

ABSTRACT

Background/Aim: ITF tournaments represent an important step in player development. Despite this, little epidemiological data is available from this playing level. This observational study aimed to present a profile of medical complaints presented by players during ITF Juniors and Pro Circuit tournaments.

Methods: 23 ITF Juniors and Pro Circuit tournaments were included in the analysis. All complaints requiring medical attention were registered. Recommendations for injury reporting were followed in regard to injury location, type, onset and place of intervention. Player gender and playing surface were also registered. Injury rates per match, 1000 games and 1000h of play were calculated.

Results: The general injury location pattern found is aligned with previous research. Pro Circuit players showed a greater number of skin and chronic onset conditions. Male players showed a greater number of hip and forearm complaints. Female players produced more knee and joint complaints. There were less shoulder and more elbow complaints originating from hard court matches. This surface also produced more tendon-related complaints. Injury rates were highest in hard courts but did not achieve significance. Lower injury rates were found in Juniors players on clay than on artificial grass.

Conclusions: A pattern of medical complaints of tennis players during ITF tournaments was presented. Injury location patterns indicate a stable pattern across competitive levels. The number of differences in injury location and type between genders adds to some contradictions in the literature and warrants further investigation.

INTRODUCTION

International Tennis Federation (ITF) tournaments represent a crucial step in player development both during their formative years and as an entry level to a professional career. In 2015, over 400 Juniors[1] and 600 Pro Circuit[2] tournaments were played all year round and all over the world, involving thousands of players in competitive tennis. Despite this competitive magnitude and its relevance to player development, little has been done to study injury patterns at this level, especially during tournaments. Also highlighting the relevance of this study is that higher injury rates have been reported during competition than during training [3].

Most epidemiological studies in tennis focus at either a domestic level[3–5] or Grand Slam/ATP/WTA tournaments[6–9], the exception being Breznik & Batagelj's study[10] which includes various playing levels but focuses only on retirements during matches. Players in ITF circuits face similar challenges as their world-class counterparts such as consecutive tournament weeks, continuous travel and competitive pressure. Unlike them, though, ITF circuits players often do not have the financial ability to travel with a dedicated team of professionals. They also tend to have poorer accommodation arrangements and fewer amenities available. These factors may have a negative influence on their general health and injury risk. As such, this is an understudied athletic population which faces significant sporting challenges with little financial rewards and the high costs.

In addition to the specific relevance of this competitive level, various authors have highlighted the need to standardize injury reporting methods in tennis [7,8,11,12] and the need for further and updated investigation in the field of tennis epidemiology [7,12–14].

The purposes of this study were to provide epidemiological data about the distribution of complaints presented by ITF Juniors and Pro Circuit players during tournaments and to check for differences according to gender, playing level and playing surface.

METHODS

Injury data were collected during 23 ITF Juniors (male and female players) and Pro Circuit (male players only) tournaments between 2011 and 2015, thus following an observational design. Any condition that caused a player to seek an evaluation or treatment by the tournament physiotherapist was recorded, regardless of the actual need for treatment or the need to reduce or refrain from sporting activity. All records were taken by the author and were anonymous and confidential.

All matches were played to the best of 3 sets. In doubles matches, the third set was played in a match tie-break format. The number of players involved in each tournament and their age was obtained through the official ITF website[1,2].

The consensus statement by Pluim et al. 2009[11] was used to categorize injury location, type and onset. Also per recommendation of this document, data about the playing surface and whether the complaints originated on or off-court were also recorded. Three measures of

exposure were also calculated: number of complaints per match, per 1000 games and per 1000 playing hours. This last measure is recommended to account for potential differences in match duration across surfaces, playing levels and match incidences[11]. To calculate these measures, the number of matches and games were obtained via the official ITF websites for the corresponding circuits[1,2]. For doubles matches, the match tie-break was counted as 2 games. Playing hours were calculated by multiplying the number of games by the average game durations for each surface proposed by Pluim et al. 2009[11].

Statistical analysis

A frequency analysis of body region, injury type, injury onset, place of treatment and treatment order was performed. Fisher's exact test for the independence of variables was performed between gender, player age (Junior or Pro Circuit) and tournament surface and body region, injury type, injury onset and place of treatment. Gender comparisons only involved Juniors players since there were no female tournaments included at Pro Circuit level.

For the injury rate variables, independent-samples testing was performed to assess for differences between genders, player age (Junior or Pro Circuit) and playing surfaces. T-tests or the Mann-Whitney U test were used according to normality, except in the playing surface analysis for Pro Circuit players where a one-way ANOVA was used. All tests were performed using IBM SPSS Statistics 20 for Windows (Armonk, NY). A significance level of 0.05 was used unless otherwise stated.

RESULTS

A total of 1823 players (1481 male and 342 female) were involved in the surveilled tournaments. Full details regarding the involved players can be seen in table 1.

Table 1 - Sample characteristics.

	Juniors			Pro Circuit	Total
	Male	Female	Total		
Number of players	474	342	816	1007	1823
Age (mean±SD)	16.28±0.56	15.72±0.41	16.06±0.47	19.94±0.66	18.20±2.02

SD, standard deviation

Descriptive data results

A total of 922 complaints were recorded. The overall results show that the most affected region was the lower limb, followed by the upper limb and trunk. This trend was also present when Juniors/Pro Circuit and male/female junior players were analyzed separately. As for the injury type, the most frequent were musculotendinous injuries, followed by skin and joint injuries in males, and joint and skin injuries in females (table 2). Overall, the shoulder was affected most often, followed by the thigh and the lower back/pelvis/sacrum region. This was

also the case for male junior tennis players. In female junior players, the knee and thigh tied as the second most frequent origin of complaints. In Pro Circuit players, the shoulder, thigh and foot/toe region formed the top three. Detailed body region results are present in table 3.

Injury onset results yielded percentages of acute complaints between 25.9% and 33.3%. Interventions performed on court accounted for 13.8% to 26.5% of complaints. Full results of the distribution across injury onset and place of intervention are present in table 3.

Regarding the sub-type of injuries, muscle complaints were the most frequent, followed by tendon and ligament injuries, except for Pro Circuit players, where skin conditions were the third most frequent. The complete injury sub-type results are displayed in table 4.

Table 2 - Distribution of complaints according to body region, injury type, injury onset and place of treatment.

	Juniors			Pro Circuit	Total
	Male	Female	Total		
N	261	174	435	487	922
Body region					
Head/neck	3 (1.1%)	5 (2.9%)	8 (1.8%)	14 (2.9%)	22 (2.4%)
Upper limb	96 (36.8%)	52 (29.9%)	148 (34.0%)	167 (34.3%)	315 (34.2%)
Trunk	72 (27.6%)	45 (25.9%)	117 (26.9%)*	85 (17.5%)	202 (21.9%)
Lower limb	87 (33.3%)	72 (41.4%)	159 (36.6%)	218 (44.8%)**	377 (40.9%)
Other	3 (1.1%)	0	3 (0.7%)	3 (0.6%)	6 (0.7%)
Injury type					
Bone	0	2 (1.1%)	2 (0.5%)	2 (0.4%)	4 (0.4%)
Joint (non-bone)	27 (10.3%)	30 (17.2%)	57 (13.1%)	53 (10.9%)	110 (11.9%)
Muscle/tendon	199 (76.2%)	124 (71.3%)	323 (74.3%)	338 (69.4%)	661 (71.7%)
Skin	21 (8.0%)	15 (8.6%)	36 (8.3%)	82 (16.8%)**	118 (12.8%)
Neurological	6 (2.3%)	3 (1.7%)	9 (2.1%)	7 (1.4%)	16 (1.7%)
Other	8 (3.1%)	0	8 (1.8%)	5 (1.0%)	13 (1.4%)
Injury onset					
Acute	87 (33.3%)	60 (34.5%)	147 (33.8%)	126 (25.9%)	273 (29.6%)
Gradual	174 (66.7%)	114 (65.5%)	288 (66.2%)	361 (74.1%)**	649 (70.4%)
Place of treatment					
On court	36 (13.8%)	25 (14.4%)	61 (14.0%)	129 (26.5%)	190 (20.6%)
Treatment room	225 (86.2%)	149 (85.6%)	374 (86.0%)	358 (73.5%)	732 (79.4%)

* significantly higher in Juniors than in Pro Circuit ($p < .05$)

** significantly higher in Pro Circuit than in Juniors ($p < .05$)

Table 3 - Distribution of complaints according to sub-regions.

	Juniors			Pro Circuit	Total
	Male	Female	Total		
Head/neck					
Head/face	1 (0.4%)	2 (1.1%)	3 (0.7%)	4 (0.8%)	7 (0.8%)
Neck/cervical spine	2 (0.8%)	3 (1.7%)	5 (1.1%)	10 (2.1%)	15 (2.4%)
Upper limb					
Shoulder/clavicle	37 (14.2%)	29 (16.7%)	66 (15.2%)	67 (13.8%)	135 (14.4%)
Upper arm	7 (2.7%)	6 (3.4%)	13 (3.0%)	11 (2.3%)	24 (2.6%)
Elbow	23 (8.8%)	8 (4.6%)	31 (7.1%)	10 (2.1%)	41 (4.4%)
Forearm	11 (4.2%)*	0	11 (2.5%)	20 (4.1%)	31 (3.4%)
Wrist	15 (5.7%)	7 (4.0%)	22 (5.1%)	22 (4.5%)	44 (4.8%)
Hand/finger/thumb	3 (1.1%)	1 (0.6%)	4 (0.9%)	37 (7.6%)	41 (4.4%)

Trunk					
Sternum/ribs/upper back	16 (6.1%)	11 (6.3%)	27 (6.2%)	26 (5.3%)	53 (5.7%)
Abdomen	27 (10.3%)	13 (7.5%)	40 (9.2%)	13 (2.7%)	53 (5.7%)
Lower back/pelvis/sacrum	29 (11.1%)	21 (12.1%)	50 (11.5%)	46 (9.4%)	96 (10.4%)
Lower limb					
Hip/groin	10 (3.8%)*	0	10 (2.3%)	18 (3.7%)	28 (3.0%)
Thigh	32 (12.3%)	26 (14.9%)	58 (13.3%)	67 (13.8%)	125 (13.6%)
Knee	21 (8.0%)	26 (14.9%)**	47 (10.8%)	30 (6.2%)	77 (8.4%)
Lower leg/Achilles tendon	7 (2.7%)	6 (3.4%)	13 (3.0%)	25 (5.1%)	38 (4.1%)
Ankle	8 (3.1%)	9 (5.2%)	17 (3.9%)	19 (3.9%)	36 (3.9%)
Foot/toe	9 (3.4%)	6 (3.4%)	15 (3.4%)	59 (12.1%)	74 (8.0%)

* significantly higher in male players ($p < .05$)

** significantly higher in female players ($p < .05$)

Table 4 - Distribution of complaints according to sub-type.

	Juniors			Pro Circuit	Total
	Male	Female	Total		
Joint					
Dislocation/subluxation/instability	4 (1.5%)	1 (0.6%)	5 (1.1%)	7 (1.4%)	17 (1.3%)
Ligament injury	23 (8.8%)	21 (12.1%)*	44 (10.1%)	41 (8.4%)	129 (13.9%)
Lesion of meniscus/articular cartilage	0	7 (4.0%)	7 (1.6%)	2 (0.4%)	9 (1.0%)
Synovitis	0	1 (0.6%)	1 (0.2%)	3 (0.6%)	4 (0.4%)
Muscle and tendon					
Muscle rupture/tear/spasm/cramp	146 (55.9%)	85 (48.9%)	231 (53.1%)	250 (51.3%)	481 (52.2%)
Tendon tear/tendinopathy/bursitis	53 (20.3%)	39 (22.4%)	92 (21.1%)	88 (18.1%)	180 (19.5%)
Skin					
Haematoma/contusion/bruise	1 (0.4%)	1 (0.6%)	2 (0.5%)	0	2 (0.2%)
Abrasion, laceration	20 (7.7%)	14 (8.0%)	34 (7.8%)	82 (16.8%)	116 (12.6%)

* significantly higher in female players ($p < .05$)

Age group differences

Considering the distribution of complaints per body region, Pro Circuit players had a significantly higher number of lower limb complaints. On the other hand, the Juniors group showed a higher number of trunk interventions. The comparison of injury type differences revealed a significantly higher number of skin complaints in Pro Circuit players. These players also showed a significantly higher proportion of gradual/overuse complaints (and a consequent lower proportion of acute complaints) when compared to their under-18 counterparts. Complete results are visible in tables 2 and 3.

Gender differences

No differences were found in the distribution of complaints according to body region between male and female Juniors players. However, when considering individual sub-regions, male players had significantly more forearm and hip and less knee complaints than female players.

Injury type comparison showed that female players had more joint complaints. No gender differences were found regarding injury onset or playing surface. These results are displayed in tables 2 to 4.

Playing surface differences

A significantly lower number of shoulder complaints arose from playing on hard court than on artificial grass or clay. A significantly higher amount of elbow complaints was found in hard court and artificial grass matches. Artificial grass also produced a significantly higher number of thigh complaints than the other two surfaces. The injury type comparison showed significantly less joint complaints in hard court matches than on artificial grass or clay. On the contrary, hard court matches produced significantly more muscle/tendon complaints. No other differences were found.

Injury rates

No significant differences were found in injury rates between surfaces in the global sample or between age groups. Interventions per match ($p=0.041$) and per 1000 hours ($p=0.049$) were significantly lower on clay than on artificial grass in Juniors matches. No differences were found between male and female players. Injury rate differences are detailed in tables 5.

Table 5 - Injury rates.

		Per match (95% CI)	P	Per 1000 games (95% CI)	P	Per 1000 hours (95% CI)	P
	Juniors	0.45 (0.31 – 0.56)	0.746	23.31 (15.57 – 30.05)	0.618	301.09 (230.21 – 428.98)	0.516
	Pro Circuit	0.42 (0.35 – 0.48)		21.79 (18.34 – 25.23)		329.60 (253.01 – 349.16)	
Juniors	Gender		0.805		0.924		0.954
	Male	0.45 (0.31 – 0.58)		23.40 (16.56 – 30.15)		337.57 (238.12 – 437.03)	
	Female	0.43 (0.29 – 0.56)		23.00 (15.72 – 30.28)		337.59 (220.32 – 447.27)	
	Surface		0.041		0.064		0.049
	Clay	0.31 (-0.08 – 0.69)		16.70 (-4.81 – 38.21)		227.91 (-65.46 – 521.27)	
	Artificial grass	0.51 (0.42 – 0.61)		27.28 (21.22 – 33.34)		390.62 (299.92 – 481.41)	
Pro Circuit			0.160		0.175		0.179
	Surface						
	Hardcourt	0.45 (0.38 – 0.53)		23.51 (19.45 – 27.57)		325.81 (269.49 – 382.12)	
	Clay	0.35 (-0.74 – 1.42)		18.93 (-37.36 – 75.22)		249.59 (-598.80 – 1097.98)	
	Artificial grass	0.31 (0.18 – 0.44)		15.17 (11.92 – 18.41)		216.65 (169.44 – 263.85)	

DISCUSSION

Descriptive data

Regarding the distribution of complaints across body regions, the lower limb was the most affected region (40.9%). This is in accordance with most epidemiology studies in tennis[3,6–

9,12–17]. The upper limb (34.2%) and trunk (21.9%) were the next most affected regions. Most of the previously mentioned studies also display this pattern, while others found the upper limb and trunk to be similarly affected[14,16] or the upper limb to be the most affected region[18]. It would seem, then, that regardless of injury definition or competitive level, there seems to be a relatively stable pattern when it comes to body region distribution.

Looking at individual sub-regions, the shoulder was the most affected in the overall and all sub-samples. The existing literature regarding this subject is not consensual. While Winge et al.[18] produced the same findings and other studies state the shoulder to be most frequently affected region of the upper limb [16,17], other authors have found the most affected individual region to be the back [6,9,19,20]. The second most affected sub-region in the overall and male samples was the thigh, which is also mentioned as a frequent origin of complaints in tennis players[8,12,17]. Female junior players had the knee and thigh tied for the second most frequent origin of complaints. There is evidence of young female tennis players having a greater risk of patellofemoral issues[20]. Junior male players had the lumbar region as the third most frequent. While a greater number of low back complaints was expected given the existing literature, the number of complaints in this sub-sample may be due to the importance of the serve in the male tennis game and the predisposition of adolescent players to develop degenerative changes in the lumbar spine[21].

Musculotendinous complaints were the most frequent across all groups. This was an expected finding and is in line with all the literature found which categorizes this parameter[5,7,10,22]. In the overall sample and for male players, skin problems were the second most frequent complaint, followed by joint issues. In female players, however, joint complaints were the second most frequent. This may be attributable to the fact that female athletes, especially in younger ages, have greater ligament laxity[23–25]. Sell et al. 2014[7] also found joint and skin complaints to follow musculotendinous issues as the most frequent.

Injury sub-type distribution revealed the two most frequent types of complaints were related to muscle and tendon, which is natural considering the dominance of the musculotendinous type previously discussed. In Pro Circuit players, the third most frequent sub-type was skin complaints, while in the overall sample ligament issues occupied third place. An increased number of foot/toe abrasions in the professional players caused this difference. This may be attributable to the higher speed of play and more aggressive cutting and sliding movements, which increase the risk of blisters and skin abrasions.

The percentage of acute complaints in this study ranged from a quarter to a third across all sub-samples. There is contradictory evidence regarding this topic, with some authors mentioning a majority of overuse complaints in tennis players [9,16–18] and others finding a majority of acute complaints[7,13]. Present results are thus in accordance with the first group.

In this study, on-court interventions accounted for 14-27% of all recordings. Silva et al.[5] found a slightly higher percentage of court calls in their study.

Age group differences

Pro Circuit players showed a significantly greater number of lower limb complaints. This was mainly due to the also significantly higher incidence of foot/toe skin conditions. A possible explanation for this difference was previously mentioned. Juniors showed a higher number of trunk complaints. The abdomen and lumbar regions were responsible for this difference. Previous studies have highlighted the lumbar injury risk related to tennis practice and greater incidence of lumbar injuries in young tennis players[6,14,21]. Pro Circuit players also showed a greater percentage of overuse injuries. This is in line with the literature, which reports a higher number of acute injuries in young tennis players[16,17].

Gender differences

Male players showed significantly more forearm and hip complaints. Sell et al. 2014[7] also found a greater amount of hip complaints in male tennis players. Results from the present study also show a greater number of joint and knee complaints in female players. A greater risk of female tennis players developing patellofemoral injuries has been previously reported[12,16,20]. Previous literature, has, however, found that injury patterns in tennis are more sport- than gender-specific[12,13,16,20]. Despite this, two recent studies of professional tennis players did find a number of gender differences both in location and injury type[7,8]. Current results add to the latter studies, providing additional information of gender-specific injury profiles in tennis players. This fact may warrant further investigation.

Playing surface differences

Differences in the affected body region and injury type found between playing surfaces are somewhat contradictory to the general consensus found in the literature. Most shoulder complaints in tennis are related to overuse, and thus it makes sense that there were fewer complaints in hard court matches, where rallies are shorter[11,26,27]. On the contrary, matches played in this surface produced more elbow complaints, which should have followed the same pattern as the shoulder. Hard courts produce greater impact forces on joints[28,29], so the lesser number of joint complaints found in this surface was unexpected.

Injury rates

Hard court matches have been noted to produce a greater rate of injuries leading to withdrawals from tennis matches[10,22]. Injury rates in hard court were also the highest in the present study, but not enough to achieve significance. Under-18 players showed significantly lower injury rates on clay than on artificial grass. This supports the general assumption that there is a lower injury risk when playing on clay than on other surfaces[12,26,30], although Hjelm et al. 2012[19] did not find differences in injury risk between surfaces and Breznik & Batagelj[10] found a greater number of retirements on clay than on grass.

Greater injury rates and number of withdrawals from matches for female players have been previously reported[5,8]. However, most authors have found either no differences or a greater injury rate in male players[3,12,13,18,31]. No difference was found in this study. Injury rates found in this study fall on the upper limit[5,12] or are higher[17,18] than what is found in the literature. Although the wide definition of injury used in this study contributed to these figures, the results do reflect the challenges imposed to these players regarding volume of play and continuous travel without the same amenities available to world-class players. Breznik & Baragelj[10] have found a greater number of withdrawals in Futures tournaments than in other competitive levels, which is in line with the presented results.

Study limitations and future directions

It must be noted that the study was meant to produce results specific to this playing level; this information should not be generalized to other samples of tennis players. The estimation of playing time was made from values calculated at matches with umpires and ball boys. This may have led to an underestimation of actual exposure time, thus increasing injury rates per playing time, since not all matches included in the present study had umpires and ball boys. The conflicting results on the differences between genders should be targeted by future studies of both male and female Pro Circuit athletes, since the latter were not included in this study. Further research on ITF tournaments from different tournament grades and locations is still needed to substantiate results from this study. In spite of the data provided by this study, this remains an understudied population at various levels and warrants more investigation.

CONCLUSION

Data about the distribution of medical complaints of tennis players during ITF tournaments were presented. Injury location patterns indicate a stable pattern across competitive levels. The number of differences in injury location and type between genders adds to some contradictions in the literature and warrants further investigation. Pro Circuit players had more skin and chronic complaints. Juniors circuit players showed lower injury rates on clay matches.

COMPETING INTERESTS AND FUNDING

No competing interests were present. No funding sources were used.

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