Full Title: Injury epidemiology of tennis players at the 2011 to 2016 Australian Open Grand Slam

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**Abstract**

**Aim:** To examine the epidemiology and in-event treatment frequency of injury at the 2011-2016 Australian Open tournaments. **Methods:** Injury incidence was defined as a medical consultation by a tournament physician, and in-event treatment frequency as the mean total number of follow-up medical/physiotheraphy consultations (2013-2016 tournaments only). Data were collated by sex, injury region and type and reported as frequencies per 10,000 game exposures. Incidence rates ± 95% confidence intervals and rate ratios were used to test effects for injury, sex and year. **Results:** Female players experienced more injuries than male players (201.7 vs 148.6). The shoulder (5.1±1.1 injuries per year), foot (3.2±1.1), wrist (3.1±1.5) and knee (3.1±1.1) were the most commonly injured regions among females. Knee (3.5±1.6) , ankle (2.3±1.3) and thigh (2.3±1.5) were the most prevalent male injuries. Upper arm injuries and in-event treatment frequency increased by 2.4 times in both sexes over the 5-year period. Muscle injuries were most frequent. There was a >2.0 fold increase in men and women with stress fractures over the 5-year period. The torso region, including the neck, thoracic spine, trunk and abdominal, lumbar spine, hip and groin, pelvis/buttock, attracted high in-event treatment frequencies in both sexes. **Conclusion:** Upper and lower extremity injuries affected females while lower limb injuries were more prominent in males. There was an increasing rate of in-event treatements of upper limb and torso injuries as well as stress fractures during the observation period.

**Introduction**

The Australian Open is one of four Grand Slam events in professional tennis. Epidemiological profiles of injuries at the Wimbledon and US Open Grand Slams have been conducted[[1](#_ENREF_1), [2](#_ENREF_2)], though as yet, the Australian Open profile remains to be reported. As the Australian Open is scheduled at a different time of year, on a different court surface (Plexcushion) and in a different climate to the other Grand Slams, its injury profile may differ.

The injury profiles of the Wimbledon and US Open Grand Slams suggest that elite tennis is highly injurious compared to other sports[[1](#_ENREF_1), [2](#_ENREF_2)]. As context, sports like rugby and basketball have reported means of 10.5[[3](#_ENREF_3)] and 8.5[[4](#_ENREF_4)] injuries per 1,000 training hours and athletic exposures, respectively. Injuries at Wimbledon between 2003-2012 resulted in a mean injury rate of 20.7 injuries per 1,000 set exposures (which typically last for less than one hour)[[1](#_ENREF_1)]. Within the Wimbledon injury rate, female players were more frequently injured than their male counterparts (23.4 vs 17.7 injuries per 1,000 set exposures). Acute injuries were more prominent than chronic injuries, with the shoulder, knee and lumbar spine the most commonly injured regions[[1](#_ENREF_1)]. At the US Open between 1994 to 2009, the mean injury rate was 48.1 injuries per 1,000 match exposures[[2](#_ENREF_2)]. Within this tournament, a higher injury incidence existed among male than female players (44.0 vs 32.2 per 1,000 match exposures), which directly contrasts with Wimbledon’s sex-based injury profile[[1](#_ENREF_1), [2](#_ENREF_2)]. Further, lower limb injuries were three and 1.3 times more prominent than trunk injuries and upper limb injuries respectively, despite similar prevalence of acute injuries as reported at Wimbledon[[1](#_ENREF_1)]. Collectively, these data highlight the variation in the injury profile of respective Grand Slam tennis events.

Injury incidence in tennis has been described in the context of match exposures[[2](#_ENREF_2)], tennis hours[[5](#_ENREF_5), [6](#_ENREF_6)] and per 100 tennis players[[7](#_ENREF_7)]. These disparate methods complicate the comparison of injury rates between tennis events. Given reporting differences, a standard method of comparison would be useful. This would also assist with comparisons between sexes given that males play the best of five-set Grand Slam singles tennis and females, the best of three-sets[[8](#_ENREF_8)]. For example, as described above, the mean women’s and men’s injuries at the US open were 32.2 and 44.0 per 1,000 match exposures respectively. However, if normalised to sets, games or duration played, the sex comparison may present different conclusions, and suggest alternate practical outcomes.

While the incidence of injury at tennis tournaments has been widely investigated, the in-event treatment frequency of injuries, through the number of practitioner consultations, has seldom been examined[[9](#_ENREF_9)]. This type of information may provide insight into the in-event medical resource burden of different types of injuries, and inform tournament physician and physiotherapist resourcing. Therefore, the aim of this study was to examine the epidemiology of injury at the Australian Open from 2011-2016 relative to sex, injury type and in-event treatment frequency.

**Methods**

Injury data from the 2011 to 2016 Australian Open Grand Slams were used for the analysis. A total of 1,170 unique injuries across the men’s and women’s qualifying and main draw singles, doubles and mixed doubles were included with a total of 3,120 players competing in these events across the six years. The mean male and female professional singles ranking of the singles cohorts were 84±71 and 81±76 respectively. Junior and wheelchair tennis player injuries were excluded[[2](#_ENREF_2)]. All consultations were entered and stored on secure, digital repositories. Consent for the use of data for research purposes was collected from all Australian Open players upon entry to the tournament, assuming player anonymity was maintained. The study was approved by the Australian Catholic University Human Ethics Committee.

**Injury Definition and Classification**

Injury incidence was defined as an injury that occurred during the Australian Open requiring a medical consultation by a tournament-appointed physician (omitting consultations not related to injuries)[[2](#_ENREF_2)]. The number of tournament-appointment physicians was 6 per year over the 6y collection period. Injury data, classified by region and type as per the Orchard Sports Injury Classification System (OSICS)[[10](#_ENREF_10)], was obtained by exporting the relevant consultations. Injury type was limited to musculoskeletal injuries (omitting lacerations/abrasions and bruising/haematomas).

**In-Event Treatment Frequency Definition**

The in-event treatment frequency dataset contained injury information from 2013-2016 as previous Women’s Tennis Association (WTA) and Association of Tennis Professionals (ATP) consultation data was not available. The in-event treatment frequency of each injury region was defined as the mean number of initial and follow-up medical and physiotherapy consultations per injury. Physiotherapy consultations were performed by Tennis Australia-appointed physiotherapists, and physiotherapists from the ATP and WTA.

De-identified, consultation frequency per injury from the ATP and WTA repositories were then migrated with the same data from the Tennis Australia repository. The physiotherapy classification system used by Tennis Australia physiotherapists was the OSICS, whereas the ATP and WTA physiotherapists used the Sports Medicine Diagnostic Coding System (SMDCS)[[11](#_ENREF_11)]. Given these disparate diagnostic-coding indices, a sports physiotherapist, with more than10 years experience in delivering and recording Grand Slam tennis physiotherapy treatments, qualitatively transformed the SMDCS codes into their equivalent OSICS code for the purposes of analysis.

**Choice of Exposure**

Although 1,000 match hours has been recommended as the preferred injury frequency[[12](#_ENREF_12)], match durations were not readily available for all matches in the current study. In order to retain all available match data, an exposure measure that was strongly and positively correlated with match duration was sought. In tennis, games are nested within sets and sets are nested within a match. Under a standard best of three-set format, the number of games in a set can range from six to 13, while the number of sets can range from two to three. This would suggest that the number of games would be the most precise measure of duration of play among these choices. In other words, being the smallest common unit of match play available, it provides a more standardised and accessible approach to quantifying exposure. An empirical correlation analysis confirmed this supposition. Using publicly available data on minutes played for 52,948 ATP and 4,625 WTA matches of all professional event types played between 2011 and 2016, the Pearson correlation coefficient and 95% confidence interval (CI) between minutes and games played and minutes and sets played was evaluated. As minutes played are nested within match, the correlation with matches played is necessarily zero. Both games (male: r = 0.87±0.00, female: r = 0.73±0.01) and sets (male: r = 0.77±0.00, female: r = 0.61±0.02) played were positively correlated with match duration, yet games played was the most strongly related to minutes played. Therefore, game exposures were used rather than the 1,000 set or match exposures as reported in the Wimbledon and US Open injury profiles[[1](#_ENREF_1), [2](#_ENREF_2)] as it provides a more accurate account of the exposure of matchplay [[13](#_ENREF_13)].

Data were collated based on sex and year, and reported as an injury frequency per 10,000-game exposures (GE). Each singles game equated to two GEs as both players were exposed to the same game. Doubles and mixed doubles equated to four GE per game. As mixed doubles concluded with a third-set super-tiebreak (first to ten points) the total points were summed and divided by the mean number of points per game (six)[[14](#_ENREF_14)] to quantify the GE.

**Statistical Analysis**

Results are reported as mean ± standard deviation (SD), incidence rates ± 95% CI, and rate ratios. Statistical programming (R Core Team, 2012) was used for the all statistical analyses. The ‘metafor’ package was used to implement the fixed-effects meta-regression analysis of incidence rates ± 95% confidence interval (CI) with precision weights. Incidence rates represent the year-on-year change in injury counts by region and type, where 2011 and 2013 were the base years for injury incidence and in-event treatment frequency respectively. The magnitude of change is inferred by rate ratios whereby a ratio of greater than 1 is considered to be an increase, and less than 1, a decrease.

**Results**

**Total Injuries**

Over the 6 years of Australian Opens, 2011-2016, female players had more injuries, per 10,000 GE than their male counterparts (201.7 vs 148.6). Females also experienced more injuries than males per individual Australian Open in all years bar 2011 (33.6 ± 1.6 versus 24.8 ± 1.2 per year). However, there was no change in injury risk by sex over time (Figure 1).

**\*\*\* Insert Figure 1 here \*\*\***

**Injury Region**

The most common male injury region over the six-year period was the knee, followed by the ankle and thigh (3.5±1.6, 2.3±1.3 and 2.3 ±1.5 injuries per year; Figure 2). The shoulder (5.1±1.1 injuries per year) was the most common injury region in females followed by the foot (3.2±1.1), wrist (3.1±1.5) and knee (3.1±1.1; Figure 2). There was a 2-fold or greater increase in the rate of male ankle and elbow (incidence rate ± 95% CI; 0.3±0.5 and 0.3±0.4) injuries over the 2011-2016 period (Table 1). The increased rate of female shoulder (2.0 times; 0.6±0.7) and wrist injuries (2.2 times; 0.4±0.7) was also pronounced. Additionally, the rate of upper arm injuries increased by at least 2.4 times in male and female (0.1±0.2 and 0.1±0.3) players over the six Australian Opens (Table 1).

**\*\*\* Insert Figure 2 here \*\*\***

**\*\*\* Insert Table 1 here \*\*\***

**Injury Type**

Muscle injuries, in both sexes, were the most prominent type of injury with a total of 45.9±3.3 and 56.5±1.3 male and female muscle injuries respectively per 10,000 GE (Figure 3). From 2011 to 2016, there was a 2.1 fold (incidence rate ± 95% CI; 0.1±0.3), and 2.4 fold (0.2±0.5) increase in the rate of stress fractures among male and female players respectively (Table 2).

**\*\*\* Insert Figure 3 here \*\*\***

**\*\*\* Insert Table 2 here \*\*\***

**In-Event Treatment Frequency by Injury Region**

The mean number of in-event treatments per injury did not differ between sex (females 3.5±1.2 vs males 2.6±0.7). The lumbar spine had the highest mean in-event treatments among male Australian Open competitors between 2013-2016 (4.0±1.6 per year; Figure 2), while the ankle had the highest mean in-event treatments among female players (4.9±2.9 per year; Figure 2). The rate of male and female upper arm in-event treatments per injury increased by 5.8 (incidence rate ± 95% CI; 0.3±0.5) and 5.2 (0.4±0.6) over the four-year period (Table 2).

**In-Event Treatment Frequency by Injury Type**

The injury types with the highest in-event treatment frequency differed between sex, with joint sprains the most common among male players (5.2±2.5 mean in-event treatment frequency ± SD per year) and cartilage injuries the most common amongst females (5.1±5.3; Figure 3). Over the four years, there was a rate increase of 8.3 (incidence rate ± 95% CI; 0.8±1.0) and 4.0 (0.7± 0.9) for stress fracture mean in-event treatments among males and females respectively (Table 3).

**Set and Match Exposure Results**

Supplementary tables including the incidence rates ± 95% CI and rate ratios for injury region, type and in-event treatement frequency per 1,000 set and match exposure are available.

**Discussion**

The aim of this study was to profile injuries at recent Australian Opens by sex, region, type, in-event treatment frequency and year. Female players sustained more injuries than male players over the tournaments except for 2011. Shoulder and wrist, as well as foot and knee injuries were most common among female players, while lower limb injuries were the most prevalent among males. Over time, there were discernible increases in the rate of male upper arm, elbow and ankle injuries, and female upper arm, shoulder, wrist and lower leg injuries. In keeping with previous accounts of Grand Slam injuries [[1](#_ENREF_1), [2](#_ENREF_2)], muscle injuries were the most prominent injury type in both sexes. However, the rate of stress fractures noticeably increased over time. The torso region (neck, thoracic spine, trunk and abdominal, lumbar spine, hip and groin, pelvis/buttock) - and more particularly the neck and lumbar spine of male players and thoracic spine of female players - attracted high treatment frequencies. Joint sprains in male players and cartilage injuries in female players were the most frequently treated injury type.

**Sex differences**

Higher injury rates have been reported among male than female players competing at Grand Slam level[[2](#_ENREF_2)]. Conversely, accounting for injuries per 10,000 GE in the present study, women were found to have a higher injury rate compared to men. This is consistent with the higher incidence of injury in female professionals previously reported at Wimbledon, which utilised a set exposure injury rate to account for differences in sex set requirements[[1](#_ENREF_1)]. While the likely mechanisms of injury are multifactorial, it is likely that sex-based physical[[15](#_ENREF_15), [16](#_ENREF_16)], technical and tactical differences[[15](#_ENREF_15), [17](#_ENREF_17)] are contributers. For example, females have slower movement speeds[[15](#_ENREF_15)], and lower absolute strength[[16](#_ENREF_16)] compared to professional male tennis players. Therefore, they may have less time to set up for optimal stroke execution resulting in compromised joint positioning[[17](#_ENREF_17)]. This could explain their high prevalence of injuries across both extremities. Additionally, males could be relatively more likely to sustain lower limb injuries owing to the heightened absolute movement demands of the men’s game[[15](#_ENREF_15)]. Indeed, the higher incidence of lower limb injury as compared to upper limb injury in male Australian Open players, is consistent with the earlier Wimbledon and US Open Grand Slam injury epidemiology research[[1](#_ENREF_1), [2](#_ENREF_2)].

**Injury by Type**

Muscle injuries were the most common across both sexes followed by tendon and joint sprains. This agrees with the injury reports at the US Open and Wimbledon Grand Slams[[1](#_ENREF_1), [2](#_ENREF_2)]. This finding was anticipated given the dynamic, high-intensity and repetitive nature of tennis that places large strain on the muscles, tendons and joints[[16](#_ENREF_16), [18](#_ENREF_18), [19](#_ENREF_19)]. It is worth noting that whilst remaining the most prominent injury, a 13% reduction in muscle injuries in males existed over the six year period, despite no reduction in total injuries. Additionally, the highest male and female injury type in-event treatment frequencies resulted from joint sprains and cartilage injuries respectively. The higher cost of such injuries suggests that these injury types require greater on-going consultation by tournament physicians and physiotherapists. Separately, stress fracture injury occurrence and in-event treatments in both sexes increased over this time-period. This is supported by findings highlighting the high risk of stress fractures in tennis players due the repetitive powerful movements demanded which could place heavy mechanical loads on athlete bone[[20](#_ENREF_20)].

**Injury by Region: Torso Injuries and In-Event Treatment Frequency**

The incidence of female thoracic and lumbar spine injury incidence increased over time. However, the incidence rate of male torso injuries and other female torso regions- including the neck, thoracic and lumbar spine, trunk and pelvis- decreased over the same time period. Despite this, the in-event treatments for torso injuries in both sexes was found to be among the Australian Open’s highest. This trend may be attributable to the mechanical demands placed on this region during stroke production, changes in equipment[[2](#_ENREF_2)] or cause players to seek further treatment. Given the literature that has highlighted the importance of trunk rotation to racquet speed - particularly in the serve[[22](#_ENREF_22)]- it is unsurprising that the pelvis-spine-trunk receive considerable medical attention in-event. This heightened medical attention in-event, coupled with the general reduction in incidence rate, suggests that injury prevention and training programs could already be focused on the torso and should remain the ongoing target.

**Injury by Region: Upper Limb Injuries and In-Event Treatment Frequency**

The rate and in-event treatment frequency of upper arm injuries in both sexes increased over time. This effect was also observed for the rate of male elbow and female shoulder injuries as well as the rate and in-event treatments of female wrist injuries. Although [McCurdie, Smith [1]](#_ENREF_1), [Sell, Hainline [2]](#_ENREF_2) did not report in-event treatment frequencies, they highlighted a high occurrence of shoulder injuries in both sexes and wrist injuries in female players. The constantly evolving racquet, string and ball technology may be one reason for these changes[[15](#_ENREF_15), [23](#_ENREF_23)]. Spikes in serve load, which are common during tournament play as compared to training, particularly at a Grand Slam at the start of the season[[24](#_ENREF_24)], might also place relatively greater strain on the upper limb joints[[25](#_ENREF_25), [26](#_ENREF_26)].

**Injury by Region: Lower Limb Injuries and Treatment Cost**

There was a rate increase of ≥2.4 times in in-event treatments of female ankle and lower leg injuries over the time-period. The prevalence of female lower leg injuries and male ankle injuries also increased, by 2 fold, between 2011-2016. [Sell, Hainline [2]](#_ENREF_2) reported the lower limb as being more suspectible to injury than the upper extremity in both sexes but noted no change in the injury rate over time. This sex-independent increase in ankle pathologies would appear related to the repeated rapid changes in direction on a hard-court surface, which places high stress on the ankle joint and lower leg[[19](#_ENREF_19), [27](#_ENREF_27)]. Interestingly, the sex-specific growth observed in in-event treatments could imply that physiotherapists treating female players adopt a precautionary/hyper-vigilant, through taping, approach.

**Limitations**

It must be noted that this study is unable to draw conclusions regarding the causative mechanisms of injury. Additionally, as the WTA and ATP datasets were de-identified, in-event treatment frequencies are calculated as an average across all injuries of the same region and type rather than each injury in isolation. Finally, the dataset does not contain injury or treatment information on players whom sought treatment outside of the tournament's doctors and physiotherapists.

**Conclusion**

The injury epidemiology of the 2011-2016 Australian Open revealed that female players were more commonly injured than male players. Lower limb injuries were more prominent in males whereas females were susceptible to injuries in both extremities, which is consistent with findings from Wimbledon and US Open Grand Slams[[1](#_ENREF_1), [2](#_ENREF_2)]. Both sexes also presented with a high prevalence of muscle injuries [[1](#_ENREF_1), [2](#_ENREF_2)], and, the high in-event treatment frequencies of the torso highlighted the demand on medical resources. Collectively, these findings demonstrate the most common injuries and workload for the medical services at the Australian Open, which is informative for the injury prevention and treatment of elite tennis players.

**New Findings**

* Using game exposures as a relative injury scale offers a more accurate measure of match volume or exposure than previously published methods. Correspondingly, this allows for more precise standardisation in epidemiological comparison between Grand Slams.
* Female players incurred more injuries than male players over the 2011 to 2016 Australian Opens per games played.
* Across both sexes, the torso region incurred high in-event treatment frequency highlighting their demand on medical resources during the Australian Open.
* In-event treatment frequency as a novel reporting of medical and physiotherapy consultations per injury, provides scope for the assessment of medical resource management at tennis events.

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**Competing Interests**

The authors have no disclosures or competing interests.

**Contributorship**

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Supplementary tables have been provided.

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**Table 1: Injury incidence ± 95% confidence interval and rate ratio, per 10,000 game exposures, for male and female injury occurrence and treatment cost by region over the 2011 to 2016 Australian Open with 2011 as the base year (2013-2016 for treatment cost with 2013 as the base year)**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Male** | | | | **Female** | | | |
|  | **Injury Occurrence** | | **Treatment Cost** | | **Injury Occurrence** | | **Treatment Cost** | |
| **Region** | Incidence rate change ± 95% confidence interval | Rate Ratio | Incidence rate change ± 95% confidence interval | Rate Ratio | Incidence rate change ± 95% confidence interval | Rate Ratio | Incidence rate change ± 95% confidence interval | Rate Ratio |
| Head | 0.00 ± 0.19 | 1.0 | 0.00 ± 0.29 | 1.0 | -0.12 ± 0.28 | 0.3 | 0.04 ± 0.35 | 1.6 |
| Neck | -0.12 ± 0.31 | 0.4 | 0.66 ± 0.79 | 150.9 | -0.11 ± 0.26 | 0.4 | 1.19 ± 0.88 | 39.3 |
| Shoulder | -0.11 ± 0.48 | 0.8 | 0.05 ± 0.56 | 1.0 | 0.57 ± 0.69 | 2.0 | 0.55 ± 1.28 | 1.8 |
| Upper Arm | 0.09 ± 0.24 | 3.1 | 0.30 ± 0.46 | 5.8 | 0.08 ± 0.26 | 2.4 | 0.41 ± 0.62 | 5.2 |
| Elbow | 0.26 ± 0.40 | 2.5 | 0.03 ± 0.59 | 1.1 | -0.31 ± 0.51 | 0.4 | 0.17 ± 0.97 | 1.3 |
| Forearm | -0.07 ± 0.28 | 0.5 | -0.38 ± 0.56 | 0.1 | -0.02 ± 0.22 | 0.8 | 0.00 ± 0.00 | 0.0 |
| Wrist | 0.08 ± 0.42 | 1.3 | -0.09 ± 0.59 | 0.7 | 0.37 ± 0.66 | 2.2 | 0.79 ± 1.03 | 3.5 |
| Chest | -0.01 ± 0.16 | 0.9 | 0.00 ± 0.00 | 0.0 | -0.01 ± 0.24 | 0.9 | -0.36 ± 0.60 | 0.3 |
| Thoracic Spine | -0.04 ± 0.17 | 0.6 | -0.49 ± 0.53 | 0.0 | 0.09 ± 0.29 | 1.8 | 0.24 ± 0.87 | 2.2 |
| Trunk and Abdominal | -0.39 ± 0.41 | 0.2 | -0.01 ± 0.52 | 1.0 | -0.34 ± 0.56 | 0.3 | -0.55 ± 1.09 | 0.2 |
| Lumbar Spine | -0.09 ± 0.38 | 0.7 | -0.68 ± 1.01 | 0.6 | 0.05 ± 0.49 | 1.3 | 1.07 ± 1.33 | -18.0 |
| Hip and Groin | -0.48 ± 0.38 | 0.2 | 0.90 ± 0.77 | 4.1 | -0.33 ± 0.45 | 0.3 | -0.29 ± 1.01 | 0.4 |
| Pelvis/Buttock | -0.20 ± 0.29 | 0.1 | 0.04 ± 0.33 | 1.7 | -0.12 ± 0.36 | 0.4 | -0.01 ± 0.80 | 1.0 |
| Thigh | 0.17 ± 0.51 | 1.9 | -0.41 ± 0.78 | 0.3 | -0.09 ± 0.57 | 0.1 | -0.12 ± 0.93 | 0.7 |
| Knee | -0.46 ± 0.67 | 0.5 | -0.11 ± 0.65 | 0.7 | 0.22 ± 0.65 | 1.5 | -0.29 ± 1.05 | 0.6 |
| Lower Leg | -0.20 ± 0.24 | 0.1 | -0.02 ± 0.29 | 0.8 | 0.13 ± 0.43 | 2.6 | 0.70 ± 0.75 | 37.0 |
| Ankle | 0.25 ± 0.51 | 2.0 | -0.09 ± 0.59 | 0.8 | 0.23 ± 0.55 | 1.6 | 1.11 ± 1.46 | 2.4 |
| Foot | -0.12 ± 0.23 | 0.4 | -0.54 ± 0.52 | 0.2 | -0.15 ± 0.57 | 0.8 | -0.73 ± 1.14 | 0.3 |

**Table 2: Injury incidence ± 95% confidence interval and rate ratio, per 10,000 game exposures, for male and female injury occurrence and treatment cost by type over the 2011 to 2016 Australian Open with 2011 as the base year (2013-2016 for treatment cost with 2013 as the base year)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | **Male** | | | | **Female** | | | | |  |  |
|  |  | | **Injury Occurrence** | | **Treatment Cost** | | | **Injury Occurrence** | | **Treatment Cost** | | |
|  | **Type** | | Incidence Rate Change ± 95% confidence interval | Rate Ratio | Incidence Rate Change ± 95% confidence interval | | Rate Ratio | Incidence Rate Change ± 95% confidence interval | Rate Ratio | Incidence Rate Change ± 95% confidence interval | | Rate Ratio |
|  | Muscle Injury | | -1.35 ± 0.91 | 0.4 | 0.19 ± 0.92 | | 1.3 | -0.64 ± 1.17 | 0.7 | 0.01 ± 1.56 | | 1.0 |
|  | Joint Sprains | | 0.26 ± 0.71 | 1.3 | -0.14 ± 1.14 | | 0.9 | -0.23 ± 1.01 | 0.9 | 0.71 ± 1.07 | | 0.4 |
|  | Tendon Injury | | -0.52 ± 0.80 | 0.6 | -0.43 ± 0.94 | | 0.6 | -0.18 ± 0.89 | 0.9 | 0.43 ± 0.94 | | 0.6 |
|  | Synovitis, Impingement, Bursitis | | -0.07 ± 0.61 | 0.9 | -0.24 ± 0.98 | | 0.8 | 0.44 ± 0.78 | 1.7 | 0.15 ± 1.42 | | 1.1 |
|  | Cartilage Injury | | -0.00 ± 0.20 | 1.0 | -0.93 ± 1.13 | | 0.2 | 0.06 ± 0.29 | 1.6 | -0.20 ± 2.00 | | -1.2 |
|  | Stress Fracture | | 0.05 ± 0.27 | 2.1 | 0.69 ± 1.02 | | 8.3 | 0.23 ± 0.49 | 2.4 | 0.70 ± 0.84 | | 4.0 |
|  | Organ Injury | | -0.00 ± 0.18 | 0.9 | 0.00 ± 0.00 | | 0.0 | -0.12 ± 0.28 | 0.3 | -0.32 ± 1.52 | | 4.1 |
|  | Chronic Instability | | -0.00 ± 0.20 | 1.0 | 0.00 ± 0.00 | | 0.0 | -0.07 ± 0.31 | 0.5 | 3.61 ± 2.76 | | 9.1 |
|  | Nerve Injury | | 0.01 ± 0.16 | 1.2 | 0.00 ± 0.00 | | 0.0 | -0.02 ± 0.32 | 0.8 | -0.30 ± 0.88 | | 0.5 |
|  | Arthritis | | -0.02 ± 0.21 | 0.7 | 0.00 ± 0.00 | | 0.0 | -0.02 ± 0.22 | 0.8 | -0.01 ± 1.75 | | 1.0 |
|  | Other Stress/Over use Injury | | 0.01 ± 0.17 | 1.2 | 0.44 ± 2.03 | | 3.6 | 0.00 ± 0.00 | 0.0 | 0.00 ± 0.00 | | 0.0 |
|  | Fracture | | 0.00 ± 0.16 | 1.0 | 0.00 ± 0.00 | | 0.0 | 0.00 ± 0.00 | 0.0 | 0.00 ± 0.00 | | 0.0 |
|  | Joint Dislocation | | 0.00 ± 0.00 | 0.0 | 0.00 ± 0.00 | | 0.0 | 0.02 ± 0.22 | 1.2 | 0.00 ± 0.00 | | 0.0 |
|  | Whiplash | | 0.00 ± 0.00 | 0.0 | 0.00 ± 0.00 | | 0.0 | -0.02 ± 0.22 | 0.8 | 0.00 ± 0.00 | | 0.0 |