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Cross-sectional study of characteristics and prevalence of musculoskeletal complaints in 1170 male golfers

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ABSTRACT

Objectives The primary aim was to describe the characteristics and prevalence of musculoskeletal complaints of a large group of non-professional golfers. Secondary aims were to compare golfers different in (A) skill-level, (B) presence of low back pain (LBP) and (C) performance of prevention exercises.

Methods A sample of 1170 male golfers (mean age 54.98, SD=13.3) were surveyed online on personal and golf-specific characteristics, medical history and complaints in the preceding 7 days. Subgroups (A) with different golfing handicap (0 to 5, >5 to 10, >10), (B) with and without LBP and (C) who performed versus did not perform injury prevention exercises were compared using analysis of variance and χ^2 test.

Results The prevalence and severity of musculoskeletal complaints was similar in everyday life and when playing golf. More than one-third of the golfers (n=436; 37.3%) reported LBP in the preceding 7 days, while other frequently affected body parts were the shoulder and knee. Golfers with different skill level differed in age and most golf-related characteristics but not in prevalence and severity of musculoskeletal complaints. Golfers with and without LBP were similar in almost all variables. Golfers who performed prevention exercises (n=371; 27.1%) were older and had a higher prevalence of complaints.

Conclusion The prevalence and severity of musculoskeletal complaints in golfers were similar to the wider population. It seems that injury prevention exercises were implemented after injury, rather than as primary prevention. Prospective studies looking at the epidemiology of injury, risk factors and interventions are required.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Recreational golfers have different injury patterns and rates than elite golfers.
⇒ Golf participation is considered as a moderate injury risk activity compared with other sports.
⇒ The International Olympic Committee's Consensus on Injuries and Illnesses in Sport was adapted for golf and published in 2020.

WHAT THIS STUDY ADDS

⇒ This cross-sectional study showed the prevalence and severity of musculoskeletal complaints during golf were similar to that of everyday life.
⇒ The majority of recreational golfers do not perform preventative exercises related to golf.
⇒ Playing handicap is not associated with prevalence or severity of injury.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Clinicians can encourage recreational golfers to play the sport without concern regarding high injury risk.
⇒ Lower back pain and osteoarthritis are common in a golfing population however, clinicians should be aware of the safety of continuing to play despite the presence of one or both.

INTRODUCTION

Golf is a sport played by more than 66 million persons of all ages and abilities globally in over two-thirds of countries and on 6 continents.[1 2] The scientific evidence suggests that golf participation is associated with health and well-being benefits[3] by providing moderate to vigorous aerobic physical activity, decreased sedentary time and potentially improving muscle strength and balance.[4] In contrast to overall physical activity levels, which have decreased during the recent COVID-19 pandemic,[5] participation in golf has increased by over 10% since 2019,[1] which may reflect the health benefits of the sport, but may also reflect golf as a sport that can be enjoyed outdoors and physically distanced during a global pandemic.[6 7]

Despite the health benefits, players can develop injuries and illness related to golf participation. A review of the injury risks of golf participation identified golf as a moderate risk activity for injury compared with other sports,[8] while prospective longitudinal studies have reported low injury rates per hour played compared with other sports, at 0.28–0.60 injuries per 1000 hours in amateur players.[9–11] Most studies identified the volume of repetitive practice and

suboptimal swing biomechanics as the leading causes of golf-related injuries in amateur players.[12]

For professional players, a systematic review noted the most frequently injured body regions to be the spine (lumbar>cervical>thoracic), followed by the hand and wrist.[13] Injury rates in professional players are higher than in amateurs, perhaps reflecting an increased volume of training and play[13–15] but relatively lower in comparison to other Olympic sports.[16] In general, musculoskeletal complaints affecting professional golfers and risk factors for injuries and health complaints are poorly understood in the scientific literature.

Almost all injury epidemiological studies in golf are over 20 years old.[12 17–19] Consensus statements, injury forms, diagnostic coding and protocols for data collection have since been developed by key stakeholders in other sports (eg, cricket,[20] football,[21] rugby union,[22] rugby league,[23] aquatic sports,[24] tennis,[25] athletics,[26] horse racing[27] to ensure consistency and enable comparison of data across studies).[28] In 2020, the consensus on recording and reporting of illness and injury in golf was published.[29]

The primary aim of this study was to describe the characteristics and burden of musculoskeletal complaints of a large group of non-professional golfers, using the methods outlined in the consensus (baseline questionnaire) on reporting and recording of injury in golf.[29] Secondary aims were (A) to compare the prevalence and severity of musculoskeletal complaints in the previous 7 days and medical history between the subgroups with different skill levels, (B) to compare golfers with and without low back pain (LBP) and (C) to compare golfers who did and did not perform injury prevention exercises or programmes.

METHODS

The participants of this cross-sectional study were recruited via the player database of the Titleist Performance Institute. The inclusion criteria were male, female or diverse gender, aged at least 18 years, living and playing golf in the USA, not competing at an international level. The subjects received information about the objectives, methodology, inclusion criteria, data protection and were requested to fill in the informed consent form and an online questionnaire on personal and golf-specific characteristics as well as on their medical history and current health complaints. The International Olympic Committee's Consensus on Injuries and Illnesses in Sport[30] adapted for the recording and reporting of epidemiological data on injuries and illnesses in golf was used for this study.[28 29] The questionnaire has previously been published as supplementary material to the international consensus statement on methods for recording and reporting of epidemiological data on injuries and illnesses in golf.[29]

Data collection and exclusion criteria

Data were collected via an app-based illness and injury surveillance system (AthleteMonitoring.com), FITSTATS Technologies, Moncton, Canada. In total 1214 people answered the questionnaire, 22 were female and one diverse. These were excluded to achieve a homogenous study population. A further 22 were excluded because they did not live and play in the USA (n=19), were younger than 18 years (n=1) or had too many missing data (n=2).

Statistical analysis

All data were processed on a Macintosh computer using Microsoft Office and SPSS (V.28). Methods applied included: frequencies, crosstabs, descriptives and means. Three groups with different golfing handicap were defined: 0–5, more than 5–10 and more than 10. Golfers were assigned to injury prevention/no injury prevention groups based on the response to the question 'Are you doing any specific injury prevention exercises or programmes?' (yes/no). Differences between groups were compared by analysis of variance if data were interval scaled or χ^2 test if data were nominally scaled. All statistical tests were two sided and results with $p<0.05$ were regarded as statistically significant.

RESULTS

Study sample

The study sample consisted of 1170 male golfers from the USA aged between 22 and 84 years (mean 54.98, SD=13.3). The vast majority had a college or university education (n=1023; 87.4%) and worked (n=800; 68.4%) for a mean of 43.4 (SD=11.7) hours per week. About 5% (n=56; 4.5%) stated that they undertake elite sport in their everyday life, mainly in combination with work and/or hobbies (n=33; 58.9% each). Almost two-thirds practised another sport than golf on a regular basis (n=428; 63.4%), mainly general fitness training (n=470; 40.2%) or cycling (n=231; 19.7%).

Golf-related characteristics

The average age of starting to play golf was 18.3 years (SD=11.1; range 1–70; median 15), and in keeping with population trends, a large majority were right handed in everyday life (n=1047; 89.5%) and a slightly greater percentage when playing golf (n=1099; 93.9%). The mean golfing handicap was 9.0 (SD=5.4; range 0–30; median 8.1). About a quarter of the study participants (n=308; 25.8%) had a golfing handicap of 5 or less, 435 (37.2%) greater than 5 and up to 10 and 432 (37.0%) more than 10 (see table 1). One golfer did not report his handicap. Most golfers (n=788; 67.4%) classified themselves as recreational players, 225 (19.2%) as sub-elite (Professional Golf Association (PGA) teaching professionals, amateurs competing in regional/county/state tournaments or with handicap 5 or less), 12 (1.0%) as elite (professional players competing on tour or amateurs competing in international/national amateur championships) and 145 (12.4%) had never participated in any golf competition.

Table 1 Characteristics of study sample and comparison of the subgroups with different golfing handicap (GH)

	Total n=1170	GH 0–5 n=308	GH >5 to 10 n=435	GH >10 n=432	Group difference
	Mean (SD) or n (%)	Mean (SD) or n (%)	Mean (SD) or n (%)	Mean (SD) or n (%)	$\chi 2$ or F with p value
Population					
Age	55.0 (13.3)	51.5 (12.2)	55.0 (13.1)	57.4 (13.6%)	18.6; p<0.001
College/university (yes)	1022 (87.4%)	262 (86.8%)	387 (89.0%)	373 (86.3%)	n.s.
Work (yes)	800 (68.4%)	240 (79.5%)	302 (69.4%)	258 (59.7%)	30.4; p<0.001
Working hours /week	43.4 (11.7)	43.2 (11.8)	44.0 (11.1)	42.8 (12.3)	n.s.
Elite sport (yes)	56 (4.8%)	32 (10.6%)	11 (2.5%)	13 (3.0%)	30.2; p<0.001
No other sport than golf	428 (36.6%)	103 (34.1%)	160 (36.8%)	165 (38.2%)	n.s.
Golf characteristics					
Age started playing golf	18.3 (11.1)	13.8 (7.8)	17.1 (9.3)	22.7 (13.0)	68.2; p<0.001
Current golfing handicap	9.0 (5.4)	2.7 (1.8)	7.8 (1.4)	14.7 (3.6)	2073.8; p<0.001
Current golfing level					681.5; p<0.001
Elite	12 (1.0%)	12 (4.0%)	0	0	
Sub-elite	225 (19.2%)	200 (66.2%)	21 (4.8%)	4 (0.9%)	
Recreational	787 (67.3%)	82 (27.2%)	380 (87.4%)	325 (75.2%)	
No golf competition	145 (12.4%)	8 (2.6%)	34 (7.8%)	103 (23.8%)	
Competitions*					
International	0	0	0	0	n.s.
National	40 (3.4%)	21 (7.0%)	10 (2.3%)	9 (2.1%)	15.4; p<0.001
Regional	300 (25.7%)	149 (49.3%)	96 (22.1%)	55 (12.7%)	129.5; p<0.001
Within the club	747 (63.9%)	208 (68.9%)	308 (70.8%)	231 (53.5%)	32.6; p<0.001
Training days per week*					
Golf course	2.6 (1.4)	2.9 (1.5)	2.7 (1.4)	2.4 (1.3)	12.0; p<0.001
Driving range	2.3 (1.5)	2.8 (1.6)	2.3 (1.4)	2.1 (1.3)	21.1; p<0.001
Putting/short game	2.6 (1.6)	3.0 (1.8)	2.4 (1.4)	2.3 (1.5)	14.4; p<0.001
Golf fitness training	3.5 (1.8)	3.7 (1.8)	3.5 (1.7)	3.1 (1.8)	4.6; p<0.05
No specific fitness training for golf	528 (45.2%)	114 (37.7%)	185 (42.5%)	229 (53%)	18.7; p<0.001
Never warm-up	91 (7.8%)	12 (4.0%)	28 (6.4%)	51 (11.8%)	16.9; p<0.001
Warm-up (always or often) before…					
Playing golf	879 (85.0%)	251 (90.6%)	336 (86.4%)	292 (79.3%)	16.7; p<0.001
Practising	741 (71.7%)	213 (76.9%)	288 (74.0%)	240 (65.2%)	12.3; p<0.001
Fitness training	535 (51.8%)	152 (54.9%)	202 (52.1%)	181 (49.2%)	n.s.
Injury prevention (yes)	317 (27.1%)	92 (30.7%)	124 (28.6%)	100 (23.1%)	n.s.

*In the preceding 12 months.
F, Fisher's exact; GH, golf handicap; n.s., not significant; χ^2, Chi squared.

Forty (3.4%) golfers reported that they played in national competitions in the preceding 12 months. About a quarter (n=300; 25.7%) played regional competitions, and 747 (63.9%) competitions within their golf club/college/university. In the preceding 12 months, 981 (83.8%) golfers practised on a driving range on average on 2.3 (SD=1.5) days per week and hit 195.4 (SD=198.7) balls per week. Slightly fewer (n=931; 79.6%) played on a golf course on average on 2.6 (SD=1.4) days per week and they played on average 42.8 (SD=27.7) holes per week. Almost the same number of golfers (n=928; 79.3%) putted or practised their short game for an average of 2.6 (SD=1.6) days or 3.1 (SD=5.4) hours per week. About one-third (n=405; 34.6%) were currently working on a technical change in their golf swing. Almost a quarter practised always or often on golf mats (n=270; 23.1%), while nearly half did this never or rarely (526; 45.0%).

Less than half (n=542; 46.3%) participated in fitness for golf, the average weekly duration was 4.3 (SD=4.1) hours per week. When asked for specific activities included in their physical fitness training for golf more than half (n=636; 54.4%) selected range of motion exercise/stretching, 436 (37.3%) aerobic exercises, 280 (23.9%) low load/high volume resistance training, 266 (22.7%) resistance band exercises, 251 (21.5%) proprioception training, 148 (12.6%) body weight explosive work, 126

Table 2 Prevalence and severity of complaints in different body parts in the preceding 7 days in everyday life and during/after training or playing golf

	Prevalence (n=1170)		Severity (n=1170)	
	In everyday life	Training or playing golf	In everyday life	Training or playing golf
Current complaints	N (%)*	N (%)*	Mean (SD)†	Mean (SD)†
Headache	28 (2.4%)	28 (2.4%)	3.64 (1.9)	2.50 (2.0)
Neck (cervical)	102 (8.7%)	101 (8.6%)	3.45 (2.1)	3.32 (2.2)
Upper back (thoracic)	58 (5.0%)	58 (5.0%)	3.29 (2.0)	3.55 (2.1)
Lower back (lumbar)	436 (37.3%)	436 (37.3%)	3.58 (2.0)	3.91 (2.1)
Right shoulder	123 (10.5%)	123 (10.5%)	3.51 (2.0)	3.71 (2.1)
Left shoulder	103 (8.7%)	103 (8.7%)	3.61 (2.0)	3.84 (2.2)
Right elbow	89 (7.6%)	89 (7.6%)	2.97 (1.8)	3.84 (2.1)
Left elbow	62 (5.3%)	62 (5.3%)	2.87 (2.1)	4.02 (2.5)
Right hand/wrist	79 (6.8%)	79 (6.8%)	3.33 (2.2)	3.89 (2.4)
Left hand/wrist	84 (7.2%)	84 (7.2%)	3.01 (2.1)	3.86 (2.3)
Right hip	114 (9.7%)	114 (9.7%)	3.60 (2.1)	3.83 (2.1)
Left hip	99 (8.5%)	99 (8.5%)	3.49 (2.1)	3.75 (2.0)
Right knee	128 (11.0%)	129 (11.0%)	3.39 (2.0)	3.53 (2.0)
Left knee	156 (13.3%)	159 (13.6%)	3.49 (1.9)	3.88 (2.2)
Other body parts	66 (5.6%)	66 (5.6%)	4.38 (2.2)	4.73 (2.2)

Severity rated on a Visual Analogue Scale (VAS) ranging from 0=no complaints to 10=worst imaginable complaints.
*Golfers with pain/complaints (VAS>0).
†Mean rating severity if VAS>0.
SD, standard deviation.

(10.8%) heavy load low volume resistance training, 126 (10.8%) weighted explosive training, 82 (7.0%) others and 528 (45.1%) stated that they did not practice a specific fitness training for golf.

Approximately a quarter of the golfers (n=371; 27.1%) performed injury prevention exercises or programmes, most frequently for the lower back (n=235; 20.1%) or shoulder (n=144; 12.3%). While the majority always or often warmed-up before playing golf (n=880; 75.2%), activities on the driving range, putting/short game (n=742; 63.4%) or fitness training (536; 45.8%); 91 (7.8%) stated that they never warm-up. Exercises included in the golf warm-up were most frequently range of motion exercises/stretching (n=872; 74.5%) or working through the clubs/preround golf practice (n=794; 67.9%), followed by balance/coordination exercises (n=192; 16.4%).

Musculoskeletal complaints in the previous 7 days

About one-fifth (n=246; 21.1%) reported current musculoskeletal problems that prevented them training or playing golf as usual. Very few rated the severity of their complaints in the preceding 7 days as very severe (n=10; 0.9%) or severe (n=32; 2.8%), one-fifth as moderate (n=218; 18.8%). The majority had only mild (n=491, 42.2%) or no complaints at all (n=412; 35.5%). The number of golfers with complaints in different body parts and the related mean severity of complaints is presented in table 2.

More than one-third of the golfers (n=436; 37.3%) reported LBP while the prevalence of pain in other body parts was lower (table 2). Golfers with and without LBP were similar in almost all variables, including age, golfing handicap and amount of training and competitions. The prevalence of complaints in the right body side was higher than in the left for shoulder, elbow and hip, while it was the opposite for the knee. The mean severity of complaints in everyday life was lowest for right and left elbow, and highest for 'others'. The severity of complaints when training or playing golf was similar in all body parts, lowest for headache and highest for 'others'. While pain in the elbows and hand/wrists was higher when playing or training golf compared with everyday life, headache was lower when golfing (all comparisons p<0.01).

Medical history

About half of the golfers had a musculoskeletal complaint that prevented them from training or playing golf as usual for more than 1 week (n=571; 49.3%) and 129 (11.1%) for up to 1 week. This may reflect the life-time prevalence of complaints that were sustained playing golf, but equally may have occurred playing a different sport, or in everyday life.

A minority of participants (n=65; 5.6%) had an injury that did not stop them from training or playing golf or did not cause complaints (n=18; 1.6%). A third of the golfers (n=376; 32.4%) reported no such injury. More than one-third (n=448; 38.7%) had had surgery on their musculoskeletal system.

Almost one-fifth of golfers (n=210; 17.9%) had been diagnosed with and/or treated for arthrosis/osteoarthritis. Affected body parts were the knee (n=107; 9.1%), fingers (n=70; 6.0%), lumbar spine (n=67; 5.7%), shoulder (n=51; 4.4%), hip (n=38; 3.2%), ankle (n=26; 2.2.%), cervical spine (n=26; 2.2%), wrist (n=24, 2.1%), foot (n=25; 2.1%), thoracic spine (n=15; 1.3%) and elbow (n=13; 1.1.%). Very few (n=11; 0.9%) golfers had previous or concurrent rheumatological disease. More than two-thirds (n=795; 68.0%) took pain killers in the preceding 12 months, other medications were less frequent: 'cortisone' (n=102; 8.7%), 'medication for stress, anxiety, depression' (n=84; 7.2%) or various others (n=205; 17.5%).

Comparison of groups with different golfing handicap

The characteristics of the subgroups with different golfing handicap are presented in table 1. The subgroups differed significantly in age, with younger golfers playing at a higher level. The percentage of participants who stated they practice no other sport than golf was similar in the subgroups.

Most golf-related characteristics differed between the subgroups (table 1). Golfers with a lower handicap started playing golf at an earlier age, trained more days per week and played in more competitions at national, regional and club level. The proportion of golfers who did not participate in specific fitness training for golf, or who never warmed-up, increased with increasing golfing handicap, while the percentage of those who always, or often warmed-up before playing or training golf decreased. However, the proportion of golfers who always or often warmed-up before fitness training and of those who do specific injury prevention exercises was not statistically different in the subgroups.

The subgroups did not differ in the prevalence and severity of musculoskeletal complaints in the preceding 7 days (table 2) with two exceptions: prevalence in the left knee (χ^2=6.4; p<0.05) and severity in the left shoulder when the training or playing golf (F=3.8; p<0.05).

The medical history was similar in the subgroups, except for arthrosis/osteoarthritis with more affected golfers in the subgroups with a higher golfing handicap (table 3).

Table 3 Current complaints and medical history in subgroups with different golfing handicap (GH)

	Total n=1170	GH 0–5 n=308	GH>5–10 n=435	GH>10 n=432	Group difference
	n (%)	n (%)	n (%)	n (%)	F with p value
Current complaints**					
Prevent playing as usual*	246 (21.1%)	66 (22.0%)	90 (20.7%)	90 (20.9%)	n.s.
Overall severity*					n.s.
None	412 (35.5%)	102 (34.1%)	157 (36.2%)	153 (35.7%)	
Mild	490 (42.2%)	132 (44.1%)	181 (41.7%)	177 (41.3%)	
Moderate	218 (18.8%)	55 (18.4%)	82 (18.9%)	81 (18.9%)	
Severe	32 (2.8%)	7 (2.3%)	10 (2.3%)	15 (35.7%)	
Very severe	10 (0.9%)	3 (1.0%)	4 (0.9%)	3 (0.7%)	
Medical history					
Previous injury					11.2; p<0.05
None	376 (32.5%)	85 (28.5%)	139 (32.1%)	152 (35.6%)	
Minor	211 (18.2%)	60 (20.1%)	64 (14.8%)	87 (20.4%)	
Affected >1 week	571 (49.3%)	153 (51.3%)	230 (53.1%)	188 (44.0%)	
Surgery on the musculoskeletal system	447 (38.6%)	103 (34.6%)	175 (40.3%)	169 (39.7%)	n.s.
Arthrosis/osteoarthritis	210 (18.1%)	32 (10.7%)	80 (18.4%)	98 (22.9%)	17.6; p<0.001
Intake of pain killers	795 (68.0%)	201 (66.6%)	298 (68.5%)	296 (68.5%)	n.s.
Disability	66 (5.7%)	12 (4.0%)	21 (4.8%)	33 (7.7%)	n.s.

*In the preceding 7 days.
F, Fisher's exact;; GH, golf handicap; n.s., not significant.

Comparison of golfers who did versus did not perform injury prevention

Golfers who stated they perform specific injury prevention exercises or programmes differed from those who did not in almost all variables (table 4). They were significantly older and had a lower golfing handicap. A higher percentage of golfers who performed prevention interventions had participated in competitions of all levels, and this subgroup had trained all types of golf activities on average on more days in the week in the preceding 12 months. More performed a specific training for golf, and more warmed-up always, or often, before training or playing golf or before their fitness training.

While about 40% of golfers who did not do any prevention exercises had no complaints in the previous 7 days, this applied to less than a quarter of the golfers who did prevention exercises. Furthermore, about twice as many golfers who did prevention exercises rated their current complaints as severe or very severe compared with those who did not. In all except one body region, the prevalence of complaints was higher in golfers who performed prevention exercises. Musculoskeletal complaints related to the neck, lower back, right shoulder, right elbow and left knee were higher in those who performed prevention exercises compared with those who did not (table 5). The severity of complaints in different body parts in the preceding 7 days was similar between the groups.

About 85% of golfers who did prevention exercises had had a previous injury compared with 60% of those who did not, and the previous injuries were more severe (ie, had prevented them playing for a longer time from training or playing golf as usually). More golfers who performed prevention interventions were older, had a surgical intervention to their musculoskeletal system, had arthrosis/osteoarthritis and took pain killers in the preceding 12 months (see table 4).

DISCUSSION

Principal findings

This study evaluated the prevalence and severity of musculoskeletal complaints in the previous 7 days in a large group of male amateur golfers. The reported musculoskeletal complaints in recreational golfers closely reflected areas of pain experienced in the general population.[31] In general, playing golf did not increase musculoskeletal complaints in our population and persons affected by these complaints in everyday life could still play golf. The lower back followed by knees, shoulders and hips were the most commonly reported areas of complaints.

Comparison to the scientific literature

Golf is a sport played by persons of all ages. Its contribution to population-level physical activity increases with age, along with other non-team based sports.[32] What is known is that golf can provide health enhancing physical activity,[4] is associated with improved longevity,[33] physical health[3] and improved well-being.[34]

This study sought to understand musculoskeletal complaints that affect male golfers, both those sustained playing golf, but also those of everyday life. The findings from this study help to identify the health issues affecting male golfers, building on studies which reported injuries sustained playing golf.[12 18 19]

In keeping with both musculoskeletal complaints in the general population and reported injuries in golf,[31] the lower back was the most reported area of complaint in recreational golfers in our study. Two previous systematic reviews reported that lower back injuries comprised 35% of all golf-related injuries.[8 35] Golf injuries to the lower back may be related to the forces and motion that the lower back is subject to in the golf swing where peak compressive load can be eight times bodyweight.[36] Back injuries have been shown to be the greatest contributor to time loss from golf participation. Gosheger *et al* reported that a high percentage of chronic injuries were related to the lower back and knee.[18] Previous work has reviewed the prevalence of lower back pain in different ages and socioeconomical environments and concluded that no major difference of 1-month prevalence among different age groups and countries was observed, ranging from 32% to 68%.[37] A systematic review of the global prevalence of lower back pain revealed point prevalence 11.9% and the 1-month prevalence 23.2% with significant increase of lower back pain in the age group 40–69 years in comparison to the 20–29 years.[38] The results have to be interpreted with caution due to significant methodological heterogeneity. The prevalence of LBP was found slightly higher among athletes with the limitation of the heterogeneity of data acquisition.[39] Our 7-day prevalence of LBP is higher than presented by Hoy *et al*, however similar to the Trompeter *et al*'s results on an athletic population.

Despite several studies describing differences in injury prevalence between elite and recreational golfers,[12 18] this study did not show a difference in prevalence or severity of musculoskeletal complaints between different levels of golfer. In addition, Gosheger *et al* showed that the lead side (left side in a right-handed golfer) is more commonly injured playing golf than the trail side,[18] however, in our study of complaints both from golf and everyday life, it was only the knee that matched those findings. The opposite was true for shoulder, elbow and hip complaints. This may reflect that injuries sustained in other aspects of life, particularly those of a dominant upper limb, may cause symptoms when a person is playing golf.

Prospective longitudinal studies reported low injury rates per hour of golf played compared with other sports, at 0.28–0.60 injuries per 1000 hours in amateur players.[9–11] Participants in our study did not report more complaints while playing golf, compared with everyday life. When taken together, the scientific literature concludes that golf is a sport that (1) provides health enhancing physical activity, (2) that has comparatively

Table 4 Comparison of golfers who did or did not perform injury prevention exercises or programmes

Injury prevention	No n=849	Yes n=317	Group difference
Population	**Mean (SD) or n (%)**	**Mean (SD) or n (%)**	**χ2 or F with p value**
Age	53.9 (13.2)	58.1 (12.9)	23.3; <0.001
College/university (yes)	728 (85.7%)	291 (91.8%)	7.7; <0.01
Work (yes)	596 (70.2%)	200 (63.1%)	5.4; <0.05
Working hours /week	44.0 (11.4)	41.8 (12.4)	5.2; <0.05
Elite sport (yes)	39 (4.6%)	16 (5.0%)	n.s.
No other sport than golf	337 (39.7%)	90 (24.4%)	12.7; <0.001
Golf characteristics	**Mean (SD) or n (%)**	**Mean (SD) or n (%)**	**χ2 or F with p value**
Age started playing golf	18.4 (11.0)	18.2 (11.4)	n.s.
Current golfing handicap	9.3 (5.5)	8.4 (5.2)	6.2; <0.05
Current golfing level			12.1; <0.01
Elite	10 (1.2%)	2 (0.6%)	
Sub-elite	151 (17.8%)	72 (22.7%)	
Recreational	567 (66.8%)	219 (69.1%)	
No golf competition	121 (14.3%)	24 (7.4%)	
Competitions*			
National	24 (2.8%)	16 (5.0%)	n.s.
Regional	198 (23.3%)	99 (31.2%)	7.6; <0.01
Within the club	519 (61.1%)	226 (71.3%)	10.3; <0.001
Training days per week*			
Golf course	2.6 (1.4)	2.8 (1.3)	8.8; <0.01
Driving range	2.2 (1.4)	2.6 (1.5)	14.3; <0.001
Putting/short game	2.5 (1.6)	2.7 (1.5)	4.6; <0.05
Golf fitness training	3.3 (1.8)	3.7 (1.6)	7.1; <0.01
No specific fitness training for golf	439 (51.7%)	88 (27.8%)	53.4; <0.001
Never warm-up	85 (10.0%)	6 (1.9%)	21.1; <0.001
Warm-up (always or often) before…			
Playing golf	604 (83.3%)	275 (89.0%)	5.5; <0.05
Practising	507 (69.9%)	234 (75.7%)	n.s.
Fitness training	329 (45.4%)	207 (67.0%)	40.3; <0.001
Current complaints†	**n (%)**	**n (%)**	**F with p value**
Prevent playing as usual†	152 (17.9%)	94 (29.7%)	19.2; <0.001
Overall severity†			34.6; <0.001
No	337 (39.8%)	73 (23.2%)	
Mild	347 (41.0%)	144 (45.7%)	
Moderate	138 (16.3%)	80 (25.4%)	
Severe	18 (2.1%)	14 (4.4%)	
Very severe	6 (0.7%)	4 (1.3%)	
Medical history	**n (%)**	**n (%)**	**χ2 with p value**
Previous injury			66.0; <0.001
No	331 (39.3%)	45 (14.3%)	
Minor	145 (17.2%)	67 (21.3%)	
Affected >1 week	367 (43.5%)	202 (64.3%)	
Surgery to the musculoskeletal system	298 (35.3%)	149 (47.6%)	14.6; <0.001
Arthrosis/osteoarthritis	128 (15.1%)	81 (25.8%)	17.6; <0.001
Intake of pain killers	556 (65.5%)	238 (75.1%)	9.8; <0.01
Disability	45 (5.3%)	21 (6.7%)	n.s.

*In the preceding 12 months.
†In the preceding 7 days.
F, Fisher's exact; n.s., not significant; SD, standard deviation; χ^2, Chi squared.

Table 5 Prevalence of complaints in different body parts in the preceding 7 days in golfers who stated they perform or not perform injury prevention exercises or programmes

Injury prevention	No n=849	Yes n=317	Group difference
Current complaints	n (%)	n (%)	χ2 with p value
Headache	19 (2.2)	9 (2.8)	n.s.
Neck (cervical)	65 (7.7)	36 (11.4)	4.0; <0.05
Upper back (thoracic)	43 (5.1)	15 (4.7)	n.s.
Lower back (lumbar)	285 (33.6)	151 (47.6)	19.5; <0.001
Right shoulder	74 (8.7)	49 (15.5)	11.1; <0.01
Left shoulder	75 (8.8)	29 (9.1)	n.s.
Right elbow	56 (6.6)	34 (10.7)	5.5; <0.05
Left elbow	43 (5.1)	19 (6.0)	n.s.
Right hand/wrist	53 (6.2)	26 (8.2)	n.s.
Left hand/wrist	64 (7.5)	20 (6.3)	n.s.
Right knee	86 (10.1)	42 (13.2)	n.s.
Left knee	116 (13.7)	62 (19.6)	6.2; <0.05
Right hip	76 (9.0)	39 (12.3)	n.s.
Left hip	66 (7.8)	33 (10.4)	n.s.
Other body parts	48 (5.7)	19 (6.0)	n.s.

n.s., not significant; χ^2, Chi squared.

low rates of injury per hour played but (3) notes that musculoskeletal complaints in golfers are prevalent and some may be due to activities other than golf. This highlights that the same musculoskeletal complaints affect the subjects in everyday life, and when they play golf. Golf does not appear to cause more problems than everyday life, although the severity of elbow and hand/wrist complaint may be higher when playing golf.

In our cohort, musculoskeletal complaints were most frequent in the lower back, the hip, knee and shoulder. Where injuries related directly to golf are studied, a systematic review highlights the lower back and the elbow are most frequently affected in non-professional players.[8] Most studies identify the volume of repetitive practice and suboptimal swing biomechanics as potential underlying causes of injuries in amateur players.[12 19]

In our study, one-fifth of patients suffered from osteoarthritis, with the knee and lumbar spine frequently affected. The distribution of complaints to the knee and lumbar spine seen in our study may also be reflected in the high prevalence of osteoarthritis. There was a higher proportion of players with osteoarthritis in the highest handicap group. The mean age of this cohort compared with the lower handicap group was 5.9 years older, which may be a contributing factor.

Golf is a sport played by a much wider age range than most other recreational sports. Golfers are often able to play despite the presence of injury, indeed golf is sometimes included as a therapeutic modality in some rehabilitation programmes.[40] This is supported by the large proportion of middle-aged and older golfers in the study who continued to play golf despite reporting osteoarthritis. There was no difference in the severity of complaints between those that did and did not undertake prevention exercises so it is therefore possible that preventative exercises may limit the severity of pain to an acceptable level. Those undertaking prevention exercises were more likely to have taken pain killers in the previous 12 months. These findings in golf mirror other sports where pain relieving medication are frequently used.[41 42]

Limitations

This cohort was limited to male players, based in the USA, and is not necessarily generalisable to female players or populations of golfers in other countries. The mean handicap of players was lower in this cohort than in the general golfing population,[43] and the amount of golf played higher than the general golfing population.[44] However, since only two significant differences in the prevalence and severity of musculoskeletal complaints in the preceding 7 days between handicap groups were noted in the present study, the results may be representative for male amateur golfers of this age group. We also recognise there may be recall bias in the self-reporting nature of the online questionnaires that the participants completed. We did not analyse the causes of musculoskeletal complaints. Since the prevalence of lower back pain and osteoarthritis was similar to the general population,[31] it can be assumed that golf was not the primary cause of these complaints. Future prospective epidemiological studies should analyse the prevalence and incidence of injuries caused by golf.

A large number of tests were performed. If the Bonferroni correction is applied, only results at p<0.001 remain significant. We decided to report all results, since this is an exploratory study. However, results below the p<0.001 level should be interpreted with caution. Furthermore, this study is retrospective in nature and the cross-sectional study design does not allow for casual conclusions.

CONCLUSIONS

The prevalence of current musculoskeletal complaints in recreational golfers is similar to an age-matched and gender-matched general population, and neither the prevalence nor the severity of complaints is higher when playing golf compared with everyday life. Also, the pattern of complaints by body region is similar to those seen in the general population, with LBP, knee, shoulder and hip pathology relatively prevalent. Routine warm-up and physical preparation for golf are inconsistently performed by this golfing cohort. Further prospective and intervention-based research is required to further understand golf-related injury and musculoskeletal complaints and subsequent prevention strategies.

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REFERENCES

1 The R&A. Record numbers now playing golf worldwide. 2021. Available: https://www.randa.org/en/news/2021/12/record-numbers-now-playing-golf-worldwide [Accessed 1 May 2022].
2 The R&A. Golf around the world. The Royal and Ancient 2019.
3 Murray AD, Daines L, Archibald D, *et al*. The relationships between golf and health: a scoping review. *Br J Sports Med* 2017;51:12–9.
4 Luscombe J, Murray AD, Jenkins E, *et al*. A rapid review to identify physical activity accrued while playing golf. *BMJ Open* 2017;7:e018993.
5 Amini H, Habibi S, Islamoglu AH, *et al*. COVID-19 pandemic-induced physical inactivity: the necessity of updating the global action plan on physical activity 2018-2030. *Environ Health Prev Med* 2021;26.
6 Robinson PG, Foster C, Murray A. Public health considerations regarding golf during the COVID-19 pandemic: a narrative review. *BMJ Open Sport Exerc Med* 2021;7:e001089.
7 Robinson PG, Murray A, Close G, *et al*. Assessing the risk of SARS-cov-2 transmission in international professional golf. *BMJ Open Sport Exerc Med* 2021;7:e001109.
8 Cabri J, Sousa JP, Kots M, *et al*. Golf-related injuries: a systematic review. *Eur J Sport Sci* 2009;9:353–66.
9 Parkkari J, Natri A, Kannus P, *et al*. A controlled trial of the health benefits of regular walking on a golf course. *Am J Med* 2000;109:102–8.
10 Parkkari J, Kannus P, Natri A, *et al*. Active living and injury risk. *Int J Sports Med* 2004;25:209–16.
11 McHardy A, Pollard H, Luo K. One-year follow-up study on golf injuries in Australian amateur golfers. *Am J Sports Med* 2007;35:1354–60.
12 McCarroll JR. The frequency of golf injuries. *Clin Sports Med* 1996;15:1–7.
13 Robinson PG, Murray IR, Duckworth AD, *et al*. Systematic review of musculoskeletal injuries in professional golfers. *Br J Sports Med* 2019;53:13–8.
14 Thériault G, Lachance P. Golf injuries. *Sports Med* 1998;26:43–57.
15 Barclay C, West S, Shoaib Q, *et al*. Injuries patterns among professional golfers: an international survey. *British Journal of Sports Medicine* 2011;45:e1.
16 Sugaya H. Asymmetric radiographic findings on the lumbar spine in elite and professional golfers. *Orthop Trans* 1997;21:312–3.
17 Batt ME. Golfing injuries. *Sports Med* 1993;16:64–71.
18 Gosheger G, Liem D, Ludwig K, *et al*. Injuries and overuse syndromes in golf. *Am J Sports Med* 2003;31:438–43.
19 McCarroll JR, Rettig AC, Shelbourne KD. Injuries in the amateur golfer. *Phys Sportsmed* 1990;18:122–6.
20 Orchard JW, Ranson C, Olivier B, *et al*. International consensus statement on injury surveillance in cricket: a 2016 update. *Br J Sports Med* 2016;50:1245–51.
21 Fuller CW, Ekstrand J, Junge A, *et al*. Consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries. *Clin J Sport Med* 2006;16:97–106.
22 Fuller CW, Molloy MG, Bagate C, *et al*. Consensus statement on injury definitions and data collection procedures for studies of injuries in rugby Union. *Clin J Sport Med* 2007;17:177–81.
23 King DA, Gabbett TJ, Gissane C, *et al*. Epidemiological studies of injuries in rugby League: suggestions for definitions, data collection and reporting methods. *J Sci Med Sport* 2009;12:12–9.
24 Mountjoy M, Junge A, Alonso JM, *et al*. Consensus statement on the methodology of injury and illness surveillance in FINA (aquatic sports). *Br J Sports Med* 2016;50:590–6.
25 Pluim BM, Fuller CW, Batt ME, *et al*. Consensus statement on epidemiological studies of medical conditions in tennis, April 2009. *Br J Sports Med* 2009;43:893–7.
26 Timpka T, Alonso J-M, Jacobsson J, *et al*. Injury and illness definitions and data collection procedures for use in epidemiological studies in athletics (track and field): consensus statement. *Br J Sports Med* 2014;48:483–90.
27 Turner M, Fuller CW, Egan D, *et al*. European consensus on epidemiological studies of injuries in the thoroughbred horse racing industry. *Br J Sports Med* 2012;46:704–8.
28 Dvorak J, Pluim BM. Injury and illness surveillance in sports: how golf, tennis, cycling and parasport extended the IOC consensus statement to tailor injury and illness surveillance to specific sports. *Br J Sports Med* 2021;55:6–7.
29 Murray A, Junge A, Robinson PG, *et al*. International consensus statement: methods for recording and reporting of epidemiological data on injuries and illnesses in golf. *Br J Sports Med* 2020;54:1136–41.
30 Bahr R, Clarsen B, Derman W, *et al*. International Olympic Committee consensus statement: methods for recording and reporting of epidemiological data on injury and illness in sport 2020 (including STROBE extension for sport injury and illness surveillance (STROBE-SIIS)). *Br J Sports Med* 2020;54:372–89.
31 Urwin M, Symmons D, Allison T, *et al*. Estimating the burden of musculoskeletal disorders in the community: the comparative prevalence of symptoms at different anatomical sites, and the relation to social deprivation. *Ann Rheum Dis* 1998;57:649–55.
32 Strain T, Fitzsimons C, Foster C, *et al*. Age-related comparisons by sex in the domains of aerobic physical activity for adults in Scotland. *Prev Med Rep* 2016;3:90–7.
33 Farahmand B, Broman G, de Faire U, *et al*. Golf: a game of life and death -- reduced mortality in Swedish golf players. *Scand J Med Sci Sports* 2009;19:419–24.
34 Sorbie GR, A. Glen J, *et al*. The association of golf participation with health and wellbeing: a comparative study. *Int J Golf Sci* 2021;9.
35 McHardy A, Pollard H, Luo K. Golf injuries: a review of the literature. *Sports Med* 2006;36:171–87.

36 Cole MH, Grimshaw PN. The biomechanics of the modern golf swing: implications for lower back injuries. *Sports Med* 2016;46:339–51.
37 Herkowitz H. Epidemiology and the economics of low back pain. In: *The lumbar spine*. 3rd ed. Lippincott Williams & Wilkins, 2004: 3–11.
38 Hoy D, Bain C, Williams G, *et al*. A systematic review of the global prevalence of low back pain. *Arthritis Rheum* 2012;64:2028–37.
39 Trompeter K, Fett D, Platen P. Prevalence of back pain in sports: a systematic review of the literature. *Sports Med* 2017;47:1183–207.
40 Parziale JR. Healthy swing: a golf rehabilitation model. *Am J Phys Med Rehabil* 2002;81:498–501.
41 Tscholl PM, Vaso M, Weber A, *et al*. High prevalence of medication use in professional football tournaments including the world CUPS between 2002 and 2014: a narrative review with a focus on NSAIDs. *Br J Sports Med* 2015;49:580–2.
42 Warner DC, Schnepf G, Barrett MS, *et al*. Prevalence, attitudes, and behaviors related to the use of nonsteroidal anti-inflammatory drugs (NSAIDs) in student athletes. *J Adolesc Health* 2002;30:150–3.
43 USGA. Handicap index statistics 2022 [Available from]. Available: https://www.usga.org/content/usga/home-page/handicapping/handicapping-stats.html [Accessed 15 May 2022].
44 National Golf Federation. The numbers are official: golf's surge in popularity in 2020 was even better than predicted. 2020. Available: https://www.golfdigest.com/story/national-golf-foundation-reports-numbers-for-2020-were-record-se [Accessed 16 May 2022].