 4. Mean (± standard error of the mean) of thoracic curve in standing, toe-touch test and maximal trunk flexion with knees flexed for lower and greater hamstring extensibility groups. * $p < 0.05$; † $p < 0.01$.

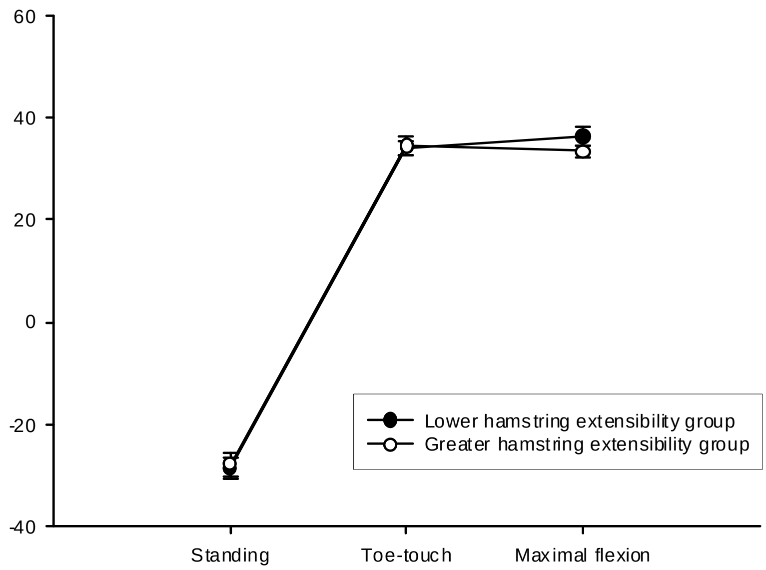

Figure 5. Mean (± standard error of the mean) of lumbar curve in standing, toe-touch test and maximal trunk flexion with knees flexed for lower and greater hamstring extensibility groups.

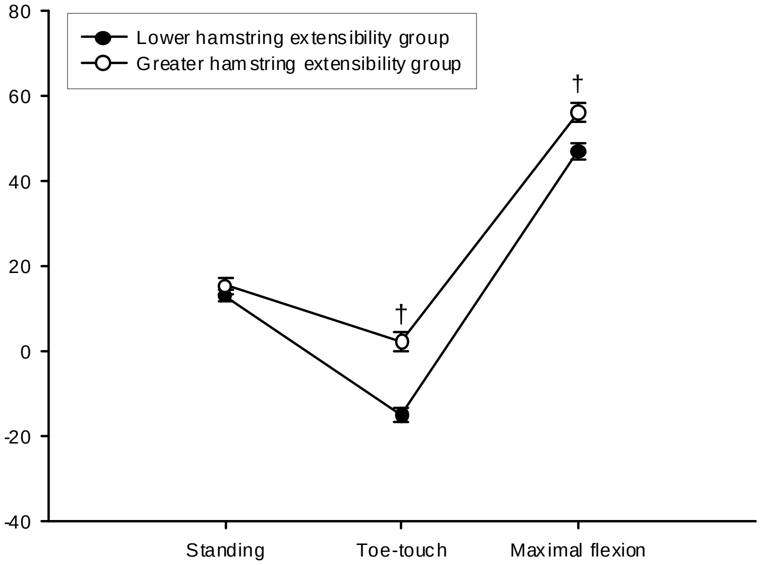

Figure 6. Mean (± standard error of the mean) of pelvic tilt in standing, toe-touch test and maximal trunk flexion with knees flexed for lower and greater hamstring extensibility groups. † $p < 0.01$.

Discussion

The objective of this study was to analyze the relation between hamstring muscle extensibility and spinal and pelvic postures in several positions. This study found that lower hamstring extensibility is associated with greater thoracic angles and more posterior pelvic tilt when maximal trunk flexion is performed. In standing, no differences were found. These results are in concordance with previous studies in younger paddlers [13] and young adults [5].

The subjects with lower extensibility presented higher thoracic angles during the flexion movements, and it could indicate that they were compensating for their pelvic restriction. Tully and Stillman [31] stated that subjects with greater ability to flex the hips with extended knees can reach their toes without needing to use the full available thoracic motion. Several studies have found that females reach lower thoracic angles when sit-and-reach tests are performed [13-17, 19, 26]. Given that females tend to have greater hamstring extensibility than males, it is possible that gender-specific postures are related to these inherent differences in extensibility.

Hamstring extensibility has been shown to affect lumbo-sacral posture due to the muscles' direct attachment on the ischial tuberosities. Previous studies found that pelvic tilt is conditioned by hamstring extensibility [1, 2, 5]. Because the hamstring muscle originates on the ischial tuberosity of the pelvis, the tension in the hamstring has a direct influence in pelvic tilt during flexion movements, especially when knees are extended. Indeed, lower hamstring extensibility was related with more posterior pelvic tilt. This posture might be associated with some risk factors. In fact, it has been recognized that, during trunk flexion, the flexed position of the lumbar spine produces larger shear forces [23].

Differences between groups were higher in the toe-touch test than maximal trunk flexion with knees flexed. When the knees are flexed, the tension in the hamstrings is reduced and the hamstring extensibility has a limited influence in spinal posture. The hamstring muscles may only influence the spinal and pelvic postures when the trunk is moderately or maximally flexed and the hamstrings are under tension. When trunk flexion is performed with knees flexed (90º) the pelvis reached a greater anterior pelvic tilt.

The hamstring extensibility appears not affect the lumbar curve in any position. Several studies referred a weak and no significant correlation between lumbar curve and hamstring extensibility in bending postures [8, 12, 16]. However, Gajdosik et al. [6] found that lumbar flexion was influenced by hamstring extensibility during maximal trunk flexion but it had no effect on standing. Kendall et al. [10] and Sahrmann [27] found an association between excessive lumbar spinal flexion and reduced hamstring extensibility when forward bending or touching the toes.

The spinal curvatures influence intradiscal pressures, compressive and shear forces in the intervertebral discs [9,18,22,32]. Reduced hamstring extensibility is related to increased thoracic angles and posterior pelvic tilt, which can overload the spine during sport and daily activities. The restriction of pelvic movement is considered to be predisposing factor for low back pain. Thus, if the pelvic tilting is limited, the more lax spinal tissues will be stressed [21].

Systematic hamstring stretching should be included in the training program of athletes to reduce the thoracic intervertebral flexion and improve anterior pelvic tilt during trunk flexion movements. Some studies have found improvements on hamstring extensibility after a stretching program [20, 24, 25]. Li et al. [11] found that hip motion during late and total forward bending was increased after stretching program.

Conclusion

The paddlers with lower hamstring extensibility show a greater thoracic and more posterior pelvic tilt when maximum trunk flexion is performed with knees flexed and extended. Because lower hamstring extensibility is related with poor thoracic and pelvic postures, a systematic stretching programme to improved hamstring extensibility is recommended.

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Correspondence

Pedro A. López-Miñarro
Department of Physical Education. Faculty of Education.
Campus Universitario de Espinardo. CP. 30100 Murcia (Spain)
Telephone number: 34868887051; FAX number: 34868884146
e-mail: palopez@um.es