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Original research

Descriptive profile of hip range of motion in elite tennis players

Victor Moreno-Pérez [a], Francisco Ayala [a, b, *], Jaime Fernandez-Fernandez [a], Francisco J. Vera-Garcia [a]

[a] Sports Research Centre, Miguel Hernandez University of Elche, Spain
[b] ISEN, Centre Affiliated to the University of Murcia, Spain

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A B S T R A C T

Objective: To describe the range of motion (ROM) profile (flexion, extension, abduction, internal and external rotation) of the hip in elite tennis players; and (b) to analyse if there are sex-related differences in the hip ROM.
Design: Cohort study.
Setting: Controlled laboratory environment.
Participants: 81 male and 28 female tennis players completed this study.
Main outcome measures: Descriptive measures of passive hip flexion, extension and abduction, and internal and external active and passive hip rotation ROM were taken. Magnitude-based inferences on differences between sex (males vs. females) and hip (dominant vs. non-dominant) were made by standardising differences.
Results: No clinically meaningful bilateral and sex-related differences in any of the hip ROM measures. In addition, it was found that both males and females had restricted mobility measures on hip flexion (<80°), extension (<0°) and abduction (<40°). Furthermore, the 30% of males also presented restricted active and passive hip internal rotation ROM values (<25°). Finally, both males and females had normal mobility measures of hip external rotation ROM (active [>25°] and passive [35°])
Conclusions: Asymmetric hip joint ROM measures found during clinical examination and screening may indicate abnormalities and the need of rehabilitation (e.g., flexibility training). In addition, clinicians should include specific exercises (e.g., stretching) in their conditioning, prevention and rehabilitation programmes aiming to avoid restricted mobility of hip flexion (males = 74°; females = 78°), extension (males = −1.5; females = −0.4), abduction (males = 35°; females = 34°) and internal rotation (males = 30°; females = 35) that might be generated as a consequence of playing tennis.

1. Introduction

Tennis has experienced a significant increase in popularity in recent years, becoming one of the most popular sports in the world, with more than 75 million people participating both, at recreational or at professional levels (Pluim et al., 2007). At professional level, the demanding competitive calendar of players can result in athletes focusing on competition and thus compromising training, leading to suboptimal recovery and preparation (Ellenbecker, Pluim, Vivier, & Stineman, 2009; Sell, Hainline, Yorio, & Kovacs, 2014). Furthermore, in a tennis match, players usually perform a high number of multidirectional and cutting movements, together with asymmetric rotational actions produced by the serve and groundstrokes (Roetert, Kovacs, Knudson, & Groppel, 2009). These above-mentioned aspects could lead to an overload in the joints, impairing their normal motion and thus increasing the relative risk of injury (Chandler, Kibler, Uhl, Wooten, Kiser, & Stone, 1990).

Previous studies analysed the impact of these high repetition loads on the upper extremity joints at elite levels in order to effectively plan and establish successful prevention and rehabilitation programs, and reported a deficit in glenohumeral internal rotation range of motion (ROM) of the dominant arm (Ellenbecker, Roetert, Bailie, Davies, & Brown, 2002; Kibler, Chandler, Livingston, & Roetert, 1996; Moreno-Pérez, Moreside, Barbado, & Vera-Garcia, 2015; Roetert, McCormick, Brown, & Ellenbecker, 1996). This deficit has been suggested as a predisposing factor for increasing the

* Corresponding author. Sports Research Centre, Miguel Hernández University of Elche, Avda. de la Universidad s/n, 03202 Elche, Alicante, Spain. Tel.: +34 965222401; fax: +34 965222409.
E-mail address: Franciscoayalarodriguez@gmail.com (F. Ayala).

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likelihood of several shoulder and elbow pathologies (Moreno-Perez et al., 2015; Myers, Laudner, Pasquale, Bradley, & Lephart, 2006; Shanley, Rauh, Michener, Ellenbecker, Garrison, & Thigpen, 2011). Thus, tennis health care professionals began to include stretching exercises of the glenohumeral external rotator muscles in the dominant arm, during both, the pre- and in-season training schedules (Kovacs, 2006).

As previously mentioned, during tennis play the lower extremities are also subjected to repetitive loading forces (e.g., cutting movements). However, joint ROM in the lower extremity has not been studied with the same vigour as that of the upper extremity. To the best of our knowledge, only two studies have examined the tennis-related alterations on the lower extremity joints (i.e., hip internal and external rotation ROM profile) in elite or professional players (Ellenbecker, Ellenbecker, Roetert, Silva, Keuter, & Sperling, 2007; Young, Dakic, Stroia, Nguyen, Harris, & Safran, 2014), showing no specific hip alterations in rotational ROM.

Thus, it remains to be clarified whether the repetitive loading forces generated during tennis play induce alterations in the complete hip joint ROM profile in elite tennis players, such as bilateral differences or deficit in one or more ROM. If these alterations do occur it may predispose tennis players to be more prone to several pathologies, such as: osteochondral and groin injuries (deficit in hip abduction ROM) (Verrall, Slavotinek, Barnes, Esterman, Oakeshott, & Spriggins, 2007), low back pain (deficit in hip flexion and internal rotation ROM) (Vad, Gebeh, Dines, Altchek, & Norris, 2003), abdominal strain (deficit in hip extension ROM) (Young et al., 2014), patello-femoral pain and hamstring strains (deficit in hip extension ROM) (Witvrouw, Danneels, Asselman, D'Have, & Cambier, 2003; Witvrouw, Van Tiggelen, & Willems, 2011).

Therefore, the aims of the present study were twofold: (a) to describe the hip ROM profile in elite tennis players; and (b) to analyse if there are sex-related differences in the ROM.

2. Methods

2.1. Participants

A total of 109 elite tennis players (81 males and 28 females) volunteered to participate in the study. Participants were recruited from 10 different high performance Spanish tennis academies. To qualify as an elite tennis player for the purpose of this study, participants held national rankings in their respective sex-related categories (48 males and 18 females) or played on the professional tennis tours (ATP or WTA) (34 males and 9 females). The exclusion criteria were: (a) history of orthopaedic problems in the previous three months that prevented practice or competition; and (b) presence of delayed onset muscle soreness at the testing session. The study was conducted during the pre-competitive phase of the year 2013. Demographic information was recorded from the participants before data collection (Table 1).

Table 1
Demographic variables for the elite tennis players.[a]

	Men	Women
Age (years)	19.7 ± 4.8	17.7 ± 2.2
Height (cm)	180.1 ± 6.5	171.3 ± 6.2
Body mass (kg)	72.1 ± 8.4	62.5 ± 5.7
Years playing tennis (years)	12.4 ± 5.3	10.7 ± 3.4
Weekly practice frequency ± SD	5.1 ± 1.2	4.7 ± 0.8
Hours of tennis practice per week ± SD	12.2 ± 2.1	10.8 ± 1.3
Hours of tennis practice per day ± SD	2.6 ± 0.5	2.1 ± 0.5

[a] All values are mean ± standard deviation.

Prior to any participation, the experimental procedures and potential risks were fully explained to the participants and all provided written informed consent. The study was approved by the University Office for Research Ethics, and conformed to the Declaration of Helsinki.

2.2. Procedure

Passive hip flexion (passive straight leg raise test [Fig. 1a]), extension (modified Thomas test [Fig. 1b]) and abduction (hip abduction with knee extended test [Fig. 1c]) ROM of the dominant and non-dominant limbs was assessed following the methodology previously described (Cejudo, Sainz de Baranda, Ayala, & Santonja, 2015). Furthermore, active and passive hip rotation (internal [Fig. 1d and f for passive and active modalities, respectively] and external [Fig. 1e and g for passive and active modalities, respectively]) ROMs was also measured using a previously described methodology (Almeida, de Souza, Sano, Saccol, & Cohen, 2012).

All tests were carried out by the same two physical therapists with more than 10 years' experience (one conducted the tests and the other ensured proper testing position of the participants throughout the assessment manoeuvres) and under stable environmental conditions.

The dominant limb was determined according to the definition of Ellenbecker et al. (2007) for assigning lower extremity dominance in tennis players, defining the dominant leg as the lower extremity of the ipsilateral side of the forehand ground stroke and the same side as the upper extremity with which the player served.

Prior to the testing sessions, all participants performed a warm-up consisting of 5-min jogging and 8-min standardised static stretching exercises, emphasising the lower-limb muscles (Cejudo et al., 2015). Participants performed 2 repetitions of 5 different unassisted static stretching exercises, holding the stretched position for 30s.

After the warm-up, participants were instructed to perform, in a randomised order (using the software at http://www.randomizer.org), 2 maximal trials of each ROM test for each limb, and the mean score for each test was used in the subsequent analyses. When a variation >5% was found in the ROM values between the two trials of any test, an extra trial was performed, and the two most closely related trials were used for the subsequent statistical analyses. Participants were examined wearing sports clothes and without shoes. A 30 s rest was given between trials, limbs and tests.

2.3. Measurements

An ISOMED inclinometer (Portland, Oregon) with a telescopic arm was used as the key measure for all hip ROM except for hip abduction, where a flexible adjustable long arm goniometer was employed. A low-back protection support (Lumbosant, Murcia, Spain) was used to standardise the lordotic curve (15°) during the assessments. The inclinometer was placed approximately over the external malleolus (for hip flexion ROM [Fig. 1a]), the mid-point of the distal end of the fibula (for hip internal and external rotation ROM [Fig. 1d–g]), and the greater trochanter of the femur (for hip extension [Fig. 1b]), and the distal arm was aligned parallel to an imaginary bisector line of the limb throughout each trial (Cejudo et al., 2015). For the assessment of hip abduction, one arm-goniometer was placed joining both anterior-superior iliac spines and the other arm was placed over the anterior face of the tested limb following its bisector line (Cejudo et al., 2015).

Variations in pelvic position and stability may affect the final score of several hip ROM measurements (Bohannon, Gajdosik, & LeVeau, 1985). Thus, to accurately evaluate hip ROM, the assistant