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Original Research

The immediate effects of serving on shoulder rotational range of motion in tennis players

Katy Williams [a, *], Clair Hebron [b]

[a] Department of Sports Development and Recreation, Sports Training Village, University of Bath, Claverton Down Road, Bath, Somerset, BA2 7AY, England, UK

[b] School of Health Sciences, Aldro Building, University of Brighton, 49 Darley Road, Eastbourne, East Sussex, BN20 7UR, England, UK

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ABSTRACT

Objective: This study aimed to investigate the immediate effects of serving on shoulder rotational range of motion (ROM) in tennis players by comparing to groundstrokes.
Design: Same-subject, randomised, crossover study.
Setting: Indoor hard courts.
Participants: Eighteen male and 12 female professional and university level tennis players.
Main outcome measures: Passive glenohumeral internal and external rotation ROM measurements, using a digital inclinometer, were undertaken at baseline and immediately following serving and groundstroke tasks on both dominant and non-dominant shoulders. Total rotation was calculated as the sum of internal and external rotation.
Results: On the dominant and non-dominant shoulders there was no significant interaction effect between the factors of tennis task (serving and groundstrokes) and time (pre and post) ($p = <0.05$). Indicating that change in rotational ROM was not specific to tennis task. On the dominant shoulder there was a significant main effect of time ($p = 0.007$), with internal, external and total rotational ROM decreasing irrespective of tennis task.
Conclusion: Both tennis tasks resulted in immediate significant reductions in shoulder rotational ROM on the dominant shoulder but not the non-dominant shoulder of professional and university tennis players. There was no significant difference between serving and groundstroke tasks.

1. Introduction

Competitive tennis players undergo a constant programme of tournaments and events that take place throughout the year (Fernandez, Mendez-Villanueva, & Pluim, 2006). Tennis stroke production involves the generation of serves and groundstrokes that are of high intensity and short duration, with matches lasting on average between 1 h 30 min to 4 h; depending on the level of tournament played and whether the player is female or male (Reid & Duffield, 2014). High training volume and competition exposure can make players susceptible to risk of injury (Myers, Sciascia, Kibler, & Uhl, 2016).

There has been a wide variation in the overall reported incidence and prevalence of injuries in tennis, across recreational, collegiate and professional level players (Dines et al., 2015). A review conducted between 1966 and 2005, reported injuries as ranging from 0.04 to 3.0 per 1000 h played, with injuries per player ranging from 0.05 to 2.9 per year (Pluim, Staal, Windler, & Jayanthi, 2006). Upper limb injuries have been found to account for 20–49 percent (%) of injuries, with the shoulder and elbow being most frequently injured and reported as overuse in nature (Abrams, Renstrom, & Safran, 2012; Dines et al., 2015).

Commonly reported injuries to the shoulder include subacromial pain syndrome, rotator cuff pathology and superior labrum anterior and posterior (SLAP) tears (Lintner, Noonan, & Kibler, 2008). Epidemiological studies have associated the serve with these overuse injuries as a potential cause, which have been found to be common in all levels of competitive tennis, although there is no evidence to disprove groundstrokes (Abrams et al., 2012; Dines et al., 2015). This is because during service games there are

* Corresponding author.
E-mail addresses: K.Williams@bath.ac.uk (K. Williams), C.L.Hebron@brighton.ac.uk (C. Hebron).
@KatyPhysio (K. Williams), @c_hebron (C. Hebron)

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more serves reported per game than any other type of stroke, accounting for 45–60% of strokes from 616 games analysed at the 2003 French Open and Wimbledon Championships respectively (Johnson & McHugh, 2006). During the repetitive overhead motion of the serve the shoulder is the focal point for force transfer and contributes to 20% of the total force generated during the stroke (Reid, Elliott, & Alderson, 2007). The shoulder is also the most mobile joint in the body, with its anatomical design allowing for a wide range of motion, leading to a fragile equilibrium between stability and mobility when serving (Van der Hoeven & Kibler, 2006).

Overhead athletes are reported to experience anatomical changes of their shoulders over time, such as thixotrophy (increased passive stiffness) of the external rotators, thickening of the posterior glenohumeral joint capsule, as well as retroversion of the humeral head (Van der Hoeven & Kibler, 2006). These changes have not been confirmed in tennis players, but a decrease in dominant shoulder internal and total rotation, in comparison to the non-dominant shoulder, has been found in both junior and senior tennis players (Ellenbecker, Roetert, Bailie, Davies, & Brown, 2002; Schmidt-Wiethoff, Rapp, Mauch, Schneider, & Appell, 2004). This decrease in range has been found to correlate with increasing years of tennis practice and play, as well as a player's age (Kibler, Chandler, Livingston, & Roetert, 1996; Moreno-Perez, Moreside, Barbado, & Vera-Garcia, 2015). This adaptation is theorised to exist as a result of the follow through of the serve, requiring the dominant shoulder to decelerate through eccentric action of the external rotators, to slow internal rotation of the shoulder and therefore arm motion (Kibler et al., 2013; Ellenbecker & Wilk, 2017). This has not been confirmed by empirical research.

A normal variation occurring in the dominant shoulder of overhead athletes is an anatomical glenohumeral internal rotation deficit (aGIRD) (Manske, Wilk, Davies, Ellenbecker, & Reinold, 2013). This is a difference in internal rotation between the dominant and non-dominant shoulders of less than or equal to 18–20°, with a corresponding symmetry of total range of motion (TROM) (sum of internal and external rotation) of less than 5°. However when this deficit becomes larger (loss in dominant shoulder internal rotation that is greater than 18–20°, with a corresponding loss of TROM of greater than 5°, when compared with the non-dominant shoulder), is termed a pathological GIRD (pGIRD) (Kibler, Sciascia, & Thomas, 2012a). This has been identified as a risk factor for shoulder injuries in overhead athletes, due to causing a shift in the humeral head instant centre of rotation on the glenoid (Wilk et al., 2011). Most recently the concept of an external rotation deficiency (ERD) (loss in dominant shoulder external rotation that is greater than 5°, when compared with the non-dominant shoulder), has also been highlighted as a risk factor in overhead athletes for shoulder injuries (Wilk et al., 2015).

Several studies have reported that short term changes to shoulder ROM are dependent on athletic exposure in the sporting environment (Kibler, Sciascia, & Moore, 2012b; Martin, Kulpa, Ezanno, Delamarche & Bideau, 2016; Moore-Reed, Kibler, Myers & Smith, 2016). Martin et al. (2016) investigated changes in dominant shoulder passive rotation during and immediately after competitive tennis play, in 8 professional adult males undertaking 3 h matches. Measurements were undertaken with a goniometer, but rater reliability statistics to calculate standard error of measurement (SEM) and minimal detectable change (MDC) were not reported. There was a significant decrease in internal rotation from pre warm up to immediately after match play (20.8°) ($p = 0.005$). The most significant decrease was following 90 min. There was also a significant decrease in TROM from pre warm up to immediately after match play (24.6°) ($p = 0.001$). The most significant decrease was following 30 min. The serve was implicated for these changes however as it was not directly compared to groundstrokes during this study its claim cannot be supported.

In contrast, Moore-Reed et al. (2016) investigated changes in dominant shoulder passive rotation after competitive tennis play in 79 professional adult females from 4 tournaments, undertaking a maximum of 3 set matches. Measurements were undertaken with a digital inclinometer and interday intra-rater reliability was established for internal rotation (intra-class correlation coefficient ($ICC_{2,1}$) = 0.80, SEM = 2.8°, MDC = 4.0°), external rotation ($ICC_{2,1}$ = 0.91, SEM = 4.7°, MDC = 6.6°) and total rotation ($ICC_{2,1}$ = 0.91, SEM = 4.7°, MDC = 6.6°). There was a significant decrease in internal rotation from baseline to immediately after match play (4°) ($p = 0.002$) and from baseline to 24 h after (5°) ($p = 0.001$). There was also a significant decrease in TROM from baseline to immediately after match play (4°) ($p = 0.04$). The percentage of measurements greater than MDC (demonstrating with 95% certainty that changes in shoulder ROM were attributed to tennis play rather than measurement error), was 17–24% for internal rotation and 14% for total rotation. Similarly the serve was also implicated for these changes and was not directly compared to groundstrokes during this study, so its claim cannot be supported. Researchers from both studies did not establish the anatomical and physiological basis behind these short term changes to shoulder ROM, but hypothesised posterior muscular tightness from repetitive eccentric contractions, based upon the amount of change and length of time the changes took (Martin et al., 2016; Moore-Reed et al., 2016).

If findings from these studies are generalisable it might suggest potential shoulder injury risk for tennis players training or competing back to back over 24 h, who develop a pGIRD or ERD and do not regain full ROM between training sessions or matches (Manske et al., 2013). Furthermore these ROM deficits may persist even longer, as measurements were only recorded in one of the studies up to 24 h following tennis (Moore-Reed et al., 2016). This might suggest a need for resolution or improvement of rotational ROM prior to training and match play, to reduce the potential risk of shoulder injury. However we cannot infer from these studies, as only ROM measurements on the dominant shoulder were recorded and were not directly compared with the non-dominant shoulder to enable detection of a pGIRD or ERD. There is currently speculation that the serve in particular is responsible for these changes in shoulder rotational ROM in tennis players, but there is no evidence to support this. This study therefore aims to investigate the immediate effects of serving on shoulder passive rotational ROM in tennis players by comparing to groundstrokes, on both dominant and non-dominant shoulders.

2. Method

2.1. Design

An invitation email including a participant information sheet was circulated to competitive tennis players, by the performance director of an International High Performance Centre (IHPC). A convenience sample of the first 30 who responded was selected. An experimental same-subject crossover design was used. Research assistant A allocated participants into either serving or groundstroke tasks in advance, through selecting concealed names at random. Each participant then undertook the allocated tasks and the order of participation in the tasks was reversed a minimum of one week later, to counterbalance order effects. Data was collected at least 48 h after their last training session or match, to allow for sufficient recovery whilst not impeding preparations. The study was given ethical approval by the ethics committee of two universities in the South of England. All participants gave written informed consent prior to participation.