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Prevalence of and factors associated with osteoarthritis and pain in retired Olympians compared with the general population: part 2 – the spine and upper limb

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ABSTRACT

Objectives (1) To determine the prevalence of spine and upper limb osteoarthritis (OA) and pain in retired Olympians; (2) identify risk factors associated with their occurrence and (3) compare with a sample of the general population.

Methods 3357 retired Olympians (44.7 years) and 1735 general population controls (40.5 years) completed a cross-sectional survey. The survey captured demographics, general health, self-reported physician-diagnosed OA, current joint/region pain and significant injury (lasting ≥1 month). Adjusted ORs (aORs) compared retired Olympians and the general population.

Results Overall, 40% of retired Olympians reported experiencing current joint pain. The prevalence of lumbar spine pain was 19.3% and shoulder pain 7.4%, with lumbar spine and shoulder OA 5.7% and 2.4%, respectively. Injury was associated with increased odds (aOR, 95% CI) of OA and pain at the lumbar spine (OA=5.59, 4.01 to 7.78; pain=4.90, 3.97 to 6.05), cervical spine (OA=17.83, 1.02 to 31.14; pain=9.41, 6.32 to 14.01) and shoulder (OA=4.91, 3.03 to 7.96; pain=6.04, 4.55 to 8.03) in retired Olympians. While the odds of OA did not differ between Olympians and the general population, the odds of lumbar spine pain (1.44, 1.20 to 1.73), the odds of shoulder OA after prior shoulder injury (2.64, 1.01 to 6.90) and the odds of cervical spine OA in female Olympians (2.02, 1.06 to 3.87) were all higher for Olympians compared with controls.

Conclusions One in five retired Olympians reported experiencing current lumbar spine pain. Injury was associated with lumbar spine, cervical spine and shoulder OA and pain for Olympians. Although overall OA odds did not differ, after adjustment for recognised risk factors, Olympians were more likely to have lumbar spine pain and shoulder OA after shoulder injury, than the general population.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Elite sport participation can increase the risk of injury, and significant joint injury is a risk factor for the development of pain and osteoarthritis.

WHAT THIS STUDY ADDS

⇒ Injury was associated with an increased risk of OA and pain at the lumbar spine, cervical spine and shoulder in retired Olympians. Overall, the odds of lumbar spine pain were greater for Olympians compared with a sample of the general population.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Primary injury prevention initiatives should be employed by athlete medical and coaching teams involved in sports with known joint specific loading and injury aetiologies around the lumbar spine, cervical spine and shoulder. Tertiary prevention initiatives targeting overweight or obesity in later life in those athletes who have had significant prior joint injury may also be beneficial.

INTRODUCTION

Significant joint injury is a risk factor for the development of osteoarthritis (OA), and the results presented in part 1 of this study confirmed that OA and pain at the knee, hip and ankle are associated with prior significant injury. In addition, the odds of suffering knee and hip OA after injury were greater for Olympians compared with the general population.[1]

To date, most retired athlete studies have focused on factors and outcomes associated with OA and pain in isolated body joints of the lower limb, such as the hip and knee.[2–6] Conversely, while a few retired athlete studies have reported the prevalence of pain and OA in the spine[7–9] and the upper limb,[8] there has been no focus on the factors influencing these outcomes in these body regions in retired elite athletes. Hence, the joint dependent response to risk factors associated with OA and pain in the spine and upper limb in retired athletes remains currently unexplored.[10] If we have a better understanding of the longer-term risks around significant joint injury, what factors contribute to later-life OA and pain within Olympic-level sport and how these differ to the general population, effective, evidence-based prevention and treatment strategies can be developed. Providing the opportunity to positively influence some of these later-life disease outcomes and protecting the longer-term health of elite athletes.

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Therefore the present study aimed to (1) determine the prevalence of spine and upper limb self-reported physician-diagnosed OA and pain in a sample of retired Olympians, (2) identify the factors that are associated with spine and upper limb OA and pain in retired Olympians and (3) make comparisons with a sample of the general population.

METHODS

This cross-sectional study collected self-report data from retired Olympians and general population controls using an online questionnaire, between April 2018 and June 2019. Retired Olympians were those who had competed in at least one summer and/or winter Olympic Games, who were aged 16 years of age or older, and considered themselves retired from Olympic-level training and competition. General population controls in the present study were any individuals who had not competed at a summer and/or winter Olympic Games, who were 16 years of age or older.

Recruitment

Recruitment of retired Olympians was carried out globally through the World Olympians Association (WOA) and IOC platforms, National Olympians Associations and via the OLY database.[1 11] General population group recruitment (controls) was conducted in three phases: (1) study promotion via WOA and IOC communication channels; (2) using Olympian 'buddies' where Olympians were asked to recruit a non-Olympian friend; and (3) by members of the research group through academic and industry organisations, and local regional public leisure, medical and community centres.[1]

Detailed participant study information, including data handling and confidentiality, was provided at the start of the survey. It was explicitly outlined that by completing and submitting the questionnaire, the participants were consenting that their information would be used anonymously for the study.

Questionnaire survey

The Olympian survey was a web-based password-protected survey.[11] The general population survey was open access and similar to the Olympic questionnaire contained four main sections: (1) baseline demographics, (2) sport participation and self-reported injury history details, (3) self-reported current musculoskeletal health, and (4) current general health and quality of life.[1]

Baseline questions requested demographics such as age and sex. Current height (cm) and weight (kg) were collected to calculate body mass index (BMI kg/m^2). Injury questions asked participants to recall significant injuries including the anatomical location, injury type and severity. Significant 'injury' was defined as 'any injury causing significant pain and/or dysfunction for a period of 1 month (or more)'. Recurrent injury was defined as the same type and same site as an index injury.[11] Injuries occurring during sport, exercise, leisure activities, at home, work or other place for both Olympians and controls were included.

Current musculoskeletal health was reported by all participants. The presence of joint pain was established using a validated question 'Do you currently experience pain, for most days of the last month, in this joint?'[1 11 12] Self-reported physician-diagnosed OA was ascertained by asking 'Have you ever been diagnosed with OA in any of your joints by a medical professional?'.[4] Additional questions on general health asked about the presence of comorbidities (eg, heart disease or diabetes). Patient and public involvement included a patient advisory group providing feedback on the clarity and understanding of the questionnaire.[1]

Confidentiality

No identifying parameters were recorded, and individuals were not identifiable at any stage of the research. All data were treated confidentially, ensuring participant anonymity at all times.

Data analysis

Prevalence was calculated dividing the number of participants with the outcome of interest by the total number of participants and presented as percentage (%) with 95% CIs. To determine if distributions of variables were statistically different between Olympians and the general population, continuous variables were analysed by unpaired t-tests or Mann-Whitney, and categorical variables by the $\chi 2$ test as appropriate. Significance was accepted at $p<0.05$. The prevalence of the primary outcome variables, OA and pain, were calculated for each region/joint individually for the lumbar spine, cervical spine and shoulder. A logistic regression model was used to estimate OR with corresponding 95% CI for each primary outcome for each independent variable, adjusted (aOR) in a multivariable model for a priori age, BMI, sex and injury, for Olympians. A separate model was used to assess putative risk factors for each primary outcome comparing Olympians versus general population controls followed by stage adjustment for age, BMI and sex; and age, BMI, sex and injury. Variables where there were less than five cases were not included.[13 14] Age and BMI were non-linear and so were categorised according to previous research.[12] Significant injuries were included in analysis if they matched the index joint and preceded OA diagnosis or episode of pain. If bilateral, the most severe joint was selected as the index joint for analysis. Where there was collinearity, variables were removed. Imputation was not undertaken for occasional missing values. Analysis was conducted using Stata IC V.16.

RESULTS

Descriptive characteristics

The median age of Olympians was 44.7 years (range 16–97) with 45% female (and 55% male) and general population controls 40.5 years (range 16–88) with 58% female (and 42% male) (table 1). Mean BMI was similar between Olympians and controls. Retired Olympians reported a higher prevalence of injury (68.5% vs 60.5%) and recurrent injury (41.5% vs 30.7%), and (any joint) OA (23.2% vs 15.7%) and current pain (41.3% vs 37.8%) compared with controls.

Prevalence of pain by body region/joint

The prevalence of self-reported pain was higher for Olympians compared with controls for the lumbar spine (19.3% vs 12.3%; $p<0.001$) and knee (12.4% vs 10.4%; $p=0.007$) and similar for the shoulder (7.4% vs 8.2%; $p=0.275$), cervical spine (6.9% vs 5.6%; $p=0.069$), hip (5.6% vs 4.6%; $p=0.122$) and ankle (3.10% vs 4.0%; $p=0.101$) (figure 1). Data from this point forwards are presented for the lumbar spine, shoulder and cervical spine.

Spine and upper limb OA in Olympians

Table 2 presents the prevalence and adjusted odds for factors associated with self-reported OA at the lumbar spine, cervical spine and shoulder in Olympians. The odds of OA were associated with increasing age for the lumbar spine (40–59 years aOR 2.32 (95% CI 1.53 to 3.52) and ≥60 years aOR 4.10 (95% CI

Table 1 Anthropometric, injury and joint health factors for Olympians and general population controls

	Olympians n=3357	Controls n=1735	P value
Anthropometrics			
Female/male, n (%)	1488/1840 (45/55)	998/723 (58/42)	<0.001
Age (years), median (range)	44.7 (16–97)	40.5 (16–88)	<0.001
BMI (kg/m^2), mean (SD)	25.7 (5.4)	25.7 (6.3)	0.937
Injury (any injury)			
Injury prevalence, n (%)	2300 (68.5)	1050 (60.5)	<0.001
Recurrent injury, n (%)	1393 (41.5)	533 (30.7)	<0.001
Joint health			
Physician-diagnosed OA (at any joint), n (%)	599/2587 (23.2)	217/1380 (15.7)	<0.001
Current pain (any joint) >1 month, n (%)	1422 (41.3)	655 (37.8)	0.002
Current stiffness (any joint) >1 month, n (%)	1720 (51.2)	777 (44.8)	<0.001
Joint surgery, n (%)	764/2844 (26.9)	284/1484 (19.1)	<0.001

Pain or stiffness (any joint) reported for most days of the last month.
BMI, body mass index; OA, osteoarthritis.

2.54 to 6.63)) and for the cervical spine. Female sex was associated with greater odds of lumbar spine OA (aOR 1.91 (95% CI 1.36 to 2.70)) and cervical spine OA (aOR 3.35 (95% CI 1.88 to 5.99)), and comorbidities associated with lumbar spine, cervical spine and shoulder OA. Prior lumbar spine injury was significantly associated with greater odds of lumbar spine OA (aOR 5.59 (95% CI 4.01 to 7.78)), and the same was observed for prior cervical spine injury and cervical spine OA, and for the shoulder. Recurrent lumbar spine injury and recurrent shoulder injury were also associated with increased odds of OA (lumbar spine aOR 3.54 (95% CI 1.85 to 6.81); shoulder aOR 5.63 (95% CI 2.27 to 13.98), respectively). Factors associated with lumbar spine, cervical spine and shoulder OA in the general population are presented in online supplemental appendices 1–3, respectively.

Spine and upper limb pain in Olympians

Table 3 presents the prevalence and adjusted odds for factors associated with pain at the lumbar spine, cervical spine and shoulder, in Olympians. Overweight and obesity were associated with increased odds of lumbar spine pain (obesity aOR 1.40 (95% CI 1.02 to 1.92)), and obesity with shoulder pain (aOR 1.73 (95% CI 1.12 to 2.68)). The prevalence of pain across the lumbar spine, cervical spine and shoulder was highest for Olympians aged 40–59 years but lowest for ≥60 years, with the odds of pain at the lumbar spine lower at ≥60 years (prevalence 14.3%, aOR 0.56 (95% CI 0.41 to 0.77)) compared with younger age. Comorbidities were associated with pain at the lumbar spine, cervical spine and shoulder, and female sex with cervical spine pain (8.74%, aOR 1.61 (95% CI 1.17 to 2.21)). Prior significant lumbar spine injury was associated with greater odds of lumbar spine pain (aOR 4.90 (95% CI 3.97 to 6.05)), and the same was observed for the cervical spine and shoulder. Recurrent lumbar spine injury was also associated with lumbar spine pain (aOR 3.31 (95% CI 2.21 to 4.96)) and recurrent shoulder injury with shoulder pain (aOR 2.56 (95% CI 1.64 to 3.98)). Factors associated with lumbar spine, cervical spine and shoulder pain in the general population are presented in online supplemental appendices 4–6, respectively.

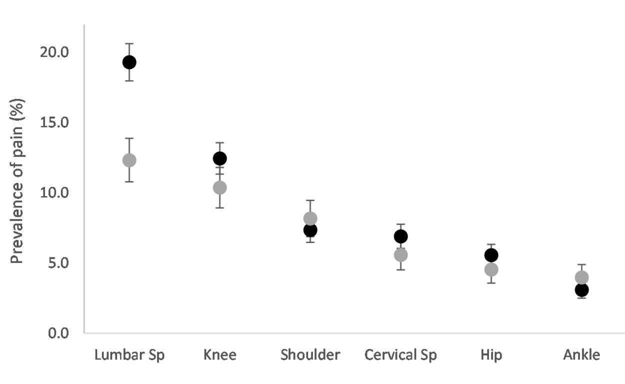

Figure 1 Prevalence of pain by body region/joint for Olympians and general population controls. CON, control; OLY, Olympian; Sp, spine.

Spine and upper limb OA in Olympians versus controls

Overall, after adjusting for covariates, the odds of lumbar spine OA (aOR 1.12 (95% CI 0.82 to 1.53)), cervical spine OA (aOR 1.32 (95% CI 0.80 to 2.17)) and shoulder OA (aOR 1.45 (95% CI 0.88 to 2.40)) were not significantly different in retired Olympians compared with general population controls (table 4). The odds of cervical spine OA in female Olympians were higher compared with women in the general population (prevalence 3.4% vs 1.5%, aOR 2.02 (95% CI 1.06 to 3.87)); and the odds of experiencing shoulder OA after prior shoulder injury were also greater for Olympians compared with controls (prevalence 6.6% vs 2.3%; aOR 2.64 (95% CI 1.01 to 6.90)).

Spine and upper limb pain in Olympians versus controls

Overall, the odds of lumbar spine pain were higher for Olympians compared with the general population (prevalence 19.3% vs 12.3%, aOR 1.44 (95% CI 1.20 to 1.73)), with the chances of pain higher for both men and women (table 5). Conversely, the odds of shoulder pain were lower for Olympians compared with controls (prevalence 7.3% vs 8.2%, aOR 0.77 (95% CI 0.61 to 0.98)). Lumbar spine pain odds were also higher for Olympians aged 20–39 years (aOR 1.72 (95% CI 1.29 to 2.29)) and 40–59 years (aOR 1.58 (95% CI 1.20 to 2.09)), but lower for Olympians aged ≥60 years (aOR 0.57 (95% CI 0.35 to 0.93)). Although it was near significance for the lumbar spine, overall, there was no difference between Olympians and controls in the odds of lumbar spine, cervical spine or shoulder pain after prior injury.

DISCUSSION

This is the first worldwide study comparing the factors associated with self-reported spine and upper limb OA and pain in

Table 2 Factors associated with spine and upper limb OA in Olympians

	Lumbar spine OA		Cervical spine OA		Shoulder OA	
	Prevalence	aOR (95% CI)	Prevalence	aOR (95% CI)	Prevalence	aOR (95% CI)
	n (%)	Adjusted a, s, b, i	n (%)	Adjusted a, s, b, i	n (%)	Adjusted a, s, b, i
Age						
20–39	35/1194 (2.93)	1.00 (reference)	6/1194 (0.50)	1.00 (reference)	15/1194 (1.26)	1.00 (reference)
40–59	89/1359 (6.55)	**2.32 (1.53 to 3.52)**	44/1359 (3.24)	**6.80 (2.82 to 16.37)**	35/1359 (2.58)	1.31 (0.75 to 2.31)
≥60	52/580 (8.97)	**4.10 (2.54 to 6.63)**	22/580 (3.79)	**11.87 (4.59 to 30.70)**	24/580 (4.14)	1.63 (0.85 to 3.13)
Sex						
Male	90/1840 (4.89)	1.00 (reference)	26/1840 (1.41)	1.00 (reference)	44/1840 (2.39)	1.00 (reference)
Female	100/1488 (6.72)	**1.91 (1.36 to 2.70)**	50/1488 (3.36)	**3.35 (1.88 to 5.99)**	35/1488 (2.35)	1.30 (0.79 to 2.16)
BMI						
Normal	86/1774 (4.85)	1.00 (reference)	41/1774 (2.31)	1.00 (reference)	33/1774 (1.86)	1.00 (reference)
Overweight	69/1063 (6.49)	**1.61 (1.11 to 2.32)**	24/1063 (2.26)	1.14 (0.63 to 2.04)	30/1063 (2.82)	1.34 (0.77 to 2.31)
Obese	25/342 (7.31)	1.53 (0.91 to 2.59)	7/342 (2.05)	0.86 (0.34 to 2.17)	14/342 (4.09)	1.80 (0.89 to 3.65)
Injury						
No	102/2815 (3.62)	1.00 (reference)	49/3209 (1.53)	1.00 (reference)	44/2827 (1.56)	1.00 (reference)
Yes	89/542 (16.42)	**5.59 (4.01 to 7.78)**	28/148 (18.92)	**17.83 (1.02 to 31.14)**	35/530 (6.60)	**4.91 (3.03 to 7.96)**
Recurrent injury	78/355 (21.97)	**3.54 (1.85 to 6.81)**	1/6 (16.7)	–	32/259 (12.36)	**5.63 (2.27 to 13.98)**
Comorbidities						
None	80/2379 (3.36)	1.00 (reference)	34/2379 (1.43)	1.00 (reference)	27/2379 (1.13)	1.00 (reference)
1	64/696 (9.20)	**2.57 (1.76 to 3.75)**	24/696 (3.45)	**1.91 (1.05 to 3.48)**	29/696 (4.17)	**2.92 (1.64 to 5.18)**
2 or more	47/282 (16.67)	**4.01 (2.57 to 6.27)**	19/282 (6.74)	**3.90 (1.96 to 7.76)**	23/282 (8.16)	**5.53 (2.95 to 10.40)**

Values are presented as count (n) and prevalence (%). aOR-adjusted a, s, b, i=OR adjusted for covariates age, sex, BMI and injury. Bold denotes statistical significance. – indicates analysis not performed due to small number of events (<5).
BMI, body mass index; OA, osteoarthritis.

retired Olympians and the general population. The main findings were: (1) 41% of Olympians reported having current (any) joint pain lasting 1 month or more, with the lumbar spine, cervical spine and shoulder among the most common sites for pain; (2) lumbar spine OA was one of the most common sites for OA in Olympians and the general population; (3) injury and recurrent injury were associated with increased odds of self-reported OA and pain in the spine and shoulder; (4) the odds of lumbar

Table 3 Factors associated with spine and upper limb pain in Olympians

	Lumbar spine pain		Cervical spine pain		Shoulder pain	
	Prevalence	aOR (95% CI)	Prevalence	aOR (95% CI)	Prevalence	aOR (95% CI)
	n (%)	Adjusted a, s, b, i	n (%)	Adjusted a, s, b, i	n (%)	Adjusted a, s, b, i
Age						
20–39	234/1194 (19.6)	1.00 (reference)	81/1194 (6.78)	1.00 (reference)	84/1194 (7.04)	1.00 (reference)
40–59	293/1359 (21.56)	1.09 (0.88 to 1.34)	103/1359 (7.58)	1.05 (0.77 to 1.46)	113/1359 (8.31)	1.20 (0.88 to 1.63)
≥60	83/580 (14.31)	**0.56 (0.41 to 0.77)**	34/580 (5.86)	0.84 (0.53 to 1.33)	37/580 (6.38)	0.96 (0.62 to 1.49)
Sex						
Male	358/1840 (19.46)	1.00 (reference)	9/1840 (5.38)	1.00 (reference)	124/1840 (6.74)	1.00 (reference)
Female	285/1488 (19.15)	0.94 (0.77 to 1.15)	130/1488 (8.74)	**1.61 (1.17 to 2.21)**	121/1488 (8.13)	1.25 (0.93 to 1.68)
BMI						
Normal	315/1774 (17.76)	1.00 (reference)	129/1774 (7.27)	1.00 (reference)	121/1774 (6.82)	1.00 (reference)
Overweight	214/1063 (20.13)	**1.24 (1.00 to 1.55)**	65/1063 (6.11)	1.02 (0.72 to 1.45)	77/1063 (7.24)	1.12 (0.81 to 1.57)
Obese	76/342 (22.22)	**1.40 (1.02 to 1.92)**	26/342 (7.60)	1.25 (0.77 to 2.04)	37/342 (10.82)	**1.73 (1.12 to 2.68)**
Injury						
No	400/2815 (14.21)	1.00 (reference)	178/3209 (5.55)	1.00 (reference)	126/2827 (4.46)	1.00 (reference)
Yes	248/542 (45.76)	**4.90 (3.97 to 6.05)**	54/148 (36.49)	**9.41 (6.32 to 14.01)**	120/530 (22.64)	**6.04 (4.55 to 8.03)**
Recurrent injury	196/355 (55.21)	**3.31 (2.21 to 4.96)**	2/6 (33.3)	–	84/259 (32.43)	**2.56 (1.64 to 3.98)**
Comorbidities						
None	377/2379 (15.85)	1.00 (reference)	130/2379 (5.46)	1.00 (reference)	136/2379 (5.72)	1.00 (reference)
1	185/696 (26.58)	**2.09 (1.67 to 2.62)**	70/696 (10.06)	**1.95 (1.38 to 2.73)**	74/696 (10.63)	**1.77 (1.28 to 2.45)**
2 or more	86/282 (30.5)	**2.23 (1.61 to 3.10)**	32/282 (11.35)	**2.63 (1.64 to 4.22)**	36/282 (12.77)	**2.16 (1.38 to 3.37)**

Values are presented as count (n) and prevalence (%). aOR-adjusted a, s, b, i=OR adjusted for covariates age, sex, BMI and injury. Bold denotes statistical significance. – indicates analysis not performed due to small number of events (<5).
BMI, body mass index.

Table 4 Odds of spine and upper limb OA for Olympians versus a general population control

	Lumbar spine OA		Olympians vs controls			Cervical spine OA		Olympians vs controls			Shoulder OA		Olympians vs controls		
	Olympians	Controls	OR (95% CI)	aOR (95% CI)	aOR (95% CI)	Olympians	Controls	OR (95% CI)	aOR (95% CI)	aOR (95% CI)	Olympians	Controls	OR (95% CI)	aOR (95% CI)	aOR (95% CI)
	n (%)	n (%)	Crude	Adjusted a, s, b	Adjusted a, s, b, i	n (%)	n (%)	Crude	Adjusted a, s, b	Adjusted a, s, b, i	n (%)	n (%)	Crude	Adjusted a, s, b	Adjusted a, s, b, i
OA	191 (5.69)	66 (3.80)	**1.53 (1.15 to 2.03)**	1.33 (0.98 to 1.80)	1.12 (0.82 to 1.53)	77 (2.29)	25 (1.44)	**1.61 (1.2 to 2.53)**	1.51 (0.93 to 2.46)	1.32 (0.80 to 2.17)	79 (2.35)	22 (1.27)	**1.88 (1.17 to 3.02)**	1.56 (0.95 to 2.58)	1.45 (0.88 to 2.40)
Age															
20–39	35 (2.93)	10 (1.28)	**2.31 (1.14 to 4.70)**	**3.09 (1.42 to 6.72)**	**2.38 (1.08 to 5.26)**	6 (0.50)	2 (0.26)	–	–	–	15 (1.26)	5 (0.64)	1.96 (0.71 to 5.42)	1.96 (0.71 to 5.46)	1.62 (0.57 to 4.54)
40–59	89 (6.55)	32 (4.95)	1.34 (0.89 to 2.04)	1.35 (0.88 to 2.07)	1.11 (0.71 to 1.72)	44 (3.24)	15 (2.32)	1.41 (0.78 to 2.55)	1.54 (0.84 to 2.82)	1.38 (0.73 to 2.64)	35 (2.58)	9 (1.39)	1.87 (0.89 to 3.92)	1.77 (0.84 to 3.74)	1.67 (0.79 to 3.53)
≥60	52 (8.97)	23 (10.84)	0.81 (0.48 to 1.36)	0.77 (0.45 to 1.35)	0.72 (0.41 to 1.27)	22 (3.79)	8 (3.77)	1.01 (0.44 to 2.29)	1.18 (0.48 to 2.89)	1.12 (0.45 to 2.75)	24 (4.14)	7 (3.30)	1.26 (0.54 to 2.98)	1.38 (0.56 to 3.38)	1.39 (0.57 to 3.42)
Sex															
Male	90 (4.89)	20 (2.76)	**1.81 (1.10 to 2.96)**	1.36 (0.81 to 2.29)	1.23 (0.73 to 2.08)	26 (1.41)	10 (1.38)	1.02 (0.49 to 2.13)	0.69 (0.32 to 1.47)	0.60 (0.27 to 1.31)	44 (2.39)	11 (1.52)	1.59 (0.81 to 3.09)	1.33 (0.67 to 2.63)	1.33 (0.67 to 2.65)
Female	100 (6.72)	46 (4.61)	**1.49 (1.04 to 2.13)**	1.31 (0.89 to 1.93)	1.09 (0.74 to 1.61)	50 (3.36)	15 (1.50)	**2.28 (1.27 to 4.08)**	**2.28 (1.22 to 4.29)**	**2.02 (1.06 to 3.87)**	35 (2.35)	11 (1.10)	**2.16 (1.09 to 4.28)**	**2.07 (1.00 to 4.30)**	1.89 (0.90 to 3.95)
BMI															
Normal	86 (4.85)	36 (3.67)	1.34 (0.90 to 1.99)	1.14 (0.75 to 1.73)	0.90 (0.58 to 1.38)	41 (2.31)	12 (1.22)	**1.91 (1.00 to 3.65)**	1.72 (0.89 to 3.34)	1.46 (0.74 to 2.89)	33 (1.86)	11 (1.12)	1.55 (0.77 to 3.09)	1.55 (0.75 to 3.20)	1.54 (0.74 to 3.18)
Overweight	69 (6.49)	19 (4.16)	1.60 (0.95 to 2.69)	1.54 (0.89 to 2.65)	1.41 (0.81 to 2.44)	24 (2.26)	7 (1.53)	1.48 (0.64 to 3.47)	1.45 (0.60 to 3.50)	1.15 (0.47 to 2.84)	30 (2.82)	7 (1.53)	2.11 (0.87 to 5.14)	1.65 (0.70 to 3.88)	1.54 (0.65 to 3.61)
Obese	25 (7.31)	10 (5.26)	1.42 (0.67 to 3.02)	1.46 (0.64 to 3.31)	1.03 (0.44 to 2.41)	7 (2.05)	5 (2.63)	0.77 (0.24 to 2.47)	0.77 (0.22 to 2.78)	0.98 (0.25 to 3.91)	14 (4.09)	4 (2.11)	–	–	–
Injury	89 (16.42)	15 (9.43)	**1.89 (1.06 to 3.36)**	1.67 (0.91 to 3.05)		28 (18.92)	5 (9.62)	2.19 (0.80 to 6.02)	1.99 (0.66 to 6.02)		35 (6.60)	5 (2.25)	**3.07 (1.19 to 7.94)**	**2.64 (1.01 to 6.90)**	
Recurrent injury	78 (21.97)	17 (17.17)	1.36 (0.76 to 2.42)	1.25 (0.68 to 2.29)		1 (16.7)	0 (0)	–	–	–	32 (12.36)	9 (9.18)	1.39 (0.64 to 3.04)	1.11 (0.50 to 2.50)	
Comorbidities															
None	80 (3.36)	33 (2.61)	1.30 (0.86 to 1.96)	1.17 (0.75 to 1.82)	0.94 (0.60 to 1.46)	34 (1.43)	10 (0.79)	1.82 (0.89 to 3.69)	2.06 (0.93 to 4.57)	1.63 (0.71 to 3.77)	27 (1.13)	8 (0.63)	1.80 (0.82 to 3.98)	1.41 (0.62 to 3.19)	1.37 (0.61 to 3.11)
1	64 (9.20)	20 (5.95)	1.60 (0.95 to 2.69)	1.35 (0.78 to 2.34)	1.21 (0.69 to 2.12)	24 (3.45)	10 (2.98)	1.16 (0.55 to 2.46)	0.96 (0.44 to 2.10)	0.89 (0.40 to 1.97)	29 (4.17)	10 (2.98)	1.42 (0.68 to 2.94)	1.26 (0.59 to 2.70)	1.10 (0.51 to 2.37)
2 or more	47 (16.67)	13 (9.56)	1.89 (0.99 to 3.63)	1.74 (0.84 to 3.59)	1.58 (0.75 to 3.37)	19 (6.74)	5 (3.68)	1.89 (0.69 to 5.18)	1.69 (0.58 to 4.90)	1.72 (0.58 to 5.04)	23 (8.16)	4 (2.94)	–	–	–

Values are presented as count (n) and prevalence (%), with comparisons made between Olympians and controls. Controls are the reference value (1.00). OR-adjusted a, s, b=ORs adjusted for covariates age, sex and BMI. OR-adjusted a, s, b, i=ORs are adjusted for age, sex, BMI and injury. Bold denotes statistical significance. – indicates analysis not performed due to small number of events (<5).
BMI, body mass index; OA, osteoarthritis.

Table 5 Odds of spine and upper limb pain for Olympians versus a general population control

	Lumbar spine pain		Olympians vs controls			Cervical spine pain		Olympians vs controls			Shoulder pain		Olympians vs controls		
	Olympians	Controls	OR (95% CI)	aOR (95% CI)	aOR (95% CI)	Olympians	Controls	OR (95% CI)	aOR (95% CI)	aOR (95% CI)	Olympians	Controls	OR (95% CI)	aOR (95% CI)	aOR (95% CI)
	n (%)	n (%)	Crude	Adjusted a, s, b	Adjusted a, s, b, i	n (%)	n (%)	Crude	Adjusted a, s, b	Adjusted a, s, b, i	n (%)	n (%)	Crude	Adjusted a, s, b	Adjusted a, s, b, i
Pain	648 (19.30)	214 (12.33)	**1.70 (1.44 to 2.01)**	**1.65 (1.39 to 1.97)**	**1.44 (1.20 to 1.73)**	232 (6.91)	97 (5.59)	1.25 (0.98 to 1.60)	**1.34 (1.03 to 1.75)**	1.26 (0.97 to 1.65)	246 (7.33)	142 (8.18)	0.89 (0.72 to 1.10)	0.87 (0.69 to 1.09)	**0.77 (0.61 to 0.98)**
Age															
20–39	234 (19.60)	83 (10.70)	**2.04 (1.56 to 2.66)**	**2.03 (1.55 to 2.67)**	**1.72 (1.29 to 2.29)**	81 (6.78)	43 (5.54)	1.24 (0.85 to 1.82)	1.28 (0.87 to 1.89)	1.21 (0.81 to 1.80)	84 (7.04)	54 (6.96)	1.01 (0.71 to 1.44)	1.03 (0.72 to 1.48)	0.86 (0.59 to 1.25)
40–59	293 (21.56)	86 (13.31)	**1.79 (1.38 to 2.32)**	**1.76 (1.34 to 2.31)**	**1.58 (1.20 to 2.09)**	103 (7.58)	41 (6.35)	1.21 (0.83 to 1.76)	1.30 (0.88 to 1.93)	1.22 (0.81 to 1.83)	113 (8.31)	65 (10.06)	0.81 (0.59 to 1.12)	0.81 (0.58 to 1.13)	0.73 (0.52 to 1.02)
≥60	83 (14.31)	32 (15.09)	0.94 (0.60 to 1.46)	0.64 (0.39 to 1.03)	**0.57 (0.35 to 0.93)**	34 (5.86)	9 (4.25)	1.40 (0.66 to 2.98)	1.57 (0.66 to 3.73)	1.49 (0.62 to 3.58)	37 (6.38)	17 (8.02)	0.78 (0.43 to 1.42)	0.70 (0.37 to 1.35)	0.72 (0.37 to 1.41)
Sex															
Male	358 (19.46)	99 (13.69)	**1.52 (1.20 to 1.94)**	**1.48 (1.15 to 1.91)**	**1.33 (1.03 to 1.73)**	9 (5.38)	30 (4.15)	1.31 (0.86 to 1.99)	1.31 (0.84 to 2.05)	1.28 (0.81 to 2.01)	124 (6.74)	61 (8.44)	0.78 (0.57 to 1.08)	0.72 (0.52 to 1.01)	0.71 (0.51 to 1.00)
Female	285 (19.15)	114 (11.42)	**1.84 (1.45 to 2.32)**	**1.83 (1.43 to 2.34)**	**1.55 (1.20 to 2.00)**	130 (8.74)	67 (6.71)	1.33 (0.98 to 1.81)	1.34 (0.97 to 1.86)	1.25 (0.90 to 1.75)	121 (8.13)	81 (8.12)	1.00 (0.75 to 1.34)	1.01 (0.74 to 1.37)	0.79 (0.57 to 1.10)
BMI															
Normal	315 (17.76)	107 (10.91)	**1.76 (1.39 to 2.23)**	**1.77 (1.39 to 2.25)**	**1.51 (1.18 to 1.94)**	129 (7.27)	56 (5.71)	1.29 (0.94 to 1.79)	1.30 (0.93 to 1.81)	1.22 (0.87 to 1.72)	121 (6.82)	84 (8.56)	0.78 (0.58 to 1.04)	0.76 (0.56 to 1.02)	**0.69 (0.51 to 0.94)**
Overweight	214 (20.13)	73 (15.97)	1.33 (0.99 to 1.78)	1.33 (0.98 to 1.80)	1.19 (0.87 to 1.63)	65 (6.11)	22 (4.81)	1.29 (0.78 to 2.11)	1.39 (0.83 to 2.35)	1.26 (0.74 to 2.15)	77 (7.24)	32 (7.00)	1.03 (0.68 to 1.59)	1.10 (0.71 to 1.72)	0.97 (0.62 to 1.52)
Obese	76 (22.22)	21 (11.05)	**2.30 (1.37 to 3.87)**	**2.60 (1.49 to 4.55)**	**2.01 (1.12 to 3.60)**	26 (7.60)	9 (4.74)	1.65 (0.76 to 3.61)	1.86 (0.79 to 4.40)	**2.81 (1.04 to 7.59)**	37 (10.82)	17 (8.95)	1.23 (0.67 to 2.26)	1.19 (0.62 to 2.28)	0.99 (0.51 to 1.93)
Injury	248 (45.76)	57 (35.85)	**1.51 (1.05 to 2.18)**	1.45 (0.99 to 2.12)		54 (36.49)	12 (23.08)	1.91 (0.93 to 3.96)	1.94 (0.87 to 4.34)		120 (22.64)	56 (25.23)	0.87 (0.60 to 1.25)	0.86 (0.59 to 1.26)	
Recurrent injury	196 (55.21)	45 (45.45)	1.48 (0.95 to 2.31)	1.41 (0.89 to 2.26)		2 (33.30)	0 (0)	–	–		84 (32.43)	34 (34.69)	0.90 (0.55 to 1.48)	0.81 (0.48 to 1.35)	
Comorbidities															
None	377 (15.85)	124 (9.82)	**1.73 (1.39 to 2.15)**	**1.77 (1.41 to 2.22)**	**1.51 (1.19 to 1.91)**	129 (7.27)	60 (4.75)	1.16 (0.84 to 1.59)	1.22 (0.87 to 1.71)	1.12 (0.79 to 1.59)	136 (5.72)	88 (6.97)	0.81 (0.61 to 1.07)	0.82 (0.61 to 1.10)	0.74 (0.55 to 1.01)
1	185 (26.58)	56 (16.67)	**1.81 (1.30 to 2.52)**	**1.78 (1.25 to 2.52)**	**1.62 (1.12 to 2.32)**	65 (6.11)	22 (6.55)	1.60 (0.97 to 2.62)	1.67 (0.99 to 2.83)	1.62 (0.94 to 2.77)	74 (10.63)	33 (9.82)	1.09 (0.71 to 1.68)	1.03 (0.66 to 1.63)	0.89 (0.56 to 1.42)
2 or more	86 (30.50)	34 (25.0)	1.32 (0.83 to 2.09)	1.09 (0.65 to 1.82)	0.94 (0.55 to 1.62)	26 (7.60)	15 (11.03)	1.03 (0.54 to 1.98)	1.43 (0.68 to 2.99)	1.47 (0.69 to 3.12)	36 (12.77)	21 (15.44)	0.80 (0.45 to 1.43)	0.76 (0.39 to 1.46)	0.58 (0.29 to 1.15)

Values are presented as count (n) and prevalence (%), with comparisons made between Olympians and controls. Controls are the reference value (1.00). OR-adjusted a, s, b=ORs adjusted for covariates age, sex and BMI. OR-adjusted a, s, b, i=ORs are adjusted for age, sex, BMI and injury. Bold denotes statistical significance. – indicates analysis not performed due to small number of events (<5).
BMI, body mass index.

spine pain were greater, but shoulder pain lower, for Olympians when compared with the general population; and (5) the odds of shoulder OA after prior injury were higher for Olympians.

Lumbar spine OA and pain

The lumbar spine was one of the most common locations for self-reported physician-diagnosed OA (5.7% of Olympians), second only to knee OA,[1] and it was the most common location for current pain (19.3%), in the present study. Previous studies in retired athletes reported 29.3% experiencing lumbar spine pain in a multisport cohort of retired male Finnish athletes,[15] 10% of retired elite cricketers experiencing back OA and 14% back pain (thoracic and lumbar spine, combined),[8] and 4.6% of retired Olympians from Great Britain reporting lumbar spine OA and 32.8% lumbar spine pain.[9] Differences that exist between studies may be due to differing cohort ages, different classifications for location of OA and pain, for example, lumbar spine, back or spine, and recordable definitions for OA and pain, such as radiographic or self-reported physician-diagnosed OA, and pain of any duration vs ≥1 month. The lumbar spine is one of the most frequently injured body locations, presenting among the highest injury severity in current[16 17] and retired Olympians.[1 9] Significant joint injury is a risk factor for the development of OA at the knee and hip in football,[5 18 19] cervical spine OA in rugby,[7] and knee and hip OA in Olympic sport[4] retired cohorts. The present study adds to these findings confirming that lumbar spine injury and recurrent lumbar spine injury are associated with significantly greater odds of experiencing both OA and pain in the lumbar spine in retired Olympians.

Female sex was associated with greater odds of self-reported physician-diagnosed lumbar spine OA compared with men in both our retired Olympian cohort and the general population control. This is similar to previous findings in the general population,[20–22] where oestrogen deficiency in postmenopausal women has been reported to increase lumbar disc degeneration and degenerative spondylolisthesis, and increase lumbar spine pain.[23 24] Increasing age was also associated with greater odds of lumbar spine OA in retired Olympians; however, this pattern was not observed for lumbar spine pain with the odds of pain lower for those 60 years or older compared with earlier age. Decreased reporting of lumbar spine pain in older age is not new and a lack of association between lumbar spine OA and pain has been reported previously in the general population.[20 22 25] This particular phenomenon appears magnified however for Olympians whereby although lumbar spine pain was greater for Olympians compared with the general population in earlier age (20–39 years and 40–59 years), in older age (≥60 years) it was lower. The occurrence of decreased pain reporting is hypothesised to be due to mortality, depression, decreased pain perception/increased tolerance and cognitive impairment.[26–29] In addition, the tool used in the measurement of pain, such as the visual analogue scale used in the present, has been cited to influence reporting in older age.[29 30]

Overall, the prevalence and odds of lumbar spine pain were greater for Olympians compared with that observed in the general population, and there is evidence to suggest that prior injury is a risk factor for this association. For the present Olympian cohort, lumbar spine nerve injuries were reported to be most common, second only to knee ligament injuries,[11] and it seems the consequences of lumbar spine injury with respect to pain may be greater for Olympians compared with the general population. Obesity is a known risk factor for lumbar spine pain and in previous studies in the general population is linked to 1.5–2.5-fold increase in the likelihood of having back pain.[31 32] In line with these findings, the odds of experiencing lumbar spine pain were greater for overweight and obese retired Olympians. When comparing our current retired Olympian cohort with general population controls, their odds of experiencing lumbar spine pain with obesity were also significantly greater, meaning the influence of obesity on the occurrence of pain may be greater in retired Olympians.

Cervical spine OA and pain

The rate of cervical spine OA in Olympians was 2.3% and pain 6.9%, and, with the exception of cervical spine OA in female Olympians, the odds of OA and pain did not appear to differ between Olympians and the general population in our study. This is despite evidence suggesting that high-level sport may increase the risk of early cervical spine degeneration.[7 33 34] In retired professional male rugby players, Brauge and colleagues[7] found that half (50.5%) experienced current neck pain, with significantly higher rates of pain and radiographic reported cervical spine degenerative changes compared with the general population. In amateur male footballers, radiographic determined cervical spine degenerative changes were also reported to be more prominent in the veteran players compared with both current active players and a general population control.[34] While the age of these study cohorts was similar to the present study, differences may exist again due to the methods of reporting OA; and single, contact-sport cohorts, where recurrent sport-specific trauma has been linked to degenerative changes,[7 34] versus the present multisport cohort. In line with findings for other body joints in this study, prior significant cervical spine injury increased the likelihood of cervical spine OA and pain in retired Olympians. Hence, while it is has previously been suggested that injury is linked to degenerative changes, this is the first study to report a direct association.

Similar to the lumbar spine, increasing age was associated with increases in cervical spine OA, but conversely this pattern was not observed for cervical spine pain. Meaning the age-related influences on reporting of pain, in particular aged 60 years and older, and the disassociation between OA and pain, may also be present for cervical spine pain.[26–29] Female Olympians were more likely to experience cervical spine OA and pain compared with male Olympians, and have greater odds of cervical spine OA when compared with women in the general population. A higher prevalence of cervical spine degeneration and higher levels of pain in women than men have also been reported in the general population,[35 36] cited to be due to sex differences in structural degeneration as well as differences in physiological mechanisms such as the menopause.[23 35 36] It is unclear why cervical spine OA may be greater for female Olympians compared with the general population but overall, targeting prevention strategies towards injury prevention in particular in female athletes would seem prudent.

Shoulder OA and pain

The rate of shoulder OA in Olympians was 2.4% and pain 7.3%. While there was no difference observed in the odds of shoulder OA between Olympians and the general population, interestingly, the odds of shoulder pain were lower for Olympians by comparison. Similar to other joints, shoulder injury and recurrent shoulder injury were associated with greater odds of shoulder OA and shoulder pain in retired Olympians, and the odds of OA after prior shoulder injury were greater for retired Olympians when compared with the general population. With shoulder dislocation injuries reported to be predominant in the present Olympian cohort,[11] cartilage damage and ongoing instability cited as key factors in the development of OA will likely be contributing factors to these findings.

There are other limited data on pain and OA in the shoulder in retired elite athletes with one previous study in tennis reporting radiographic shoulder OA in retired players[37] and more recently a study on self-reported shoulder OA in retired cricketers.[8] In the retired tennis player study, OA changes were reported to be greater compared with control subjects, in contrast to the present study findings.[37] In current athletes, shoulder pain is common in sports such as swimming,[38 39] volleyball, handball,[40–42] and kayaking;[43] including in youth athletes.[44] Hence, while evidence on the long-term consequences is sparse, it is unsurprising that retired athletes continue to experience shoulder problems in later life when there is a wealth of evidence on the prevalence of shoulder pain and dysfunction in current athletes participating in high-load overhead sports.[40–42 45]

Strengths and limitations

There is increasing knowledge that OA and pain present a long-term health burden in elite athletes in later life and that this differs to what might be expected in the general population. Injury is seen as a key factor in its occurrence and presents an occupational risk for sports people for knee and hip OA and pain.[1 5] Previous studies have focused largely on single sports and joints of the lower limb and there is a paucity of research into retired elite athlete musculoskeletal health at the spine and none in the upper limb.[7 15] This study provides new evidence for specific factors associated with pain and OA across the lumbar spine and cervical spine, and shoulder in both retired male and female Olympians globally, with comparison with the general population.

There are a number of limitations to the present study. Individual sport nuances around joint pain and OA risk may be lost with results in the present study influenced by the homogeneous multisport cohort. However, with injury and recurrent injury-recurring risk factors for pain and OA across a number of joints, current sports injury epidemiology may act as a proxy to tell us which sports athletes may be at increased risk, and in which joints. It is also understood that pain and OA may be associated with different sport-specific factors such as shoulder or lumbar loading,[8 40 42 43 46–49] or contact mechanisms.[7] Hence, it can be anticipated that athletes participating in sports with these types of known loading may also be at increased risk. Some ORs were associated with wide CIs, meaning categories may be affected by sparse data. Categories with values less than 5 were not presented; however, there may still be limitations in the interpretability of some findings. There is a self-selection bias whereby Olympians with a history of significant injury may have been more motivated to participate in this study. In an effort to combat this, a participant prize draw was included to try to incentivise those less inclined to participate.[11] It was not known how many retired Olympians the survey reached and hence the true response rate is unknown, and the conclusions are limited to this sample.[11] An additional limitation of the present study may be the control group itself, and whether this is truly representative of the general population. While the reach of study promotion to the general population was wide geographically (with responses from across 73 countries), the present control cohort was recruited from WOA and IOC social media and as 'Olympian buddies'. It is possible therefore that this general population group was more interested and active in sport and exercise and conversely less sedentary than other comparison general population controls, which may explain some of the lack of difference observed between our two groups.

In combination with findings from part 1–the lower limb, results in this study could be used to provide direction on where to target primary injury prevention initiatives in current athletes. For example, injury prevention by sport, body joint and sex. Secondary injury prevention should focus on allowing sufficient recovery and full and proper rehabilitation from significant index injuries, in order to prevent recurrences.[50 51] For tertiary prevention initiatives, preventing OA and pain in retired athletes could include targeting those who have had significant prior injury in certain joints combined with overweight or obesity in later life. Initiatives could include weight reduction strategies, exercise interventions or a combination of both,[52–54] which have proven to be effective in reducing pain and symptomatic OA previously in the knee and also the lumbar spine, cervical spine and shoulder.[52–58]

CONCLUSIONS

In summary, the lumbar spine, cervical spine and shoulder were among the most common locations for current joint pain, and injury was associated with increased risk of both pain and OA in these joints in retired Olympians. Overall, the odds of OA did not differ between Olympians and controls; however, the odds of lumbar spine pain in Olympians were greater than that seen in the general population. These findings may be used to help inform prevention strategies in order to reduce the risk of OA and pain for both current and retired Olympians.

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