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Prevalence and factors associated with low back pain in retired Great Britain's Olympians: a cross-sectional study

Dale J Cooper[1], Mark E Batt[2], Mary S O'Hanlon[3], Debbie Palmer[4]

[1] School of Allied Health Professions, Keele University, Keele, Staffordshire, UK.

[2] Centre for Sport, Exercise and Osteoarthritis Research Versus Arthritis, Nottingham University Hospitals NHS Trust, Nottingham, UK.

[3] Academic Department of Orthopaedics, Trauma and Sports Medicine, Queen's Medical Centre, University of Nottingham, Nottingham, UK.

[4] Institute for Sport, PE and Health Sciences Moray House School of Education and Sport, University of Edinburgh, Edinburgh, UK.

1. **Corresponding Author:** Dale J Cooper, School of Allied Health Professions, Keele University, Keele, Staffordshire, UK. Email: d.cooper1@keele.ac.uk

ABSTRACT

This study determined the point prevalence and factors associated with low back pain (LBP) in retired Great Britain's (GB) Olympians. Six hundred and thirteen retired athletes completed a cross-sectional survey. Prevalence of LBP (pain on most days in the past 4-weeks) was 32.1%. LBP was associated with a prior significant low back injury [aOR 2.51; 95% CI, 1.60- 3.92, p<0.001] and a change from a healthy to a high BMI [aOR 2.21; 95% CI, 1.46-3.34, p<0.001]. Fewer cases of LBP were reported in those with a moderate training volume [aOR 0.29; 95% CI, 0.18-0.48, p<0.001] and those aged 75 years and older [aOR 0.51; 95% CI, 0.29-0.91, p=0.022]. Chronic LBP (symptoms past ≥ 12-weeks) was associated with a higher pain severity [aOR 1.18; 95% CI, 1.02-1.37. p=0.031], widespread pain [aOR 2.62; 95% CI, 1.15-5.99, p=0.022], anxiety (aOR 2.99; 95% CI, 1.14-7.80, p=0.025) and depression [aOR 2.47; 95% CI, 1.08-5.63, p=0.031]. LBP is common in retired GB Olympians. Chronic symptoms were associated with features of central sensitization and imply that different pain mechanisms are involved in those with persistent symptoms. Strategies to promote health among retired athletes should consider the importance of psychological factors in the management of back pain.

Keywords: Prevention, spine, pain, prevalence, risk factor, athlete.

1. INTRODUCTION

Low back pain (LBP) is a common disorder.(1) Most episodes recover quickly but it can become recurrent and persistent. In the general population, LBP is known to cause a considerable proportion of work absence,(2) and is associated with depression,(3) coronary heart disease,(4) reduced longevity,(5) and is a global cause of disability.(1) Sedentary people at greatest risk of LBP are those with physical and mental comorbidities, obesity, and physically demanding jobs that require frequent lifting, bending and twisting.(6)(7) Elite athletes are exposed to a high physical workload through competition and training and this has been linked to an increased risk of back pain.(8)(9) Despite this, there is limited knowledge about its impact on health across the lifespan of the athlete and there is insufficient evidence to determine the sports that pose the greatest risk.

Previous studies have shown that LBP in athletes is associated with a high training volume, spikes in training/competition, and a prior episode of LBP.(10) There is inconsistent evidence to demonstrate an association with increasing age and sex. Many potential risk factors require investigation including psychological factors such as anxiety and depression that may predispose athletes to persistent LBP.(11)(12) The gap in current evidence means that healthcare professionals, coaches and governing bodies have limited knowledge of how to mitigate the risks for LBP. Identifying risk factors for LBP in the retired athlete will help provide the basis for longitudinal follow-up and subsequent intervention studies. The aim of this study is to determine in retired Great Britain's (GB) Olympians aged 30 years and older the prevalence and factors associated with LBP.

2. MATERIAL AND METHODS

2.1 Research Ethics Approval

This study was approved by the University of Nottingham Research Ethics Committee (Ref: K13022014). All procedures involving research participants were in accordance with the ethical standards of the university institution review board. Participants received detailed information at the start of the questionnaire, detailing how data would be handled to ensure confidentiality and anonymity. It was made explicitly clear to participants that by completing and returning a questionnaire they gave implied consent for their data to be used anonymously for the purposes of this study.

2.2 Study Design

This cross-sectional study involved distributing a letter by post or email inviting GB Olympians the opportunity to complete and return a postal questionnaire or the option of completing an online version. The questionnaire was distributed to current and retired athletes registered on the BOA database. Recruitment took place between May 2014 and April 2015 and involved distributing the questionnaire to those living in the UK and overseas. Two email reminders and one postal reminder were sent to non-responders between August 2014 and April 2015. The second phase of recruitment involved the BOA Athlete's Commission distributing copies of the questionnaire to GB Olympians at their request. All questionnaires were returned by December 2016. For the present study, we excluded responses from those who were training to quality for or compete at an upcoming Olympic Games and/or were aged less than 30 years.

2.3 Data Collection and Management

The questionnaire collected data on demographics, medical history, musculoskeletal health, and career details.(13)(14) Baseline questions captured self-report information on age (years), sex, height (cm), weight (kg), and ethnicity. A composite measure of body mass index (BMI) was calculated from Olympic career (t_o) and current (t_1) BMI (kg/m^2). Data was coded using World Health Organisation BMI categories into: 1) $t_1 \leq 24.9$ kg/m^2 (reference standard); 2) $t_o \leq 24.9$ and $t_1 \geq 25.0$; and 3) t_0 and t_1 remained ≥ 25.0. Sport participation included the frequency and duration for the period of training and competition leading up to their first Olympic Games until retirement from their last Olympic Games. A mean annual volume of training during the participants Olympic career was categorised according to 0-199 hr, 200-399 hr, 400-549 hr, 550-699 hr, and ≥ 700 hours.(9) The sporting discipline in which participants spent the longest time competing in at the Olympic Games was dichotomised into sports with and without specific back loading.(9) The history of a significant low back injury was determined by asking participants: "have you ever sustained a significant low back injury that caused pain for most days during a one-month period and for which you consulted a medical professional or a health provider such as a general practitioner?" Injury data was collected in line with International Olympic Committee injury surveillance methods.(15)(16)(17) For the present study we examined injuries to the lower back that occurred during training for, and/or competition, as part of the athletes Olympic-career. Non-sporting occupations were classified according to high or low risk groups.(18) Joint flexibility was determined by self-examination using a validated line drawing instrument of the modified 9-point Beighton score.(19) A cut-off threshold of equal to or greater than 4 out of 9 was used to denote generalised joint hypermobility.(20) A 100mm visual analogue scale was used to rate current back pain intensity from no pain (0 mm) to unbearable pain (100 mm). Widespread pain was recorded if an individual had greater than or equal to 7 out of 19 regions on the Widespread Pain Index.(21) A cutoff point of 45.6 on the Short Form-12 Mental Health Composite Scale was used to screen for 30-day depressive disorders.(22)

2.4 Outcome Measures

The questionnaire incorporated a standardised back pain question: ‘have you had low back pain on most days in the past 4-weeks’.(23) This was repeated for ‘low back pain on most days in the past 12-weeks’. Pain from feverish illness or menstruation were excluded. Pain was included if lasting 4-weeks or longer to avoid trivial bouts of pain. Participants were also asked to self-report the location of their back pain and other bodily pain on a body manikin.(24) Low back pain on the manikin was defined as the area on the posterior aspect of the body from the lower margin of the twelfth ribs to the lower gluteal folds (+/-pain referred into one or both lower limbs).(23)(25) The point prevalence of LBP was stratified according to: subacute (SLBP; 4-weeks to less than 12-weeks), and chronic (CLBP; 12-weeks or more).(26)

2.5 Power Calculation

A power calculation was estimated using nQuery and was based on an estimated 30% LBP prevalence from published data.(9)(27) With the assumption of a 30% response rate, assuming all exposures could at least be dichotomised into binary variables and assuming a ratio of exposed to unexposed individuals of 1:1 for any given risk factor, the study had at least 80% power to detect odds ratios of 1.75 or greater at 5% significance.

2.6 Statistical Analysis

Statistical analyses were conducted within SPSS 25.0 (SPSS Inc., Chicago, IL, USA). For each potential risk factor, descriptive statistics are presented as frequencies (proportion) for categorical variables, and for numerical variables data are presented with the mean and standard deviation, or median and range where data are not normally distributed. Crude and adjusted odds ratios with 95% confidence intervals were estimated in binary logistic regression for potential factors and outcomes of low back pain. The univariable model is presented and was adjusted for a priori confounders of age, sex, and BMI. Continuous independent variables that were non-linear were categorized. Missing values were excluded from the analysis.

3. RESULTS

3.1 Recruitment

The questionnaire was distributed to 2742 current and retired athletes registered on the BOA Olympian database. Of the 743 who replied (27.1% response rate), 613 were retired and aged 30 years or older and had data for the prevalence analysis of LBP. The research team did not have consent to access personal details of non-responders on the database. This permits us from providing the response rate from the total number of retired GB Olympians.

3.2 Olympic Athletes Characteristics

Table 1 presents the characteristics of the participants who replied to the questionnaire. The median BMI was 24.3 kg/m^2 with 1.1% being classed as underweight, 62.2% normal, 27.4% overweight, and 9.3% obese. All participants had retired from Olympic sport, 65 had competed in 11 sports at the Winter Olympics: and 548 had competed in 26 sports at the Summer Olympics (Appendix A, Supplementary Table).

TABLE 1 INSERT

3.3 Prevalence

The point prevalence of LBP was 32.1% (10.1% subacute; 22.0% chronic) and was similar between sexes (males 31.5%; females 33.1%). 9.6% of females and 10.5% of males reported SLBP, compared to 23.5% of females and 21.0% of males reporting CLBP. The prevalence of CLBP peaked in males and females between ages 60-69 years (Figure 1). Of the sports with a minimum of 15 participants, the point prevalence of LBP was highest in sailing, field athletics, and gymnastics, and lowest in fencing (Appendix A, Supplementary Table). The odds of LBP were greater in throwing events (javelin, hammer, discus, shot put) (OR 3.04; 95% CI, 1.19-7.73, p=0.02) compared to athletics (track and road).

INSERT FIGURE 1

3.4 Risk Factors

After adjustment (age, BMI and sex), LBP was associated with a history of significant low back injury, and a change from a healthy BMI ($\leq$ 24.9 kg/m^2) to a high BMI ($\geq$ 25.0 kg/m^2) following retirement from Olympic sport, whereas fewer cases of LBP were reported in those with a moderate training volume of 400-549 hours/year and in those aged 75 years and older (Table 2). We then compared participants with symptoms of CLBP compared to SLBP to determine if those with CLBP were more likely to report current symptoms of depression, anxiety, a higher pain intensity, and widespread pain (Table 3). After adjustment CLBP was associated with a 10 mm increase in pain severity, widespread pain, anxiety, and depression.

TABLE 2 INSERT

TABLE 3 INSERT

4. DISCUSSION

The aim of this study were to determine in retired Great Britain's (GB) Olympians aged 30 years and older the prevalence and factors associated with LBP. The present study found that: (i) LBP is common in retired GB Olympians aged 30 years and older; that (ii) a previous significant low back injury and a change in BMI from $\leq$ 24.9 kg/m^2 to $\geq$ 25.0 kg/m^2 was associated with LBP; that (iii) LBP was less common in those aged 75 years and older and there was a U-shaped curve with fewer cases in those with a moderate annual training load; that (iv) sex, high risk occupation, comorbidities, trunk flexion, hypermobility, and Olympic sport exposure (hours/years) were not detected to be associated with LBP; and that (v) chronic symptoms of LBP were associated with a 10 mm increase in pain severity, widespread pain, anxiety and depression. It remains unclear if sports that involve repetitive twisting and bending are associated with LBP in retired athletes.

The present study found a LBP point prevalence of 32.1% (10.1% subacute; 22.0% chronic). The low back was the most commonly affected area and this was identical for retired athletes in each sporting discipline, sex and age groups. Our findings accord to those reported in cross-country skiers,(28) and elite German athletes(29)(8) that found the low back was the most commonly affected area of pain. Comparison of LBP prevalence rates with other studies is impractical because of different LBP definitions and participant numbers.

The relationship between sex and LBP prevalence in athletes is inconsistent.(10) The present study found no association between LBP and sex in retired athletes despite females in the general population being more likely to report LBP and chronic symptoms.(30)(27)(31)(32) Higher physical activity levels seen in our female study population may have an inverse proportional relationship with the prevalence of LBP. Further studies are required to confirm this and to determine if musculoskeletal core conditioning and bone health in elite female athletes reduces the risk of LBP associated with pregnancy(33) and menopause,(34) compared with less active females living in the community.

Previous studies in sport have demonstrated increasing age was associated with a higher lifetime prevalence of back pain in 1114 German elite athletes,(8) and a greater likelihood of developing LBP among 76 international elite rowers.(35) Our study population examined retired athletes in a much wider age range and found the point prevalence of LBP was less common in those aged 75 years and older. A similar decline in the prevalence of LBP was found in the general population and thought to stem from mortality and underreporting of pain in the elderly and this may extend to our population.(36)

A recent review demonstrated an inconsistent relationship between LBP and BMI in athletes.(10) The use of univariable analysis in previous studies may account for this inconsistency. Our study used a more rigorous multivariable analysis and confirmed that a change from a healthy BMI to a high BMI following retirement from sport was associated with LBP after adjustment for a priori confounders. This accords to previous studies in the general population that have demonstrated those with a higher BMI are more likely to complain of back pain, with structural body weight having a biomechanical effect, and the spine being placed under increased mechanical stress.(37)

There is inconsistent evidence to support whether training volume is a risk factor for LBP in sport; with studies demonstrating no trend between training volume and LBP prevalence and intensity,(9)(29) whereas other studies have confirmed a positive relationship.(35)(38)(39) In the general population, both inactivity and excessive physical activity presents an increased risk for back pain, according to the U-shaped exposure-response curve.(40) Our study extends this knowledge by providing evidence that the relation between training volume and LBP in elite retired athletes is U-shaped with a medium training volume (400-549 hours/year) aligned to a lower prevalence of LBP. These findings require confirmation in a longitudinal study and have implications for monitoring the dose of sport exposure in the management and prevention of LBP in the elite athlete.

Previous studies have investigated LBP and the loading characteristics associated with different sports and found it was no more common among cross-country skiers and rowers than orienteers and nonathletic controls.(9) Elite athletes from badminton, beach volleyball, handball, tennis and volleyball who engaged in repetitive overhead activities were not more likely to complain of back pain than active controls.(38) The present study extends this knowledge and found no difference in LBP prevalence and participants from sports with and without specific back loading or overhead activities. However, when we investigated participants with overhead throwing activities from field athletics they were more likely to report LBP. The repetitive axial loading type movements of field athletes is believed to contribute to their greater prevalence of LBP. The different types of loading patterns that individual Olympic sports place on the spine require investigation in a much larger population of retired athletes from other National Olympic Committees.

The present study found a prior significant low back injury was the dominant factor associated with LBP. Intervertebral disc injury, fracture, and overload injuries were more common in those with LBP. Our findings illustrate the importance of injury prevention strategies in reducing the number of spinal injuries during the athlete’s career in order to mitigate the long-term sequelae of LBP. Our analysis revealed no association between hypermobility and lumbar spine flexion range of movement with LBP. Our findings do not support reports that athletes with lower extremity ligamentous laxity are reported to be at greater risk of LBP,(41) or that a lower segment range of motion at the lumbar spine is thought to be a predictor of back pain,(42) and this may be due to superior core control in elite athletes. The present study found no association between back pain and comorbidities or high-risk non-sporting occupation.

In our study population, the factors associated with LBP differed after stratifying for those with and without chronic symptoms. Chronic LBP was associated with features of central sensitization including anxiety, depression, a higher pain severity, and widespread pain. These features imply that different pain mechanisms are involved in those with chronic LBP and that psychological factors play a significant role in chronic low back pain among retired GB Olympians. In the general population, depression can influence pain perception,(43) and have an adverse effect on the prognosis of LBP and this may extend to our population.(44) Strategies to promote health in retirement in elite athletes should consider the importance of psychological factors.

There are several caveats to this study. Firstly, we asked participants to recall medical and training history during their Olympic careers and the presence of current LBP. The use of self-report questionnaire data is subject to recall bias. Secondly, those with health problems may have been more likely to respond to the questionnaire compared to those without and despite inviting all participants on the BOA Olympian database to participate in this study – there is a possibility of recruitment bias. Thirdly, we have a limited number of participants from some team sports and our results may not reflect sports pursued by retired athletes from other National Olympic Committees. Fourth, the cross-sectional study design does not allow for direct causal inferences to be made. However, our results are in line with published literature in the general population. Nevertheless, a longitudinal prospective follow-up study in current athletes and across their lifespan is required in order to establish causality. Lastly, we cannot account for all confounders.

5. CONCLUSION

Our study confirmed that LBP is common in retired GB Olympians. Several factors were detected to be associated with LBP including a prior significant low back injury, a high training load and a change from a healthy to high BMI. Prominent factors associated with chronic LBP included high pain intensity, widespread pain, depression and anxiety. A longitudinal study is required to determine if psychological factors predispose the athlete to persistent symptoms. Our findings imply that a more biopsychosocial management approach should be considered in the management of LBP in retired Olympic athletes.

6. PERSPECTIVES

LBP in retired GB Olympians was associated with a history of a significant low back injury, extremes of training volume, and a change from a healthy to a high BMI following retirement from sport. Injury prevention strategies are required to reduce the number of spinal injuries during the athlete's career and to mitigate the long-term sequelae of LBP. Medical staff, coaches, and policy makers should encourage the monitoring of training load during the athlete's career and educate the athlete of the benefits of maintaining a healthy BMI following retirement from Olympic sport. After stratification, the factors associated with LBP differed – chronic LBP was associated with features of central sensitization including anxiety, depression, a higher pain severity, and widespread pain - and imply that different pain mechanisms are involved in those with persistent symptoms. Strategies to promote health among retired athletes should consider the importance of psychological factors in the management of low back pain.

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AUTHOR'S CONTRIBUTIONS: DJC conceived and contributed to the design of the study, distributed the survey, collected, analysed and interpreted the data, and drafted the manuscript. MEB assisted with the conception of the study, with accessing the study participants, with the distribution of the survey and with the interpretation of the data. MEB critically revised the manuscript and gave final approval of the version to be published. MO assisted with the analysis and interpretation of the data. MO critically revised the manuscript and gave final approval of the version to be published. DP assisted with the conception of the study, with the distribution of the survey, with the interpretation of the data. DP critically revised the manuscript and gave final approval of the version to be published. All authors read and approved the final manuscript.

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Table 1: Comparison of characteristics of male and female retired Great Britain's Olympic athletes (n=613)

	All (n=613)		Female (n=251)		Male (n=362)		P Values
Anthropometrics:							
Age (years), median (range)	62	30-97	54	30-93	66.5	30-97	**<0.001**
Height (cm), median (range)	175.3	144.8-205.0	168.5	144.8-198.1	180.3	147.3-205.0	**<0.001**
Weight (kg), median (range)	75.0	45.0-133.0	65.3	45.0-123.8	82.0	51.7-133.0	**<0.001**
BMI (kg/m^2), median (range)	24.3	18.0-43.9	22.8	18.0-43.9	24.9	18.0-38.4	**<0.001**
BMI during career (kg/m^2), median (range)	22.7	16.0-34.9	21.3	16.0-32.9	23.4	16.8-34.9	**<0.001**
Ethnicity (White British), n (%)	588	95.9	240	95.6	348	96.1	0.751
Sport exposure:							
Athletes by summer Olympic sport, n (%)	548	89.4	228	90.8	320	88.4	0.335
Number of national / international years doing Olympic sport, median (range)	9	1-38	9	1-38	8	1-37	**0.029**
Number of years retired from Olympic participation, median (range)	34	1-75	27	1-75	37	1-66	0.103
Health factors:							
Physician-diagnosed low back OA, n	29	4.7	20	8.0	9	2.5	**0.002**

(%)							
Neck pain (most days of the past 4-weeks), n (%)	57	9.3	25	10.0	32	8.8	0.639
Spinal injection to compete / train, n (%)	25	4.1	9	3.6	16	4.4	0.837
Spinal surgery, n (%)	57	9.3	24	9.6	33	9.1	0.853
Current NSAIDs, n (%)	21	3.4	10	4.0	11	3.0	0.527
Current OTC Painkillers, n (%)	27	4.4	11	4.4	16	4.4	0.979
Current LBP, n (%)	197	32.1	83	33.1	114	31.5	0.681

The p values represent comparison between male and female retired athletes, using unpaired t-test for continuous variables, or Mann-Whitney where appropriate, and categorical variables were analysed using X^2. Statistically significant differences are highlighted in bold. National/International: data are presented as median and range, or as proportions (%).

Table 2: Factors for and the point prevalence of low back pain (n=613)

Risk Factors	Prevalence (%)	Odds Ratio (95% Confidence Interval)			
		Crude	Adjusted 1	Adjusted 2	Adjusted 3
Age (Years)					
30-44	38/94 (40.4)	1	-	1	1
45-59	62/192 (32.3)	0.70 (0.42, 1.17)	-	0.68 (0.40, 1.13)	0.68 (0.40, 1.14)
60-74	59/184 (32.1)	0.70 (0.42, 1.16)	-	0.66 (0.39, 1.12)	0.68 (0.40, 1.15)
≧ 75	38/143 (26.6)	**0.53 (0.31, 0.93) ***	-	**0.50 (0.28, 0.87) ***	**0.51 (0.29, 0.91) ***
Change in BMI Kg/m^2					
Normal ≤ 24.9	108/388 (27.8)	1	1	1	1
Increased ≥ 25.0	60/134 (44.8)	**2.10 (1.40, 3.16) *****	**2.18 (1.45, 3.28) *****	-	**2.21 (1.46, 3.34) *****
Remained ≥ 25.0	29/91 (31.9)	1.21 (0.74, 1.99)	1.25 (0.76, 2.06)	-	1.28 (0.77, 2.13)
Sex (Female)	83/251 (33.1)	1.08 (0.76, 1.52)	0.99 (0.69, 1.41)	1.09 (0.75, 1.58)	-
High-risk occupation	17/69 (24.6)	0.66 (0.37, 1.17)	0.69 (0.38, 1.23)	0.66 (0.36, 1.20)	0.67 (0.37, 1.21)
History of a significant low back injury	52/104 (50.0)	**2.54 (1.65, 3.91) *****	**2.45 (1.58, 3.79) *****	**2.48 (1.59, 3.85) *****	**2.51 (1.60, 3.92) *****
High risk sport					
Non-loading	60/204 (29.4)	1	1	1	1
Loading	137/409 (33.5)	1.21 (0.84, 1.74)	1.20 (0.83, 1.73)	1.15 (0.80, 1.67)	1.17 (0.80, 1.69)
Beighton ≧ 4/9	23/76 (30.3)	0.85 (0.50, 1.44)	0.78 (0.45, 1.33)	0.74 (0.43, 1.29)	0.74 (0.42, 1.28)
Finger-tip-floor	36/113 (31.9)	0.95 (0.61, 1.47)	0.92 (0.59, 1.43)	0.94 (0.60, 1.48)	0.95 (0.61, 1.49)

Total exposure (training/competition Olympic career hours)					
0-999	54/171 (31.6)	1	1	1	1
1000-5999	36/134 (26.9)	0.80 (0.48, 1.31)	0.81 (0.49, 1.34)	0.91 (0.54, 1.51)	0.91 (0.54, 1.51)
6000-10999	46/130 (35.4)	1.19 (0.73, 1.92)	1.14 (0.69, 1.86)	1.20 (0.73, 1.98)	1.20 (0.73, 1.97)
≥ 11000	61/178 (34.3)	1.13 (0.72, 1.77)	1.01 (0.63, 1.62)	1.08 (0.67, 1.74)	1.08 (0.67, 1.74)
Mean annual volume of training during the participants Olympic career (hours/year)					
0-199	107/262 (40.8)	1	1	1	1
200-399	19/60 (31.7)	0.67 (0.37, 1.22)	0.65 (0.36, 1.18)	0.61 (0.33, 1.14)	0.61 (0.33, 1.14)
400-549	26/153 (17.0)	**0.30 (0.18, 0.48)** ***	**0.29 (0.18, 0.48)** ***	**0.30 (0.18, 0.49)** ***	**0.29 (0.18, 0.48)** ***
550-699	20/64 (31.3)	0.66 (0.37, 1.18)	0.64 (0.35, 1.16)	0.67 (0.37, 1.23)	0.67 (0.37, 1.23)
≥ 700	25/60 (41.7)	1.04 (0.59, 1.83)	0.81 (0.44, 1.52)	0.82 (0.43, 1.54)	0.81 (0.43, 1.54)
Widespread pain	50/148 (33.8)	1.10 (0.75, 1.64)	1.16 (0.78, 1.73)	1.15 (0.76, 1.73)	1.15 (0.76, 1.72)
Anxiety	38/106 (35.8)	1.22 (0.79, 1.90)	1.22 (0.78, 1.89)	1.25 (0.80, 1.95)	1.24 (0.79, 1.94)
Depression	48/125 (38.4)	1.42 (0.94, 2.13)	1.45 (0.96, 2.20)	1.47 (0.97, 2.24)	1.49 (0.98, 2.26)
Comorbidities:					
No	75/231 (32.5)	1	1	1	1
1	60/209 (28.7)	0.84 (0.56, 1.26)	0.91 (0.60, 1.38)	0.88 (0.58, 1.34)	0.88 (0.58, 1.35)
2 or more	62/173 (35.8)	1.16 (0.77, 1.76)	1.47 (0.93, 2.32)	1.37 (0.86, 2.18)	1.37 (0.86, 2.18)

Adjusted 1: OR was adjusted for age

Adjusted 2: OR was adjusted for age, and BMI

Adjusted 3: OR was adjusted for age, BMI, and Sex

*p<0.05, **p<0.01, ***p<0.001.

Table 3: Factors for and the point prevalence of chronic low back pain (n=197)

		Odds Ratio (95% Confidence Interval)			
Risk Factors	Prevalence (%)	Crude	Adjusted 1	Adjusted 2	Adjusted 3
Age (Years)					
30-44	22/38 (57.9)	1	-	1	1
45-59	43/62 (69.4)	1.65 (0.71, 3.81)	-	1.74 (0.75, 4.08)	1.76 (0.75, 4.11)
60-74	41/59 (69.5)	1.66 (0.71, 3.87)	-	1.73 (0.73, 4.07)	1.82 (0.76, 4.35)
≧ 75	29/38 (76.3)	2.34 (0.87, 6.29)	-	2.49 (0.92, 6.75)	2.53 (0.93, 6.90)
Change in BMI Kg/m^2					
Normal ≤ 24.9	76/108 (70.4)	1	1	1	1
Increased ≥ 25.00	38/60 (63.3)	0.73 (0.37, 1.42)	0.67 (0.34, 1.33)	-	0.71 (0.35, 1.41)
Remained ≥ 25.00	21/29 (72.4)	1.11 (0.44, 2.75)	1.04 (0.41, 2.63)	-	1.15 (0.44, 3.00)
Sex (Female)	59/83 (71.1)	1.23 (0.67, 2.27)	1.31 (0.69, 2.45)	1.29 (0.66, 2.49)	-
High-risk occupation	12/17 (70.6)	1.07 (0.36, 3.19)	0.98 (0.32, 3.00)	0.90 (0.29, 2.77)	0.94 (0.30, 2.92)
History of a significant low back injury	37/52 (71.2)	1.23 (0.62, 2.48)	1.23 (0.60, 2.50)	1.22 (0.60, 2.49)	1.19 (0.58, 2.44)
High risk sport					
Non-loading	39/60 (65.0)	1	1	1	1
Loading	96/137 (70.1)	1.26 (0.66, 2.40)	1.42 (0.73, 2.75)	1.46 (0.75, 2.85)	1.47 (0.75, 2.87)
Beighton ≧ 4/9	17/23 (73.9)	1.35 (0.50, 3.63)	1.41 (0.51, 3.87)	1.46 (0.53, 4.02)	1.43 (0.52, 3.98)
Finger-tip-floor	23/36 (63.9)	0.79 (0.37, 1.68)	0.79 (0.37, 1.71)	0.77 (0.36, 1.66)	0.78 (0.36, 1.69)

Total Exposure (Training / competition Olympic career hours)					
0-999	41/54 (75.9)	1	1	1	1
1000-5999	22/36 (66.1)	0.50 (0.20, 1.25)	0.44 (0.17, 1.12)	0.39 (0.15, 1.01)	0.39 (0.15, 1.01)
6000-10999	33/46 (71.7)	0.81 (0.33, 1.97)	0.80 (0.32, 2.01)	0.80 (0.32, 2.02)	0.79 (0.32, 2.00)
≥ 11000	39/61 (63.9)	0.56 (0.25, 1.27)	0.61 (0.27, 1.41)	0.60 (0.26, 1.38)	0.59 (0.25, 1.36)
Mean annual volume of training during the participants Olympic career (hours/year)					
0-199	74/107 (69.2)	1	1	1	1
200-399	14/19 (73.7)	1.21 (0.40, 3.65)	1.23 (0.41, 3.73)	1.26 (0.41, 3.84)	1.25 (0.41, 3.81)
400-549	18/26 (69.2)	0.97 (0.38, 2.47)	0.95 (0.36, 2.48)	0.95 (0.36, 2.48)	0.91 (0.34, 2.40)
550-699	15/20 (75.0)	1.30 (0.44, 3.87)	1.37 (0.45, 4.21)	1.30 (0.42, 4.03)	1.25 (0.40, 3.90)
≥ 700	14/25 (56.0)	0.55 (0.23, 1.34)	0.69 (0.26, 1.81)	0.70 (0.26, 1.86)	0.68 (0.25, 1.81)
Pain severity (VAS)	4.43 ± 2.26	**1.17 (1.01, 1.35) ***	**1.16 (1.01, 1.35) ***	**1.18 (1.02, 1.37) ***	**1.18 (1.02, 1.37) ***
Widespread pain	41/50 (82.0)	**2.57 (1.16, 5.70) ***	**2.71 (1.20, 6.08) ***	**2.68 (1.19, 6.04) ***	**2.62 (1.15, 5.99) ***
Anxiety	32/38 (84.2)	**2.90 (1.14, 7.35) ***	**3.09 (1.20, 8.00) ***	**3.03 (1.16, 7.90) ***	**2.99 (1.14, 7.80) ***
Depression	39/48 (81.3)	**2.39 (1.08, 5.32) ***	**2.47 (1.09, 5.58) ***	**2.38 (1.05, 5.41) ***	**2.47 (1.08, 5.63) ***
Comorbidities:					
No	48/75 (64.0)	1	1	1	1
1	41/60 (68.3)	1.21 (0.59, 2.49)	1.12 (0.54, 2.33)	1.10 (0.53, 2.30)	1.11 (0.53, 2.33)
2 or more	46/62 (74.2)	1.62 (0.77, 3.39)	1.37 (0.61, 3.07)	1.40 (0.62, 3.17)	1.37 (0.61, 3.11)

Adjusted 1: OR was adjusted for age

Adjusted 2: OR was adjusted for age, and BMI

Adjusted 3: OR was adjusted for age, BMI, and Sex

*$p<0.05$, **$p<0.01$, ***$p<0.001$.

FIGURE CAPTIONS

Figure 1. The point prevalence of chronic low back pain by sex and age categories in retired Great Britain's Olympians.