©Journal of Sports Science and Medicine (2013) 12, 588-593
http://www.jssm.org

Research article

Sagittal Spinal Morphology in Highly Trained Adolescent Tennis Players

José M. Muyor [1]✉, Estefanía Sánchez-Sánchez [2], David Sanz-Rivas [3], Pedro A. López-Miñarro [4]
[1] Faculty of Education Sciences, Nursing and Physiotherapy, Laboratory of Kinesiology, Biomechanics and Ergonomics (KIBIOMER), University of Almería, Almería, Spain; [2] Faculty of Physical Activity and Sport Sciences, University of Granada, Granada, Spain; [3] Faculty of Sport Sciences, University Camilo José Cela, Madrid, Spain; [4] Faculty of Education, University of Murcia, Murcia, Spain.

Abstract
Sports with a predominance of forward-bending and extension postures have been associated with alterations in the sagittal spinal curvatures and greater risk of spinal injury. Because, the tennis players adopt these postures, the aims of this study were: 1) to describe spinal curvatures and pelvic tilt in male and female highly trained adolescent tennis players during relaxed standing posture and with thoracic spine corrected (in prone lying on the floor); and 2) to determine the frequency of thoracic hyperkyphosis and lumbar hypo/hyper lordosis in these postures. Forty adolescent tennis players (24 male and 16 female) aged 13-18 years, participated voluntarily in this study. The Spinal Mouse system was used to measure sagittal spinal curvatures and pelvic tilt. The mean values in the relaxed standing posture were 43.83° ± 7.87° (thoracic kyphosis), - 27.58° ± 7.01° (lumbar lordosis), and 13.38° ± 5.57° (pelvic tilt) for male tennis players, respectively; and 36.13° ± 6.69° (thoracic kyphosis), - 32.69° ± 5.06° (lumbar lordosis), 20.94° ± 5.36° (pelvic tilt) for female tennis players ($p < 0.05$ between genders in all spinal parameters). The male and female tennis players showed a frequency of 62.5% and 93.8% ($p = 0.032$) for neutral thoracic kyphosis, and 83.3% and 93.8% ($p = 0.062$) in neutral lumbar lordosis, respectively. In conclusion, due to the high percentage of neutral spinal curvatures in both male and female tennis players, to practice tennis in these levels does not alter sagittal spinal morphology in the relaxed standing posture in adolescent highly trained tennis players.

Key words: Spinal mouse, posture, thoracic, lumbar, pelvic.

Introduction

The spine has several physiological curvatures in the sagittal plane. During development ages these spinal curvatures evolve as the changes resultants from posture and balance (Cil et al., 2005) and they are more sensible to alter the spinal morphology. In this sense, in athletes, Uetake et al. (1998) found that the vertebral curvatures had distinctive features and shapes depending on specific sport practised.

Tennis is an acyclic and one-sided sport that is classified in sports games as involving a racquet and a ball. Adolescent tennis players spend several years training to reach professional status. Fast movements of the trunk in flexion and extension in the sagittal and frontal plane, and rotational movements around the long axis are very common in this sport. In this sense, repetitive, strenuous, and intense training during developmental stage play an important role in the occurrence of trunk injuries or adaptation in the spinal morphology (Ellenbeckker et al., 2009; Pluim et al., 2006). In this line, alterations in the lumbar spine joints and high levels of abdominal and lumbar muscle activation have been reported in elite adolescent tennis players (Alyas et al., 2007; Chow et al., 2009).

Alterations in physiological spinal curvatures have been associated to an increased risk of injury due to an increase of intervertebral stress (Beach et al., 2005), viscoelastic deformation of spinal tissues (Solomonow et al., 2003) or higher intradiscal pressure (Wilke et al., 1999). It is important to consider these implications in sports medicine and training to prevent possible spinal injuries. For these reasons, several studies have analysed the influence of specific postures on the spinal curvatures in sports where flexion-extension movements of the trunk are frequently carried out, such as in young ballet dancers (Nilsson et al., 1993), skiers, (Alricsson and Werner, 2006; Rachbauer et al., 2001), volleyball players (Grabara and Hadzik, 2009), soccer players (Wodecki et al., 2002), and rowers (Caldwell et al., 2003). Also, athletes in sport where the thoracic and/or lumbar spine are maintained in flexion, such as in paddlers (López-Miñarro et al., 2010; 2011), wrestlers (Rajabi et al., 2007), and cyclists (Muyor et al., 2011a; 2011b; 2012) have been analysed. However, to date no study has assessed the implications of this in tennis.

Sports with a predominance of forward-bending postures have been associated with greater thoracic kyphosis in standing (Rajabi et al., 2007). Alricsson and Werner (2006) reported an increased thoracic kyphosis in adolescent elite skiers after five years of intensive training. In canoeists, López-Miñarro et al. (2010) found a high frequency of thoracic hyperkyphosis in standing. However, when these athletes were in their canoes, the posture was characterized by reduced thoracic and lumbar curvatures. Muyor et al. (2011b; 2011c) reported similar findings in elite cyclists. These authors found a high frequency of thoracic hyperkyphosis in standing, but on the bicycle the thoracic spine was straighter than in the standing posture. Grabara and Hadzik (2009) observed asymmetries brought about by unilateral loads and a progressive thoracic kyphosis and a flattened lumbar lordosis in adolescent female volleyball players.

Because the sport-specific asymmetric work in tennis, combined with trunk flexion and hyperextension

Received: 27 August 2012 / Accepted: 16 July 2013 / Published (online): 01 September 2013

Table 1. Descriptive characteristics of tennis players. Data are means (± SD).

	Male (n=24)	Female (n=16)	Total sample
Age (years)	15.75 (1.42)	15.65 (1.14)	15.70 (1.30)
Stretch stature (m)	1.74 (1.00)	1.66 (0.81)	1.71 (1.00)
Body mass (kg)	67.20 (10.93)	61.44 (6.43)	64.89 (9.72)
BMI (kg·m^{-2})	21.82 (2.05)	22.06 (1.47)	21.92 (1.82)
Training (years)	6.38 (2.96)	6.59 (1.47)	6.46 (2.45)
Training (days/week)	5.33 (.70)	5.50 (.51)	5.40 (.63)
Training (hours/day)	2.95 (.72)	2.84 (.65)	2.91 (.68)

BMI: Body Mass Index

movements could generate morphological spine adaptations in adolescent tennis players, the aims of this study were: 1) to describe spinal curvatures and pelvic tilt in male and female highly trained adolescent tennis players during relaxed standing posture and with thoracic spine corrected (in prone lying on the floor); and 2) to determine the frequency of thoracic hyperkyphosis and lumbar hypo/hyper lordosis in these postures.

Methods

Participants

Forty adolescent tennis players (24 male and 16 female) aged 13-18 years, participated voluntarily in this study. Sample characteristics are shown in Table 1.

The inclusion criteria were 1) trained between 2-5 hours on a daily basis; 2) trained 5-7 times per week; 3) had played tennis in federated competitions at least 4 years The exclusion criteria were 1) a history of spinal pain in the three months prior to the study, 2) a history of spinal surgery, or 3) a medically diagnosed spinal disorder, e.g. scoliosis. Because the muscular fatigue could influence in the posture, all participants were instructed to avoid physical activity 24 hours prior to the study.

Procedures

This study was approved by the Ethics and Research Committee of the University of Almería (Spain). It was designed and conducted in concordance with the Ethical Standards in Sports and Exercise Science Research (Harris and Atkinson, 2009). All participants were informed of the procedures and signed a consent form prior to the measurements.

Sagittal spinal curvatures and pelvic tilt were measured in the relaxed standing position and prone position, using a Spinal Mouse system (Idiag, Fehraltdorf, Switzerland). The Spinal Mouse is an electronic computer-aided measuring device, which measures sagittal spinal range of motion and intersegmental angles in a non-invasive way, a so-called surface-based technique. The Spinal Mouse is a valid and reliable device to measure the spinal curvatures and pelvic tilt (Guermazi et al., 2006; Mannion et al., 2004; Post and Leferink, 2004).

All measurements were performed twice and the average was calculated. Each subject was evaluated by the same examiner in a single session. Prior to taking measurements, the main researcher determined the spinous process of C7 (starting point) and the top of the anal crease (end point) by palpation and marked the skin surface with a pencil. The Spinal Mouse was guided along the midline of the spine (or slightly paravertebrally, particularly in thin individuals with prominent processus spinous) starting at the processus spinous of C7 and finishing at the top of the anal crease (approximately S3) (Figure 1). For each testing position, the position of 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 plane) were recorded. Negative values corresponded to lumbar lordosis (posterior concavity). The tennis players were examined wearing underwear and barefoot. No warm-up or stretching exercises were performed by the subjects prior to the test measurements. The measurements were performed in random order. There was a 5 minutes rest between the different tests. The laboratory temperature was standardised at 24° C.

Figure 1. Evaluation of the spinal curvatures and pelvic tilt in relaxed standing posture with the Spinal Mouse system.

Relaxed standing

The tennis players stood in a straight position on the floor with the eyes and ears in line horizontally, arms relaxed at the side of the body, knees close to individual full extension, and feet shoulder-width apart. To classify the posture in categories for thoracic kyphosis, the thoracic curvature classification proposed by Mejia et al. (1996) was used: values between 20º and 45º were accepted as neutral thoracic kyphosis, values below 20º were considered thoracic hypokyphosis, and values above 45º were considered thoracic hyperkyphosis. For the lumbar curvature, values between 20º and 40º were considered neutral, values below 20º were considered hypolordotic, and values above 40º were considered hyperlordotic (Tüzün et al., 1999).

Prone position

The tennis players laid face down on the floor with arms extended vertically over the head so as to raise the shoulders. The thorax and forehead remained in contact with the floor.

Statistical analysis

Means and standard deviations were calculated for all variables. The hypotheses of normality and homogeneity of variance were analysed using the Kolmogorov-Smirnov test and Levene's test, respectively. Pairwise comparison of means (Student t test) was used to examine the differences between male and female tennis players in relaxed standing posture. Paired t test was used to compare the thoracic spine between relaxed standing posture and lying on the floor.

Differences among categorical variables were evaluated using Fisher´s exact test. The data was analysed using the SPSS v.18.0. The level of significance was set at $p \leq 0.05$.

Results

The means and standard deviations of thoracic kyphosis, lumbar lordosis and pelvic tilt for both groups of tennis players are shown in Figure 2. In the relaxed standing posture, significant differences were found between male and female tennis players ($p < 0.05$). The male tennis players showed greater thoracic kyphosis, and lower lumbar lordosis and pelvic tilt than the female tennis players (Figure 2).

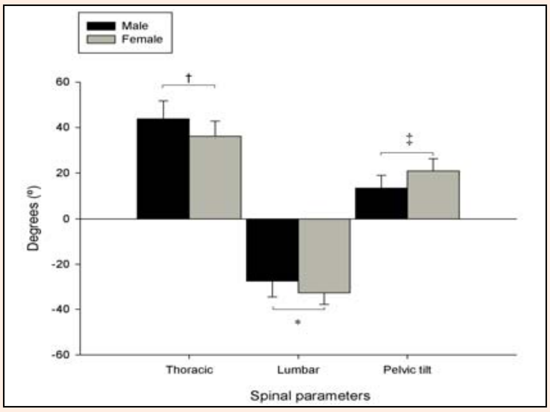

Figure 2. Mean ± standard deviation of thoracic and lumbar curvatures and pelvic tilt in relaxed standing posture. * $p < 0.05$; † $p < 0.01$; ‡ $p < 0.001$

The paired *t* test analysis showed significant differences for thoracic spine between relaxed standing and in prone posture ($p < 0.001$) in both males and females tennis players. The thoracic spine reduced from 43.83º ± 7.87º in relaxed standing posture to 18.12º ± 4.08º in prone posture (-25.70º ± 9.48º of difference) in male tennis players. The thoracic spine reduced from 36.13º ± 6.69º in relaxed standing posture to 28.25º ± 4.53º in prone posture (-7.87º ± 8.38º of difference) in female tennis players.

The percentage of frequencies in each thoracic and lumbar category in the relaxed standing posture for male and female tennis players are presented in Figures 3 and 4, respectively. The male tennis players showed 31.3% more cases for thoracic hyperkyphosis than the female tennis players ($p = 0.032$). The female tennis players showed a high percentage for neutral lumbar lordosis and without any cases with lumbar hypolordosis.

Discussion

One of the objectives in the present study was to determine the frequency of thoracic hyperkyphosis and lumbar hypo/hyper lordosis during the relaxed standing posture and to compare the results between male and female highly trained adolescent tennis players.

The main finding of the present study was that, when the tennis players were classified by thoracic and lumbar angle values proposed by Mejia et al. (1996) and Tuzün et al. (1999) respectively, a high percentage of the total sample showed angular values in the references of normality (75% neutral thoracic kyphosis and 87.5% neutral lumbar lordosis). Moreover, we found statistical reductions in thoracic spine in both genders when relaxed standing posture and lying on the floor were compared. These results reported that the cases with thoracic hyperkyphosis found in male and female tennis players were functional and not structural postures.

In the current study, the normality percentages have been greater than previous studies. López-Miñarro et al. (2010) found 37% of young kayakers having neutral thoracic kyphosis and 63% with hyperkyphosis, whereas the percentage in neutral lumbar lordosis was in concordance with the current study (87.5%). Muyor et al. (2011a) reported that 41.7% of elite cyclists showed neutral thoracic kyphosis and 58.3% thoracic hyperkyphosis.

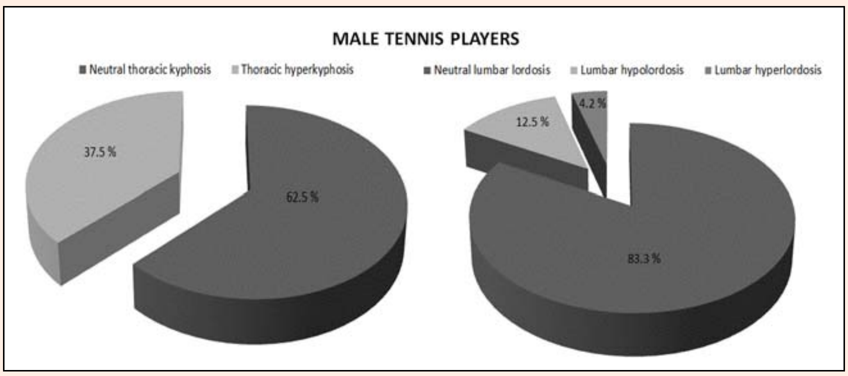

Figure 3. Percentage of male tennis players in each category of thoracic and lumbar curvatures in the relaxed standing posture.

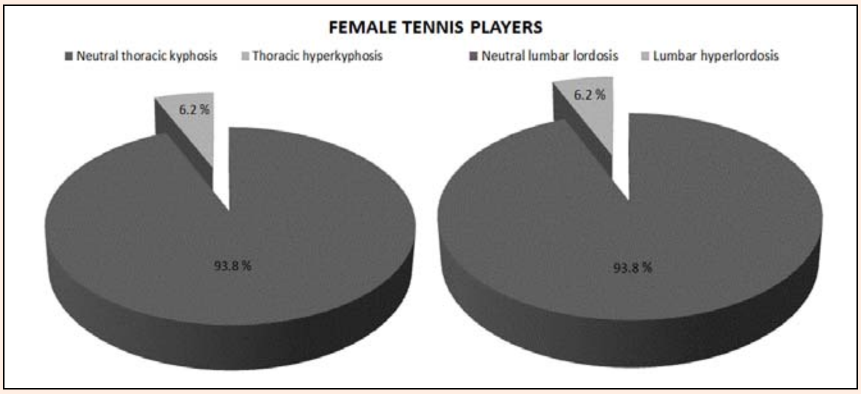

Figure 4. Percentage of female tennis players in each category of thoracic and lumbar curvatures in the relaxed standing posture.

It appears that these cyclists maintained the thoracic spine straighter on the bicycle than while standing on the floor. The lumbar spine showed 88.3% in neutral lumbar values. In other study, Muyor et al. (2011b) reported that elite cyclists showed a statistically higher thoracic hyperkyphosis than non-athlete subjects. These authors justified their findings with specific sport adaptations. In this sense, Grabara and Hadzik (2009) found that a kyphotic posture tended to be more frequent and the lordotic one less frequent in volleyball players than in untrained subjects. The authors attributed that finding to the typical volleyball posture consisting of forward bending with rounded back, as well as, the arms and shoulders protruding. Wojtys et al. (2000) reported that a high intensity training increases the risk of developing adolescent hyperkyphosis. In this sense, Alricsson and Werner (2006) found that after 5 years of intensive training the skiers increased their thoracic kyphosis but no change in lumbar lordosis. However, in the current study, where the tennis players had an average experience around 6 year of training, they showed a low percentage of thoracic hyperkyphosis.

When the spinal values were compared between male and female tennis players, the female tennis players showed a higher percentage in neutral thoracic kyphosis and lumbar lordosis (93.8% and 93.8%, respectively) than male tennis players (62.5% and 83.3%, respectively). These differences in the percentages of spinal references in the relaxed standing posture may be because the female tennis players showed statistical differences in a greater anterior pelvic tilt. These results are in agreement with Widhe (2001) who reported similar results in adolescent girls (15-16 years, the same ages that the average age in the current study). However, this author did not evaluate the pelvic tilt.

The pelvis is considered the base of the spine. An anterior pelvic tilt increases the lumbar lordosis and a posterior pelvic tilt decreases the lumbar lordosis. In this sense, a person properly trained in a pelvic tilt maneuver can voluntarily rotate his pelvis a sufficient amount to alter the lumbar lordotic curve (Day et al., 1984). Moreover, the lumbar spine and pelvis work together in order to maintain lumbopelvic balance (Chanplakorn et al., 2010). An asymptomatic population tends to stand with a relatively stable sagittal global balance (Mac-Thiong et al., 2010). For these reasons, the female tennis players who showed a greater anterior pelvic tilt and lumbar lordosis could adopt a lower thoracic kyphosis to find the best balance.

On the other hand, Chow et al. (2009) reported high lumbar spinal loads expected during the phase of acceleration because of the hyperextension posture and profound front-back and bilateral co-activations in lower trunk muscles. In the current study, the spinal curvatures and pelvic tilt in the specific sport posture as in the serve were not evaluated. This might be an important issue for future research to quantify the spinal angular values in specific tennis postures and their relationships with possible spine injuries. It might also be interesting to compare the sagittal spinal curvature between elite tennis players and non-athlete population and to evaluate the spinal curvatures in frontal plane to identify possible scoliosis in tennis players. Moreover, future studies should be done to analyse the spinal curvatures in tennis players according to their specific hand grip.

Conclusion

In conclusion, tennis does not alter sagittal spinal morphology in the relaxed standing posture in adolescent highly trained tennis players. The thoracic hyperkyphotic posture in relaxed standing in male tennis players may be more related to factors other as a lack of postural scheme than the specific training in tennis. Due to the differences found in the spinal curvatures and pelvic tilt between male and female tennis players, it is recommended to separately analyse both groups and to develop the specific postural strategies in each group.

Acknowledgments
We are grateful to Dr. Mikel Zabala for his cooperation with the study.

References

Alricsson, M. and Werner, S. (2006) Young elite cross-country skiers and low back pain. A 5-year study. *Physical Therapy in Sport* **7,** 181-184.

Alyas, F., Turner, M. and Connell, D. (2007) MRI findings in the lumbar spines of asymptomatic, adolescent, elite tennis players. *British Journal of Sports Medicine* **41,** 836-841.

Beach, T., Parkinson, R., Sothart, P. and Callaghan, J. (2005) Effects of prolonged sitting on the passive flexion stiffness of the in vivo lumbar spine. *Spine Journal* **5,** 145-154.

Caldwell, J.S., McNair, P.J. and Williams, M. (2003) The effects of repetitive motion on lumbar flexion and erector spinae muscle activity in rowers. *Clinical Biomechanics* **18,** 704-711.

Chanplakorn, P., Wongsak, S., Woratanarat, P., Wajanavisit, W. and Loahacharoensombat, W. (2010) Lumbopelvic alignment on standing lateral radiograph of adult volunteers and the classification in the sagittal alignment of lumbar spine. *European Spine Journal* **20,** 706-712.

Chow, J.W., Park, S.A. and Tilman, M.D. (2009) Lower trunk kinematics and muscle activity during different types of tennis serves. *Sports Medicine, Arthroscopy, Rehabilitation, Therapy & Technology* **13(1),** 24

Cil, A., Yazici, M., Uzumcugil, A., Kandemir, U., Alanay, A., Alanay, Y., Acaroglu, R.E. and Surat, A. (2005) The evolution of sagittal segmental alignment of the spine during childhood. *Spine* **30,** 93-100.

Day, J.W., Smidt, G.L. and Lehmann, T. (1984). Effect of pelvic tilt on standing posture. *Physical Therapy* **64,** 510-516.

Ellenbecker, T.S., Pluim, B., Vivier, S. and Sniteman, C. (2009) Common injuries in tennis players: Exercises to address muscular imbalances and reduce injury risk. *Strength and Conditioning Journal* **31,** 50-58.

Grabara, M. and Hadzik, A. (2009) Postural variables in girls practicing volleyball. *Biomedical Human Kinetics* **1,** 67-71.

Guermazi, M., Ghroubi, S., Kassis, M., Jaziri, O., Keskes, H., Kessomtini, W., Hammouda I.B. and Elleuch, M.H. (2006) Validity and reliability of Spinal Mouse® to assess lumbar flexion. *Annales de Réadaptation et de Médecine Physique* **49,** 172-177.

Harriss, D.J and Atkinson, G. (2009) International Journal of Sports Medicine – Ethical Standards in Sport and Exercise Science Research. *International Journal of Sports Medicine* **30,** 701-702.

López-Miñarro, P.A., Muyor, J.M. and Alacid, F. (2010) Sagittal spinal curvatures and pelvic tilt in elite young kayakers. *Medicine dello Sport* **63,** 509-519.

López-Miñarro, P.A., Muyor, J.M. and Alacid, F. (2011) Sagittal spinal and pelvic postures of high-trained in young canoeists. *Journal of Human Kinetics* **29,** 41-48.

Mac-Thiong, J.M., Roussouly, P., Berthonnaud, E. and Guigui, P. (2010) Sagittal parameters of global spinal balance. Normative values from a prospective cohort of seven hundred nine Caucasian asymptomatic adults. *Spine* **35,** E1193-E1198.

Mannion, A.F., Knecht, K., Balaban, G., Dvorak, J. and Grob, D. (2004) A new skin-surface device for measuring the curvature and global and segmental ranges of motion of the spine: reliability of measurements and comparison with data reviewed from the literature. *European Spine Journal* **13,** 122-136.

Mejia, E.A., Hennrikus, W.L., Schwend, R.M. and Emans, J.B. (1996) A prospective evaluation of idiopathic left thoracic scoliosis with MRI. *Journal of Pediatric Orthopedics* **16,** 354-358.

Muyor, J.M., Alacid, F., López-Miñarro, P.A. (2011a) Influence of hamstring muscle extensibility on spinal curvatures and pelvic tilt in highly trained cycling. *Journal of Human Kinetics* **29,** 15-23.

Muyor, J.M., Alacid, F., López-Miñarro, P.A. and Casimiro, A.J. (2012) Evolution of spinal morphology and pelvic tilt in cyclists of different ages. A cross sectional study. *International Journal of Morphology* **30,** 199-204.

Muyor, J.M., López-Miñarro, P.A. and Alacid, F. (2011b) A comparison of the thoracic spine in the sagittal plane between elite cyclists and non-athlete subjects. *Journal of Back and Musculoskeletal Rehabilitation* **24,** 129-135

Muyor, J.M., López-Miñarro, P.A. and Alacid, F. (2011c) Spinal posture of thoracic and lumbar spine and pelvic tilt in highly trained cyclists. *Journal of Sports Science and Medicine* **10,** 355-361.

Nilsson, C., Wykman, A. and Leanderson, J. (1993) Spinal sagittal mobility and joint laxity in young ballet dancers. *Knee Surgery, Sports Traumatology, Arthroscopy* **1,** 206-208.

Pluim, B.M., Staal, J.B., Windler, G.E. and Jayanthi, N. (2006) Tennis injuries: occurrence, aetiology, and prevention. *British Journal of Sports Medicine* **40,** 415-423.

Post, R.B. and Leferink, V.J. (2004) Spinal mobility: sagittal range of motion measured with the SpinalMouse, a new non-invasive device. *Archives of Orthopaedic and Trauma Surgery* **124,** 187-192.

Rachbauer, F., Sterzinger, W. and Eibl G. (2001) Radiographic abnormalities in the thoracolumbar spine of young elite skiers. *American Journal of Sports Medicine* **29,** 446-449.

Rajabi, R., Doherty, P., Goodarzi, M. and Hemayattalab, R. (2007) Comparison of thoracic kyphosis in two groups of elite Greco-Roman and free style wrestlers and a group of non-athletic subjects. *British Journal of Sports Medicine* **42,** 229-232.

Solomonow, M., Zhou, B., Baratta, R.V. and Burger, E. (2003) Biomechanics and electromyography of a cumulative lumbar disorder: response to static flexion. *Clinical Biomechanics* **18,** 883-889.

Tüzün, C., Yorulmaz, I., Cindas, A. and Vatan, S. (1999) Low back pain and posture. *Clinical Rheumatology* **18,** 308-312.

Uetake, T., Ohtsuki, F., Tanaka, H. and Shindo, M. (1998) The vertebral curvature of sportsmen. *Journal of Sports Sciences* **16,** 621-628.

Widhe, T. (2001) Spine: posture, mobility and pain. A longitudinal study from childhood to adolescence. *European Spine Journal* **10,** 118-123.

Wilke, H., Neef, P., Caimi, M., Hoogland, T. and Claes, L. (1999) New *in vivo* measurements of pressures in the intervertebral disc in daily life. *Spine* **24,** 755-762.

Wodecki, P., Guigui, P., Hanotel, M.C., Cardinne, L. and Deburge, A. (2002) Sagittal alignment of the spine: comparison between soccer players and subjects without sports activities. *Revue de Chirurgie Orthopédique et Réparatrice de l`Appareil Moteur* **88,** 328-36.

Wojtys, E., Ashton-Miller, J., Huston, L. and Moga, P. (2000) The association between athletic training time and sagittal curvature of the immature spine. *The American Journal of Sports Medicine* **28,** 490-498.

Key points

- This study evaluated thoracic and lumbar spinal curvatures and pelvic tilt during several postures in young highly trained tennis players.
- Female tennis players showed statistically significant greater anterior pelvic tilt, lumbar lordosis and lower thoracic kyphosis than male tennis players.
- The high percentage of neutral thoracic kyphosis and lumbar lordosis posture in both groups of young tennis players in relaxed standing might affirm that tennis does not negatively affect sagittal spinal posture at these ages.
- A specific postural program could be recommended to improve the slumped sitting and maximal trunk flexion in knees extended postures.

AUTHORS BIOGRAPHY

José M. MUYOR
Employment
Assistant Professor. Faculty of Education Sciences, Nursing and Physiotherapy, University of Almería, Almería, Spain
Degree
MSc, PhD
Research interests
Spine posture and hamstring muscle extensibility.
E-mail: josemuyor@ual.es

Estefanía SÁNCHEZ-SÁNCHEZ
Employment
Student of PhD in Sport Sciences, University of Granada, Spain.
Degree
MSc
Research interests
Sport performance
E-mail: estefi-sanchez@hotmail.com

David Sanz RIVAS
Employment
Director of research and coaches education Department RFET. Professor of Sports Sciences in University Camilo José Cela, Spain
Degree
MSc, PhD
Research interests
Motor and control learning, physical conditioning and adapted sport for physical disabilities.
E-mail: david.sanz@rfet.es

Pedro A. LÓPEZ-MIÑARRO
Employment
Professor of Physical Activity and Health at the Research Department of Physical Education, Faculty of Education, University of Murcia, Spain
Degree
PhD
Research interests
Hamstring flexibility and spine posture.
E-mail: palopez@um.es

✉ **José M. Muyor**
Assistant Professor, Faculty of Education Sciences, Nursing and Physiotherapy, University of Almería. Edificio de Humanidades A. Despacho 2.54. Ctra. Sacramento s/n. 04120, La Cañada de San Urbano, Almería, Spain