

Systematic review of musculoskeletal injuries in professional golfers

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ABSTRACT

Objective The distribution of injuries affecting professional golfers is yet to be fully understood. We performed a systematic review of the clinical literature to establish the epidemiology of musculoskeletal injuries affecting professional golfers.

Design Systematic review.

Data sources Searched databases in July 2018 were PubMed, SPORTDiscus and Embase.

Eligibility criteria Published observational research articles relating to the incidence or prevalence of musculoskeletal injuries in professional golfers, which were written in the English language and not restricted by age or gender.

Results Of the 1863 studies identified on the initial search, 5 studies were found to satisfy the inclusion criteria for analysis. The mean age of the golfers in these studies was 34.8 (±3.6) years. The gender of patients in included studies comprised 72% males and 28% females. Four studies reported that lumbar spine injuries were the most common (range 22%–34%). Excluding injuries to the spine (lumbar, thoracic and cervical), the hand/wrist was the next most common region of injury (range 6%–37%). The quality of the studies was relatively poor with no study satisfying >50% of the quality assessment tool questions and only one study giving a clear definition of how they defined injury.

Conclusion There is a paucity of well-designed epidemiological studies evaluating musculoskeletal injuries affecting professional golfers. Injuries to the spine are the most frequently affected region, followed by the hand/wrist. This study has identified targeted areas of future research that aims to improve the management of injuries among professional golfers.

INTRODUCTION

There are approximately 17 500 golfers registered as professionals in Europe¹ and the growing worldwide schedule for these players is placing a considerable demand on their physical capability to perform.² Injuries to high profile, professional players has commanded considerable media and popular attention. Injuries can have a major impact on a golfing career, including sporting absence, reduced performance and loss of income. While substantial attempts have been made to establish the most frequent injuries affecting amateur golfers,^{3–7} the epidemiology of musculoskeletal injuries affecting professional golfers is less well understood.

The profile of injuries affecting amateur players appears to differ when compared with those affecting

professionals.^{5 8 9} This may be attributed to differences in swing characteristics and biomechanics in professional golfers such as creating more ‘X-factor’ (a greater rotation of the thoracic spine and restricted hip rotation at the top of the backswing)^{10 11} and the different use of the forearm muscles in the trail and lead arm.¹² Furthermore, club head speeds and playing volume are on average much greater for the professional golfer.⁵ Professional golfers typically hit >2000 balls per week with 73.3% striking 200 balls or more per day on average. In contrast, only 19.4% of amateurs hit >200 balls per week.⁵ As the game of golf has evolved, so too have the biomechanics of the golf swing.^{13–15} It is speculated that a modern day professional swing generates increased torque, which may contribute to increased rates of lower back pain in professional golfers.^{16–18} Professionals and amateurs should therefore be considered as distinct patient groups sustaining differing injury profiles.

The literature to date has focused on injuries known to be prevalent among social or amateur golfers, with a paucity of literature focusing on injuries affecting professional golfers. Given the differences in amateur and professionals swing biomechanics and distribution of injuries we believe they should be analysed separately and therefore, the aim of our systematic review was to describe the epidemiology of musculoskeletal injuries in professional golfers.

METHODS

A search of PubMed, SPORTDiscus and Embase was performed in July 2018 in line with the 2009 Preferred Reporting Items for Systematic Review and Meta-Analysis statement.¹⁹ The study was registered using the PROSPERO International prospective register of systematic reviews (CRD42017075191).²⁰

Titles and abstracts identified were independently reviewed by two authors (PGR, ADD) and those not meeting the inclusion criteria were excluded before full-text review. On occasions when it was not clear from the abstract if studies were relevant, the full text of the article was reviewed. Attempts were made to contact the authors of articles when the data included were not clear. Unanimous consensus was met on the inclusion of proposed studies for full-text review among the authors (PGR, ADD). Full-text studies were further evaluated against the inclusion and exclusion criteria. A search of the references of the selected studies was conducted to ensure no other relevant studies were missed.



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Search terms and criteria for inclusion

Search terms were 'golf AND (injur* OR back OR lumbar OR cervical OR thoracic OR shoulder OR elbow OR wrist OR hand OR hip OR knee OR ankle OR foot)'. Grey literature was searched in each database in the form of conference proceedings and abstracts. Studies were excluded from analysis if they were case reports, injuries not related to the physical activity of golfing, that is, golf cart injuries, ocular injuries or head injuries or injuries occurring in recreational golfers. The criteria for inclusion was as follows:

1. Published epidemiological, observational, research articles including cohort studies, case-control studies or cross-sectional studies using original data.
2. Studies reporting the incidence or prevalence of musculoskeletal injuries in professional golfers.
3. English language studies.
4. Not restricted by age or gender.
5. Year of publication between 1980 and present.

Data extraction

Data were collected from each study by two authors (PGR, ADD) and included age, sex, data collection methods, diagnosis, region of injury, side of injury, incidence/prevalence of injury, definition of injury, nature of injury, severity of injury, mechanism of injury, risk factors, length of golfing career, injury management and time to return to sport.

Data analysis and quality assessment

All studies were assessed by two authors (PGR, ADD) using the Quality Assessment Tool for Observational Cohort and Cross-sectional Studies.²¹ The assessment tool uses 14 questions to give an evaluation of the internal validity of a study. If there was disagreement regarding the scoring of a study, consensus was met after discussion among both assessors. The authors of the Quality Assessment Tool for Observational Cohort and Cross-sectional Studies have discouraged users from attempting to tally up the scores from the tool. However, we have represented the number of applicable questions answered 'yes' for each study as a percentage. Data analysis was primarily in the form of reporting variables collected in the data extraction process and efforts were made to consolidate data if it was comparable, such as the players' age. A meta-analysis was not performed due to the heterogeneous nature of the data in each included paper.

RESULTS

Of the 1863 articles identified in the initial search of databases and reference lists, 1014 studies remained following removal of duplicate studies. After initial screening of titles and abstracts, 23 articles met the inclusion criteria for review. On full-text screening, a further 18 studies were removed; 2 studies were review articles, 1 study analysed amateur golfers and 1 study lacked adequate information on injury distribution/frequency. Fourteen of the studies excluded were case reports or case series: two papers relating to the lumbar spine, three to the shoulder, two to the hand/wrist, two to the hip, three to the lower leg and two miscellaneous articles (figure 1).

A list of studies meeting the inclusion criteria and details of each study can be seen in table 1. The years of publication ranged from 1982 to 2012. Included in our review were five observational studies representing cohort data. There were no intervention studies assessing injury prevention efforts.

Participant demographics

The mean age of the golfers in these studies was 34.8 (± 3.6) years. Of the 5 included studies, 2 did not report the age of the

golfers. Three studies reported on the gender of players, which comprised 821 males (72%) and 320 females (28%). The studies were performed in the UK, Germany, Japan and the USA. The mean career length was reported in two studies (McCarroll and Gioe, and Sugaya *et al*) (table 1).

Quality assessment

The results of the quality assessment of included studies can be seen in online supplementary appendix 1. The studies were of overall poor quality with no study being able to answer >50% of the questions successfully and no study consistently reported exposure measures.

Data collection

Three studies (Gosheger *et al*, McCarroll and Gioe and Sugaya *et al*) used questionnaires to acquire injury data from selected players over 2 seasons and researchers were at hand to assist with the completion of the questionnaires. Sugaya *et al* distributed the questionnaires during four tournaments with 4 different groups of professional golfers (2 male and 2 female). They appear to report injuries sustained during an entire career, but this is not explicitly stated. McCarroll and Gioe posted a questionnaire to a group of male and female professional players. All three studies asked players to retrospectively report injuries occurring during their past playing career.

Smith and Hillman analysed data retrospectively which was collected from male European Tour players visiting the mobile physiotherapy unit during two seasons. Injury data were collected by one of their medical practitioners during each player's visit to the unit. The study by Hadden *et al* retrospectively analysed data collected on male golfers seeking medical attention who were competing in the Open Championship across 7 years.

Injury incidence and prevalence

Reporting of injury varied among all studies. Hadden *et al* described the incidence of injury that required medical attention over 7 different Open Championships. This was the only study to report 'new' injuries. We believe Gosheger *et al*, McCarroll and Gioe and Sugaya *et al* all reported the prevalence of injuries across a career; however, Gosheger *et al* and McCarroll and Gioe did not overtly describe the type of injury frequency methodology used.

Sugaya *et al* appeared to use the terms incidence and prevalence interchangeably to describe the same data. McCarroll and Gioe, and Sugaya *et al* reported the mean length of a players' career. Smith and Hillman reported the prevalence of injuries across 2 seasons on the European Tour but did not specify the rate of new injuries during the study period. Unfortunately, it was not possible to perform a synthesis of the data to give overall percentages of injuries given the lack of information from each study regarding time points and the at-risk population. Injuries were presented as percentage proportions of total injuries reported in each study and this is demonstrated in table 2.

Definition of injury, nature of injury, severity of injury/time to return to sport

McCarroll and Gioe, Hadden *et al* and Sugaya *et al* failed to give a definition of how they defined injury. Smith and Hillman defined injury as 'an event or incident, which occurred during training or match play, which necessitated attention from the unit's practitioners'. Gosheger *et al* defined severity of injury but not what constituted an injury itself. The severity of injury was classified as minor, moderate or major and loss of playing

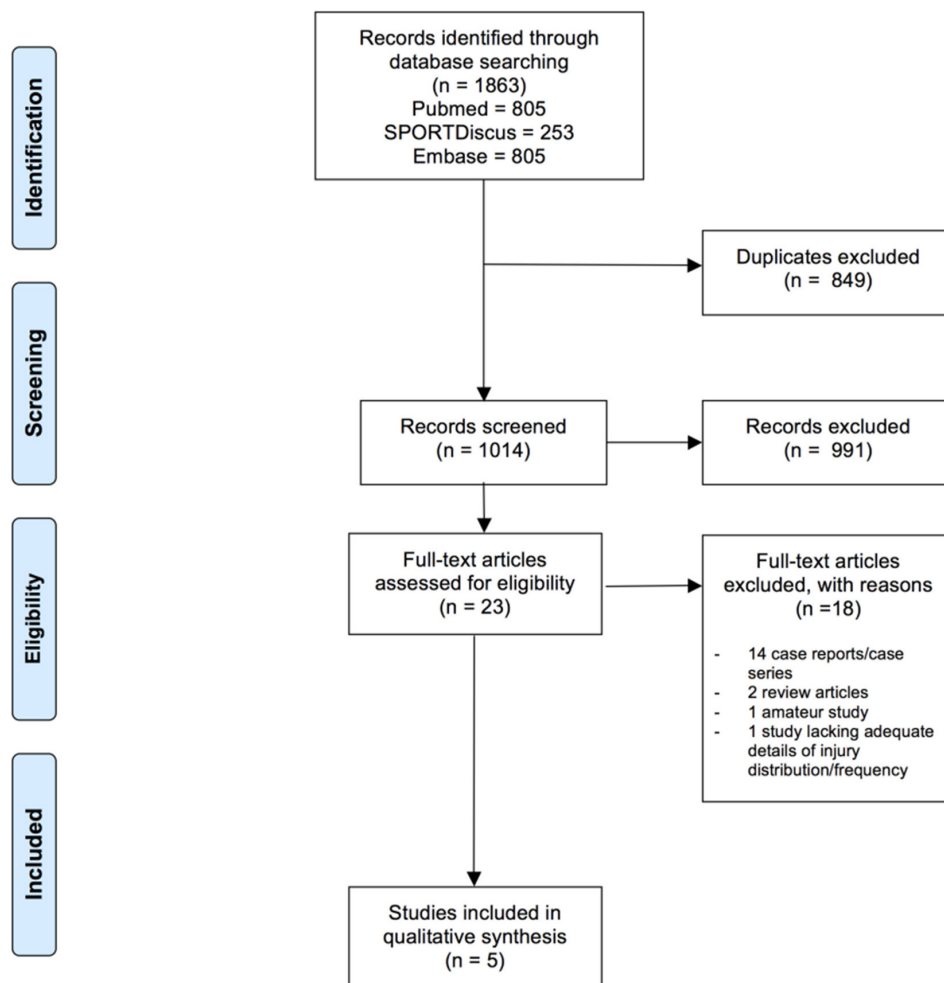


Figure 1 Preferred Reporting Items for Systematic Review and Meta-Analysis flow diagram representing the epidemiological article search process.

time was the parameter used. A minor injury was one 'requiring a golfer to sit out <1 week' and a moderate injury resulted in '>1 week to <1-month-long layoff' and a major injury was 'an absence from the golf course of 1 month or even longer'. Sugaya *et al* reported 72% of players missed at least one tournament or played to an unsatisfactory level as a direct result of injury. Gosheger *et al* reported 'time lost from golf injury' and

correlates it with region of injury; however, it is not clear if this time lost is competitive golf or practice and the authors did not separate out amateur and professional data. Smith and Hillman and Hadden *et al* did not report severity of injury. McCarroll and Gioe used time lost from the tour as a marker of severity and reported an average of 9.3 weeks for men and 2.8 weeks for women.

Table 1 Demographics and quality of studies reporting the epidemiology of professional golf injuries

Author	Data collection	Setting	No. of participants	Questionnaire response rates (%)	Mean age (range)	Gender (%)	Mean length of career (years)	LoE
Gosheger <i>et al</i> ⁵	Retrospective questionnaire distributed over a period of 2 seasons	Randomly selected professional golfers in Germany	60	100	37 (22–63)	Male, 90% Female, 10%	NR	III
Hadden <i>et al</i> ⁴¹	Retrospective report over 7 years	Injuries occurring at the Open Championship and reviewed by the on-call medical officer	88	NA	NR	MC	NR	III
McCarroll and Gioe ⁴²	Retrospective questionnaire	Questionnaires mailed to PGA and LPGA tour players	226	45	30 (23–70)	Male, 56% Female, 44%	Men=18 (1–36) Women=9 (1–23)	III
Smith and Hillman ²	Prospective collection over 2 years	Audit of the service delivered by the mobile physiotherapy unit on the European Tour	2328 'injuries'	NA	NR	MC	NR	III
Sugaya <i>et al</i> ¹⁶	Retrospective questionnaire	Questionnaires returned during four different professional events in Japan	281	57	40 (20–63)	Male, 60% Female 40%	Men=27 Women=14	III

LoE, level of evidence; MC, male only cohort; NA, not available; NR, not recorded.

Table 2 The regions of injuries reported as percentages of total injuries per study

Study	Cervical spine (%)	Thoracic spine (%)	Lumbar spine (%)	Shoulder (%)	Elbow (%)	Hand/Wrist (%)	Hip (%)	Knee (%)	Ankle/Foot (%)	Other (%)
Gosheger <i>et al</i> ³ n=95	12	3	25	15	12	23	3	6	1	0
Hadden <i>et al</i> ⁴¹ n=101	22	13	31	0	1	15	1	5	7	6
McCarroll and Gioe ⁴² n=393	3	2	24	9	7	37	1	7	5	5
Smith and Hillman ² n=2212	25	22	22	7	1	6	3	4	6	4
Sugaya <i>et al</i> ¹⁶ n=458	20	0	34	10	10	11	0	6	7	3

Two studies (Hadden *et al* and McCarroll and Gioe) reported the nature of the injury (whether it was a new injury or exacerbation of a long-standing injury). Hadden *et al* reported 43% new injuries and 57% were exacerbations of chronic injuries. McCarroll and Gioe found 69% of injuries were caused by repetitive load and a further 21% of injuries were caused by hitting an object during the swing.

Diagnosis, risk factors, mechanism and treatment/prognosis

No study reported a specific diagnosis but instead reported injury by anatomical location. In relation to upper limb injuries, only McCarroll and Gioe reported on the side of the injuries sustained in the upper limb. They found the left side was injured 5 times more frequently than the right; 84.5% of injuries were left sided, which is the lead side in a right-handed golfer. When Sugaya *et al* reported the side of lumbar back injuries, 51% were right-sided pain, 28% reported left-sided pain and 21% reported central or generalised pain.

McCarroll and Gioe reported risk factors for injury including years spent on tour, experience and age and concluded none of these were related to an increase in injury. Gosheger *et al* reported the injury type and a variety of variables including gender, stretching/warming up, playing time, carrying the golf bag, body mass index and playing other sports. However, the authors did not differentiate between amateur and professionals. No other study reported risk factors for injury. The mechanism of injury was not adequately reported by any study. Gosheger *et al* reported on the mechanism but did not differentiate between amateur and professional golfers.

The treatment of injuries was reported by 3 studies (Hadden *et al*, McCarroll and Gioe and Smith and Hillman). Hadden *et al* reported the types of treatments used but did not separate the management of spectators and competitors at a tournament.

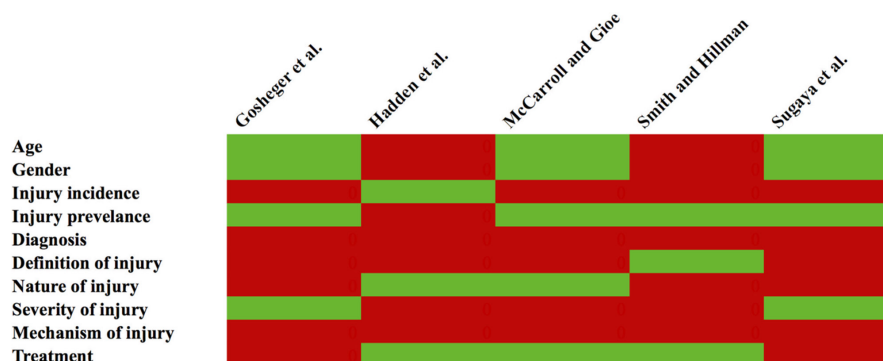
McCarroll and Gioe reported 16% of players were managed with rest alone, 24% were given physical therapy or chiropractic treatment and 21% received anti-inflammatory medication or cortisone injections; 7% of players required surgery. Smith and Hillman reported 71% of players received massages, manipulation or stretching. The reporting of key variables used to describe injuries in professional golfers in each study can be seen in figure 2.

Professional female golf injuries

McCarroll and Gioe, and Sugaya *et al* reported frequency and anatomical distribution of injuries in female golfers as well as male golfers. McCarroll and Gioe found both sexes sustained approximately 2 injuries per player over a career. However, the average golfing career was 13 years shorter for females (table 1). They found female lumbar spine (22%) and hand/wrist injuries (38%) to be most common. However, cervical spine injuries only contributed 2% of injuries and there were no reports of thoracic spine injuries. Sugaya *et al* reported lumbar spine injuries (41%), cervical/thoracic injuries (26%) and wrist injuries (9%) to be most common.

Amateur golf injuries

One study (McCarroll *et al*) studied the injuries of amateur golfers as well as professionals. They found amateurs sustained 2.07 injuries during their golfing career compared with 3.06 injuries in professionals. Career length was not recorded but the authors did report 19.4% of amateurs hit >200 balls per week compared with 73.3% in professionals and 11.6% of amateurs played at least 4 rounds of golf per week compared with 30% in professionals. The most common amateur injuries were elbow (24.9%), shoulder (18.6%) and lumbar spine injuries (15.2%).

**Figure 2** A heatmap representing injury variables reported by each study.

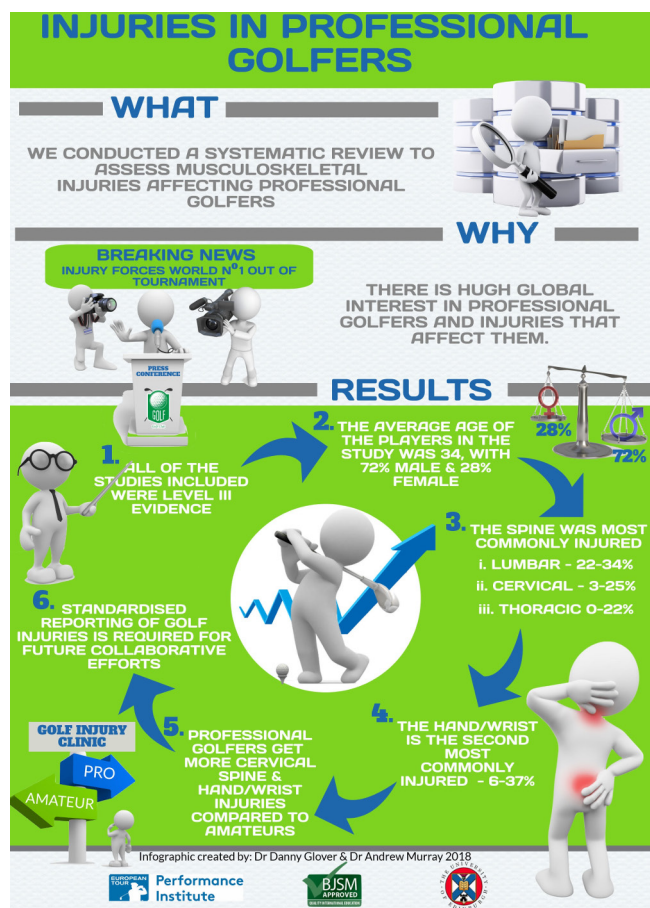


Figure 3 Infographic summarising the key findings of the study.

DISCUSSION

This is the first study to systematically review the current literature reporting the epidemiology of musculoskeletal injuries in professional golfers. The principal finding is the limited number of robust studies evaluating the epidemiology of these injuries in this group. Given the variety of methods used in studies reporting on golfing injuries, as well as the inconsistent definition of injuries used, detailed comparison between studies was not possible.

The most frequently reported injury affecting professional golfers—lumbar spine injuries—appears to be relatively well represented by a range of studies (clinical reviews and outcome-based) in the literature; however, these studies generally relate to injuries in non-professional players.^{16 17 22–32} Despite being the second most common body region injured in professional golfers, cervical spine injuries do not appear to be the focus of any study in the current golf literature (figure 3).

The level of golf research published appears to be of relatively low quality. Gold standard methodology for sports injury surveillance (such as prospectively designed studies with injury assessment by experienced clinicians)^{33–35} was not seen among our included studies. Key aspects of injury reporting such as injury diagnosis, nature of injury, injury mechanism and injury severity were poorly reported (figure 2). All studies were retrospective in nature and 3 studies required recall of the injuries by the players themselves. We hope that the findings of this study will act as a stepping-stone to methodologically precise epidemiological studies on professional golf injuries and further focused, high-quality research on the most common injuries in golf.

Despite the frequency of back injuries in professional golfers shown in our review of epidemiological studies, we could find only 7 (non-epidemiological) studies in the current golf literature specifically studying back injuries in professional golfers^{16 23 27 36–39} (all of which focus on the lumbar spine). In comparison to the prevalence of cervical spine injuries in amateur golfers (2%–4%),^{34 6 39} professionals appear to be burdened with injuries in this region more often. We could find no studies in the current golf literature focusing on aetiology, prevention or outcome of cervical spine injuries specifically.

The hand/wrist was the second most commonly injured area of the body after the exclusion of all spine injuries. Unfortunately, the studies included in our review did not report on whether these represented lead or trail side injuries. Without knowing if the golfer was right or left handed, no definitive conclusions could be made with regard to the frequency of lead or trail sided injuries. However, it is probable that the majority of players in the included studies were right handed, and injuries are thus more frequent in the lead side (left side in a right-handed golfer).

The severity and burden of injury was not well reported in the studies included in our review. Although knowledge of the most common regions of injury is important, knowledge of the effect of the injury on the golfer's performance is equally necessary. Some injuries may require long periods away from the game, operations and have high risks of recurrence. One recent study has encouraged the utilisation of 'injury burden' as a more accurate description of the severity of injury.⁴⁰

Limitations

This review should be interpreted with consideration of its limitations. The epidemiological studies included in our review lacked homogeneity in their reporting of injuries. Many of the studies did not provide information on the mechanism of injury, previous injuries or time to return to sport. Therefore, this made it difficult to make valid conclusions in these areas. Furthermore, there was heterogeneity in the definition of injury between all studies and 3 studies failed to give a precise definition at all. In all studies, classification of injury was limited to the region of injury rather than the specific diagnosis. Clearly, this is only partially helpful when attempting to extract this information to plan future injury-specific research.

The study evolved over time and there are some modest differences in the registered PROSPERO report and the final paper. We used a different quality assessment tool, which we felt was more suited to analysing the data compared with the original tool. We decided not to include case reports/series in the analysis as this would have introduced bias in the reporting of the most common injuries sustained by professional golfers. Our review was initially intended to analyse elite golfers, which included collegiate golfers, and/or competitive amateur golfers, as well as professionals. However, there were no epidemiological papers analysing collegiate or competitive amateur golfers and hence only professional golf studies were included in final analysis. Finally, we had a relatively small number of studies meeting the inclusion criteria which ranged in date from 1982 to 2012. With the changes in swing mechanics and the more widespread adoption of strength and conditioning programmes, the epidemiology of golf injuries may have also evolved.

CONCLUSION

The principal finding from this study is the current paucity of quality literature and the heterogenous data included in studies reporting injuries in professional golfers. The lumbar spine

was the most frequent region of injury and there were a higher number of injuries in the region of the cervical spine in professional golfers that has not been reported for amateur golfers. Injury nomenclature varies considerably within the existing literature making comparison between studies challenging. Standardisation of diagnosis and injury nomenclature within the golf literature would encourage a wider collaborative effort. The use of well-recognised epidemiological methods of reporting injuries are required to make useful comparisons moving forward.

What is already known?

- Professional golfers may sustain different patterns of injuries compared with amateurs.

What are the new findings?

- The most frequently injured regions are the spine (cervical, thoracic and lumbar) and the hand/wrist.
- Regions of injuries in professional male and female golfers are similar.
- Definition of injury is often not clear and varies if it is present.
- Nature of injury, injury mechanism and severity of injury/time to return to sport are poorly reported.

Contributors PGR: study design, data collection, data analysis, writing of manuscript. IRM: study design, writing of manuscript. ADD: study design, data collection, data analysis, writing of manuscript. RH: study design, writing of manuscript. DG, NT, RH, CWO: writing of manuscript. AM: study design, writing of manuscript.

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