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The effect of tennis match play on joint range of motion in junior players

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Background: Tennis players perform a large number of multidirectional and cutting movements, together with asymmetrical rotational motions resulting from serves and groundstrokes. Numerous shot repetitions and multidirectional motions directly influence a tennis player's upper and lower extremity joint range of motion (ROM). **Objective:** This study evaluated the changes in the range of motion of junior tennis players before and after match play. **Methods:** Twelve male (age 14.4 ± 1.3 years) and twelve female (age 13.4 ± 2.1 years) junior tennis players participated in the study. Two skilled experts performed 13 tests to measure passive range of motion of the dominant and non-dominant shoulder, elbow, wrist, hip, knee, and subtalar joints, before and after match play. The *t*-test and Wilcoxon test were used to determine the differences between the ROM before and after the tennis match, and the differences between the dominant and non-dominant sides of the body. **Results:** Bilateral measurement of the internal rotation of the shoulder joints, forearm pronation, and inversion of the subtalar joints before match play, show significant differences between extremities, similarly as the elevation of the arm in the coronal plane and forearm pronation, after a tennis match, were also found to display statistically significant differences. ROM values were higher for the internal rotation of both shoulders, external rotation of the non-dominant shoulder, elevation of the arms in the coronal plane, flexion in the elbow joints, pronation in the forearms, adduction in the hips, as well as eversion and inversion of the subtalar joints. **Conclusions:** Male and female junior tennis players increase their joint ROM during match play through motions which are involved in the execution of tennis shots and tennis movement patterns. Tennis matches that last 90 minutes or less do not have a negative impact on the flexibility of young tennis players.

Keywords: racket sports, youth, goniometer, flexibility

Introduction

In tennis, it is widely accepted that success requires a great deal of training and frequent participation in competitions in all age categories (Reid, Crespo, Santilli, Miley, & Dimmock, 2007; Reid & Morris, 2011). Kovacs (2006) found that the physical demands of tennis match play cause musculoskeletal adaptations that are sometimes positive (increased strength) and sometimes negative (decreased joint range of motion and reduced muscular flexibility). Gillet, Begon, Sevrez, Berger-Vachon, and Rogowski (2017) note that the range of motion (ROM) of glenohumeral joints in young tennis players decreases with age, while absolute power increases. The optimal ratio between flexibility and strength is thought to be crucial in protecting the shoulder complex during intensive overhead motions. Lack of flexibility in athletes has been linked to a decrease in performance and increase in muscular injuries (Shellock & Prentice, 1985).

During a tennis match, players usually perform a large number of multidirectional and cutting movements along with asymmetric rotational motions resulting from the execution of a serve or groundstroke (Roetert, Kovacs, Knudson, & Groppel, 2009). Tennis match load is expressed as the number of shots a player makes and the distance covered while performing movement patterns that include fast starts, directional changes, stops, and jumps. Weber (2001) reported that in an average rally, professional players hit three shots and cover 3 m for each contact with the ball, which amounts to approximately 1,000 executed shots and 3 km of distance covered during a best of three sets match. Kovacs (2006) found that all movements

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directly influence the upper and lower limb joints' range of motion in tennis players.

Effective stroke execution in tennis maximally utilizes the entire kinetic chain. Coordinated use of specific body segments (legs, hips, trunk, arms) in rhythmical movements allows tennis players to adapt to different game situations and perform strokes with controlled, optimal variation. Tennis strokes (serve, forehand, backhand) are performed as throwing motions, where lower body force production is transferred up into the upper body and out through the racket into the ball (Kibler & Chandler, 2003).

Previous studies have analyzed flexibility (Chandler et al., 1990) and the glenohumeral joint ROM (Ellenbecker & Roetert, 2003; Ellenbecker, Roetert, Piorkowski, & Schulz, 1996; Gillet, Begon, Diger, Berger-Vachon, & Rogowski, 2018; Schmidt-Wiethoff, Rapp, Mauch, Schneider, & Appell, 2004; Stanley, McGann, Hall, McKenna, & Brigfa, 2003). Due to numerous shot repetitions, especially pertaining to the serve, there is often a reported deficit in glenohumeral internal rotation ROM of the dominant arm of tennis players (Ellenbecker, Roetert, Bailie, Davies, & Brown, 2002; Kibler, Chandler, Livingston, & Roetert, 1996; Moreno-Pérez, Moreside, Barbado, & Vera-Garcia, 2015; Roetert, McCormick, Brown, & Ellenbecker, 1996). Similarly, Martin, Kulpa, Ezanno, Delamarche, and Bideau (2016) found a significant decrease in passive shoulder internal rotation and total ROM during a 3-hour tennis match. Elite junior tennis players have a relative muscular strength imbalance between the internal and external shoulder rotators of the dominant arm (Ellenbecker & Roetert, 2003). Junior tennis players have a stronger horizontal abduction and adduction in their dominant versus their non-dominant shoulder (Silva et al., 2006).

Few studies have dealt with the influence of tennis match play on ROM of the lower extremities. Young et al. (2014) assessed hip range of motion and its association with injury but was unable to identify any specific side-to-side rotational adaptation in the dominant or non-dominant hip of female tennis players. Moreno-Pérez, Ayala, Fernandez-Fernandez, and Vera-Garcia (2016) found that male and female tennis players had restricted mobility measures of hip flexion, extension, and abduction. At the same time, they pointed out that asymmetric hip joint ROM measurements may indicate abnormalities and the need for flexibility training.

The use of goniometric measurement of joint range of motion is a widespread practice in orthopedic and sports physical therapy (Norkin & White, 2016). An objective range of motion measurement is a necessary part of player evaluation, as well as demonstration of injury treatment efficacy. Rothstein, Miller, and Roettger (1983) studied goniometric measurements of the knee and elbow and found high intratester and intertester reliability in the clinical setting. The reliability of goniometric measurements of joint motion has been extensively studied by Horger (1989), who indicated that measurements of wrist motion were highly reliable. Riddle, Rothstein, and Lamb (1987) found suitable reliability of goniometric ROM measurements of the shoulders. Watkins, Riddle, and Lamb (1991) suggested the use of a goniometer to make repeated ROM measurements of the knee to minimize the error associated with these measurements.

Previous studies of ROM among tennis players have focused mainly on shoulder and hip joints (Vad, Gebeh, Dines, Altchek, & Norris 2003) while studies that focused on other joints (wrist and ankle) were rare (Kibler & Chandler, 2003). Chiang, Hsu, Chiang, Chang, and Tsai (2016) compared the internal and external rotation of the dominant and non-dominant shoulders of junior female tennis players. The internal rotation of the dominant shoulder was significantly smaller than that of the non-dominant shoulder. Flexibility of the glenohumeral internal rotation may be a factor affecting performance in juniors. Kovalchik and Reid (2017) believe that physical loads, in professional, as well as junior tennis, are more and more demanding. Movements are faster and more diverse, and tennis strokes are executed in dynamic conditions with larger amplitudes. With this in mind, the present study aimed to use goniometric measurements to assess how the range of motion in the dominant and non-dominant shoulder, elbow, wrist, hip, knee, and ankle, changes, before and after junior match play.

Methods

Participants

Twelve male (14.4 ± 1.3 years, 165.7 ± 13.8 cm, 57.1 ± 14.6 kg) and twelve female junior tennis players (13.4 ± 2.1 years, 156.7 ± 9.4 cm, 45.5 ± 14.3 kg) volunteered to participate in the study. Participants were recruited from five tennis clubs, all were right-handed and used a two-handed backhand stroke. The study was conducted during the pre-competitive season. All players were in regular training and were ranked on the national ranking list. Five players also had an ITF junior ranking. Subjects were free from any upper and lower extremity injury.

Measurement

A standard plastic universal goniometer (66fit Goniometer – 30 cm, 66fit, Spalding, United Kingdom) was used for measurement, with scales marked in one-degree increments. Prior to participation, the experimental procedures and potential risks were explained to the legal representatives of participants in full, and all signed written informed consent. The study was approved by the University Office for Research Ethics and conformed to the Declaration of Helsinki.

The testing procedure was standardized and undertaken in the following order. On arrival, each participant completed a questionnaire pertaining to age, dominant playing hand, level of play, duration of training and competition attendance, starting age, and history of injuries. All participants performed a 20-minute warm-up, which included running, dynamic warm-up exercises, and athletic activation movement tasks. This was followed by measurements of body weight and height. Two skilled experts (physiotherapists) measured the following movements of the tennis players before and after the tennis match:

- internal rotation in the shoulder joint – shoulder internal rotation,
- external rotation in the shoulder joint – shoulder external rotation,
- elevation of the arm in the coronal plane – arm elevation,
- flexion in the elbow joint – elbow flexion,
- pronation of the forearm – forearm pronation,
- supination of the forearm – forearm supination,
- dorsal flexion (extension) in the wrist joint – wrist dorsal flexion,
- volar flexion in the wrist joint – wrist volar flexion,
- abduction in the hip joint – hip abduction,
- adduction in the hip joint – hip adduction,
- flexion in the knee joint – knee flexion,
- eversion (pronation) in the subtalar joint – subtalar eversion,
- inversion (supination) in the subtalar joint – subtalar inversion.

Passive range of motion was measured as the maximal range of joint motion attained by a participant during the application of external force (Horger, 1989). Measurements were performed according to protocols by Jakovljević and Hlebš (2017). The task of the first examiner was to perform a specific motion on the participant's body in accordance with instructions laid out by the protocol, while the second examiner then measured the amplitude of the movement in each individual joint. A 30-second rest period was given between trials, limbs, and tests. Each measurement was performed twice and the higher score was included in the analysis. Following the completion of the measurements, the participant played an unofficial training tennis match, which lasted 90 minutes. Workload of the tennis match was monitored, using a wearable device (Armbeep Wrist Monitoring Device 1.0, Biometrika, Maribor, Slovenia) and system for movement and biometric data acquisition (Kos & Kramberger, 2017). The device monitored and collected the following parameters: the number of shots, wrist speed, and acceleration in the contact zone. After the tennis match was concluded, we repeated the measurement of all 13 tests for passive range of motion on both sides of the participant's body. All ROM tests were performed after the tennis match (12.6 ± 8.5 minutes) in a closed environment where the temperature was stable for the duration of the tests.

Statistical analyses

The means and standard deviations were calculated for all variables. The *t*-test for dependent variables was used to determine the differences between the range of motion before and after the tennis match, and the differences between the dominant and non-dominant sides of the body. Before determining these differences, we tested the assumption of normal distribution (Shapiro-Wilk test). When this assumption was violated, we used the Wilcoxon test. A result was deemed statistically significant when $p \leq .05$. Statistical analysis was done using IBM SPSS (Version 24; IBM, Armonk, NY, USA).

Results

During the match, tennis players performed 522.3 ± 53.6 shots in 127.5 ± 24.3 rallies, which, on average, computes to 4.5 ± 1.1 shots in an individual rally.

The results obtained in this study showed only statistically significant bilateral differences before the match for internal rotation in the shoulder joint (higher ROM was found in the non-dominant joint), forearm pronation and inversion in the subtalar joints (in both variables higher ROM values were observed in the dominant joint), see Table 1. After the match (Table 2) statistically significant bilateral differences were observed in elevation of the arm in the coronal plane and forearm pronation (higher ROM values in the dominant joint for both variables).

The comparison of ROM before and after the match showed that the differences in internal shoulder rotation, arm elevation, elbow flexion, forearm pronation, hip adduction, subtalar eversion, and inversion in both joints after the match were significant (Table 3). Significant differences were also shown in external shoulder rotation of the non-dominant shoulder.

The results reveal a significant increase of range of motion in the internal rotation of the dominant and non-dominant shoulder. The same was found in the external rotation of the non-dominant shoulder.

Table 1

Differences in range of motion between the dominant and non-dominant joint before match play. Values are presented in degrees as mean ± SD.

Variable	Dominant	Non-dominant	*t*	*p*
Internal rotation in the shoulder joint	59.5 ± 8.2	63.7 ± 7.2	−3.32	.005[1]
External rotation in the shoulder joint	83.3 ± 16.5	83.2 ± 10.5	0.04	.967
Elevation of the arm in the coronal plane	120.2 ± 26.7	116.6 ± 25.1	1.89	.075
Flexion in the elbow joint	152.2 ± 3.2	152.1 ± 5.3	−0.19	.847
Pronation in the forearm	81.8 ± 5.8	78.2 ± 6.7	−3.18	.005[1]
Supination in the forearm	83.4 ± 5.3	84.7 ± 3.8	−1.52	.146
Dorsal flexion in the wrist joint	81.8 ± 5.5	82.9 ± 7.4	−0.87	.393
Volar flexion in the wrist joint	83.3 ± 9.2	81.7 ± 6.8	1.17	.255
Abduction in the hip joint	49.3 ± 11.6	49.4 ± 10.2	−0.11	.909
Adduction in the hip joint	21.3 ± 4.4	20.7 ± 4.6	0.71	.493
Flexion in the knee joint	157.9 ± 9.0	159.1 ± 6.6	−1.51	.148
Eversion in the subtalar joint	6.9 ± 1.7	7.1 ± 1.6	−0.40	.698
Inversion in the subtalar joint	33.4 ± 5.9	29.9 ± 5.8	2.44	.026[1]

Note. [1]*t*-test showed significantly different value between the dominant and non-dominant joint ($p \le .05$).

Table 2

Differences in range of motion between the dominant and non-dominant joint after match play. Values are presented in degrees as mean ± SD.

Variable	Dominant	Non-dominant	*t*	*p*
Internal rotation in the shoulder joint	67.4 ± 5.6	69.7 ± 5.9	−1.53	.144
External rotation in the shoulder joint	88.9 ± 4.5	88.2 ± 5.3	0.80	.433
Elevation of the arm in the coronal plane	134.1 ± 23.6	124.3 ± 22.0	5.04	< .001[2]
Flexion in the elbow joint	156.8 ± 3.8	156.9 ± 4.1	−0.06	.949
Pronation in the forearm	84.3 ± 4.6	81.6 ± 7.0	2.79	< .001[1]
Supination in the forearm	84.9 ± 4.0	86.3 ± 2.5	−1.82	.086
Dorsal flexion in the wrist joint	83.0 ± 10.5	85.1 ± 8.9	−1.57	.134
Volar flexion in the wrist joint	84.0 ± 4.7	83.6 ± 7.7	0.31	.759
Abduction in the hip joint	52.9 ± 9.9	51.1 ± 7.5	0.74	.465
Adduction in the hip joint	24.9 ± 4.5	23.7 ± 3.5	1.53	.143
Flexion in the knee joint	159.4 ± 6.1	159.4 ± 6.3	0.00	> .99
Eversion in the subtalar joint	10.4 ± 2.3	10.9 ± 2.6	−0.92	.368
Inversion in the subtalar joint	37.2 ± 4.9	35.2 ± 5.1	1.83	.083

Note. [1]*t*-test showed significantly different value between the dominant and non-dominant joint ($p \le .05$). [2]Wilcoxon test showed significantly different value between the dominant and non-dominant joint ($p \le .05$).

A significant increase of ROM was also observed in the elevation of both arms in the coronal plane. The range of motion of the dominant shoulder in elevation in the coronal plane increased by 14 degrees after the match. No significant differences were detected in the external rotation of the dominant shoulder.

Significant differences were also observed in the flexion of both elbow joints and pronation in both forearms. Differences in ROM values in flexion and pronation of both elbows amounted to an increase of 3–4 degrees, after the match. There were no significant differences found in the supination of the forearms, or in the dorsal and volar flexion of the wrist joints of both limbs.

The changes of ROM before and after the tennis match were significant in the adduction of both hip joints, and in the eversion and inversion of both subtalar joints. No statistically significant differences were observed in the abduction of either hip joint, or the flexion in either knee joint.

Table 3

Range of motion before and after the match in the dominant and non-dominant shoulder, elbow, wrist, hip, knee, and ankle. Values are presented in degrees as mean ± SD.

Variable	Before the match	After the match	*t*	*p*
Internal rotation in the dominant shoulder joint	59.5 ± 8.2	67.4 ± 5.6	−4.86	< .001[1]
Internal rotation in the non-dominant shoulder joint	63.7 ± 7.2	69.7 ± 5.9	−5.64	< .001[1]
External rotation in the dominant shoulder joint	83.3 ± 16.5	88.9 ± 4.5	−1.47	.160
External rotation in the non-dominant shoulder joint	83.2 ± 10.5	88.2 ± 5.3	−2.62	.018[1]
Elevation of the dominant arm in the coronal plane	120.2 ± 26.7	134.1 ± 23.6	−4.40	.006[1]
Elevation of the non-dominant arm in the coronal plane	116.6 ± 25.1	124.3 ± 22.0	−3.16	< .001[1]
Flexion in the dominant elbow joint	152.2 ± 3.2	156.8 ± 3.8	−6.00	< .001[1]
Flexion in the non-dominant elbow joint	152.1 ± 5.3	156.9 ± 4.1	−5.76	< .001[1]
Pronation in the dominant forearm	81.8 ± 5.8	84.3 ± 4.6	−2.76	< .001[1]
Pronation in the non-dominant forearm	78.2 ± 6.7	81.6 ± 7.0	−3.01	.008[1]
Supination in the dominant forearm	83.4 ± 5.3	84.9 ± 4.0	−1.30	.209
Supination in the non-dominant forearm	84.7 ± 3.8	86.3 ± 2.5	−1.65	.118
Dorsal flexion in the dominant wrist joint	81.8 ± 5.5	83.0 ± 10.5	−0.61	.550
Dorsal flexion in the non-dominant wrist joint	82.9 ± 7.4	85.1 ± 8.9	−1.07	.300
Volar flexion in the dominant wrist joint	83.3 ± 9.2	84.0 ± 4.7	−0.37	.717
Volar flexion in the non-dominant wrist joint	81.7 ± 6.8	83.6 ± 7.7	−0.95	.355
Abduction in the dominant hip joint	49.3 ± 11.6	52.9 ± 9.9	−1.14	.269
Abduction in the non-dominant hip joint	49.4 ± 10.2	51.1 ± 7.5	−0.59	.560
Adduction in the dominant hip joint	21.3 ± 4.4	24.9 ± 4.5	−3.58	.002[1]
Adduction in the non-dominant hip joint	20.7 ± 4.6	23.7 ± 3.5	−2.65	.017[1]
Flexion in the dominant knee joint	157.9 ± 9.0	159.4 ± 6.1	−1.38	.184
Flexion in the non-dominant knee joint	159.1 ± 6.6	159.4 ± 6.3	−0.54	.595
Eversion in the dominant subtalar joint	6.9 ± 1.7	10.4 ± 2.3	−7.51	< .001[1]
Eversion in the non-dominant subtalar joint	7.1 ± 1.6	10.9 ± 2.6	−6.49	< .001[1]
Inversion in the dominant subtalar joint	33.4 ± 5.9	37.2 ± 4.9	3.96	< .001[1]
Inversion in the non-dominant subtalar joint	29.9 ± 5.8	35.2 ± 5.1	−4.04	< .001[1]

Note. [1]*t*-test showed significantly different value between before and after match play ($p \leq .05$).

Discussion

The purpose of this study was to analyze the influence of match play on shoulder, elbow, wrist, hip, knee, and ankle range of motion in young tennis players. Using a special wearable device, players' workloads were assessed. It was found that the average number of shots in a rally was comparable to the values observed in the present study (Kovalchik & Reid, 2017).

Our results showed that the internal rotation of the dominant shoulder was significantly lower before the tennis match than that of the non-dominant shoulder. The same observation was made by Stanley et al. (2003). Chandler et al. (1990) measured flexibility in junior elite tennis players and concluded that the decrease of the dominant shoulder's internal rotation was due to an adaptation of the posterior shoulder musculature and the capsular structure of the tennis stroke. No significant difference was found between the dominant and non-dominant arm in the external rotation of the shoulder, which is in line with previous findings (Ellenbecker et al., 2002). After 90 minutes of match play only the values of the external rotation of the non-dominant shoulder increased.

Differences were detected in comparing ROM during elevation in the coronal plane between the dominant and non-dominant shoulders before and after the match. A comparison of ROM of the shoulders showed that the values before and after the match increased in the internal rotation of both shoulder joints. The results are in line with the findings of Schmidt-Wiethoff et al. (2004), who found significant differences in the rotations of both the dominant and non-dominant shoulders in professional tennis players.

Junior tennis players performed approximately 60% of forehand shots and serves, where those two strokes included external, as well as internal, dominant shoulder rotations. High upper arm internal rotation angular velocities developed through extensive range of motion of circumduction (Kibler, 1995), and have been noted to play a similarly positive and substantial role in the development of racquet velocity in serve and forehand strokes (Elliott, Marshall, & Noffal, 1995). This has been confirmed by the findings of Elliott, Reid, and Crespo (2003), who found that serve shoulder rotation, together with forearm pronation, add as much as 40% to the final speed of the serve.

Similarly, Kovacs (2006) concluded that tennis players, in comparison to other athletes, have a better-defined ROM of the internal than the external rotation in the shoulder of the dominant arm. Kovacs states that repetitive and numerous executions of the serve are one of the critical reasons for this phenomenon.

ROM values in the elevation of the arm in the coronal plane of both shoulders, before and after the match, increased. According to functional analysis of the serve, elevation in the coronal plane and external rotation of the shoulder joint are included in the preparatory part of the serve. It can be concluded that optimal match duration and players' stroke performance have a positive effect on ROM in the shoulder joint.

Results of ROM measurements of the elbow show significantly higher values after the match than what was expected following functional analysis. Elbow flexion in tennis strokes is not only incorporated into the serve but also into both baseline shots. The range of flexion in the dominant elbow during the forehand is smaller than that of the backhand, where the dominant hand performs the entire range of motion. Reid, Giblin, and Elliot (2013) analyzed ROM of the elbow and wrist during the serve forward swing phase and found that the changes to the ROM and peak angular velocity of the elbow joint extension, during the forward swing, indicate that the role of elbow extension decreases, rather than becomes more pronounced. The latter is incorporated into serve execution as a concentric type of contraction, which mainly has the function of directing the projectile. The increase in ROM is expected due to the involvement of elbow movements. On the other hand, we can conclude that no differences in the increased range of motion, before and after the match, in the wrist were found. With this, we can indirectly respond to the frequent question of tennis coaches, that the wrist is not actively involved in the performance of tennis strokes.

Young et al. (2014) highlighted adequate hip range of motion values, which are required for the transfer of energy from the lower to the upper extremity, along the kinetic chain. Moreno-Pérez et al. (2016) warn against high loads for tennis players that can negatively influence ROM in the hips, and consequently increase the risk of injury. These findings are similar to the present study, as the research mentioned above also failed to find significant differences in passive hip flexion or extension and abduction between extremities. Normal mobility was measured in both male and female tennis players. An increase of adduction range was observed in both hips (before and after the match). The increase in adduction range, results from both concentric and eccentric muscular contractions due to the large number of directional changes in the lateral direction, submaximal movements and sideward cutting steps, sliding and returning to starting position after forehand and backhand executions on the baseline, in addition to both returns of the serve.

A comparison of the results of the inversion of the subtalar joint between the dominant and non-dominant side, after match play, indicates a higher load on the dominant leg. This leg is used to support both the execution of the forehand and all movements or direction changes, especially those that the player makes to the left. Furthermore, Verstegen (2003) suggests that players' muscles need to be able to generate forces through varying ranges of motion, both from the aspect of high-performance enhancement, as well as injury prevention.

Llana-Belloch, Brizuela, Pérez-Soriano, García-Belenguer, and Crespo (2013) found that sideward cutting movements followed by direction changes are of crucial importance in tennis. They added that this is also influenced by footwear which limits supination and allows tennis players to perform faster sideward cutting movements. Our study has shown, that there is an increase in ROM of the subtalar joint due to numerous direction changes and split-step executions. Ankle function is essential for the positioning and setting of the foot, in addition to affecting the player's movement acceleration, and deceleration.

There are several limitations to this study that should be considered. First, due to limitations in the measurement features of the wrist monitor, we were unable to include data on the number of shots during a match, the average number of shots during a rally, and wrist speed during the time of acceleration. As discussed earlier, the load on the observed parts of the body varied during different strokes, which indirectly affected the changes in the range of motion in individual joints. Additionally, we were unable to measure the distance covered or the number of directional changes during a rally.

Secondly, due to all test tennis matches being played on the same day, outside temperatures were not monitored.

Thirdly, the somewhat small sample size was attributed to the fact that only young tennis players were included in the study and their participation was voluntary.

In the future, optimal values of ROM in individual joints should also be evaluated more accurately for other young athletes.

Conclusions

Bilateral measurements of internal rotation in the shoulder joint, forearm pronation, and inversion of the subtalar joints before match play, and of elevation of the arm in the coronal plane, forearm pronation after match play, have identified significant differences between extremities. In the case of junior male and female tennis players, a 90-minute match positively affected ROM values, especially in those motions that were part of tennis movement patterns and shots. Junior tennis players can, with adequate warm-up and preparation, hold or even slightly increase ROM in certain joints, especially if the match is followed by appropriate stretching. Our study suggests that matches lasting up to an hour and a half do not have a negative impact on young athletes.

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Conflict of interest

There were no conflicts of interest.

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