HIP AND KNEE REPLACEMENT AS A PROXY MEASURE FOR LOWER LIMB OSTEOARTHRITIS IN SCOTTISH MILITARY VETERANS

Short running title: Hip and knee replacement in veterans

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ABSTRACT

Introduction

Physical activity is an important component of military training. Although injuries and musculoskeletal disorders are the commonest cause of medical retirement from the Armed Forces, the long-term risk of lower limb osteoarthritis in veterans is unknown. We used data on hip and knee replacement in Scottish military veterans as a proxy measure.

Methods

Retrospective cohort study of 78,000 veterans born between 1945 and 1995 and a comparison group of 253,000 non-veterans, matched for age, sex and area of residence, followed up for up to 37 years, using survival analysis to examine the risk of hip and knee replacement.

Results

Veterans were significantly less likely to undergo hip replacement than non-veterans, Cox proportional hazard ratio (HR) 0.87, 95% confidence intervals (CI) 0.80-0.95, $p<0.001$. There was no significant difference between veterans and non-veterans in respect of knee replacement, HR 1.02, 95% CI 0.94-1.11, $p=0.643$, and there was no difference in the ages at which veterans and non-veterans underwent joint replacement. People who had served for longest in the military had similar risk to those with the shortest service.

Conclusions

Based on the likelihood of undergoing joint replacement surgery in later life, we found no evidence of a positive association between military service and an increased risk of lower limb osteoarthritis.

KEY MESSAGES

Military training is physically demanding by necessity, and injuries and musculoskeletal disorders are the commonest causes of medical retirement from military service.

No previous UK research has explored whether this results in an increased risk of osteoarthritis in veterans in later life.

This study used joint replacement surgery as a proxy measure for osteoarthritis of the hip and knee, comparing veterans with matched people with no record of military service.

There was no difference in risk of knee replacement between veterans and non-veterans, the risk of hip replacement was lower in veterans, and the risk of joint replacement was independent of length of service, indicating that military service is not a specific risk factor for lower limb osteoarthritis.

It is valid to use data from the wider community as a basis for planning services and support for veterans with osteoarthritis-related mobility problems.

INTRODUCTION

Military training necessarily involves intensive physical activity, and participation in competitive contact sport is encouraged. Musculoskeletal disorders and injuries are the commonest cause of discharge or retirement from the Armed Forces for medical reasons, accounting for nearly two-thirds of all medical discharges, and this pattern has changed little over many years.(1, 2) The predominant underlying conditions are injuries and disorders of the knee, ankle and foot, and back pain, but the long-term sequelae are unknown. With an estimated 36,500 people having been medically discharged from service between 1991 and 2014,(3) and more in previous years when the Armed Forces were larger,(4) there is the potential for a substantial impact on veterans' health, especially in the longer term when mobility and independence may be affected.

Traumatic injury is a risk factor for the later development of osteoarthritis, which has been reported to be more common among US veterans than non-veterans in a questionnaire-based study of self-reported doctor-diagnosed arthritis, (5) although a later questionnaire-based study reported no overall difference.(6) It is therefore possible that the risk of osteoarthritis, especially affecting the joints of the lower limb, is increased in UK veterans, and might be expected to be higher in people who had served for longer. Other risk factors include obesity, biomechanics, bone density, nutritional status and genetic factors.(7-9) Osteoarthritis and other musculoskeletal conditions are common in the general population, but no studies have examined whether UK veterans are at increased risk of these disorders in comparison with people who have never served.

The predominant symptoms of osteoarthritis are pain, stiffness and loss of function.(10)

Assessing the prevalence of musculoskeletal disorders in the veteran community is

problematic as there is no single overarching measure, notwithstanding that mobility and pain are important components of needs assessment for the provision of welfare services to veterans. The ability to purchase anti-inflammatory medications without prescription in the UK means that community prescribing databases will not cover the many people who self-medicate. Also, since many of the drugs used are not specific to musculoskeletal disorders, the prescribing data that are available are unreliable for this purpose.

Using data from the Trends in Scottish Veterans' Health study, a large national retrospective cohort study, we examined hip replacement and knee replacement as proxy measures of more severe musculoskeletal disorder potentially affecting mobility and quality of life, allowing risk in veterans and non-veterans to be compared.

METHODS

Trends in Scottish Veterans' Health is a retrospective cohort study of 78,385 military veterans resident in Scotland who were born between 1 January 1945 and 31 December 1995, and a comparison group of 252,637 individuals with no record of service matched 3:1 for age, sex and postcode sector of residence (mean population 5,000). Veterans were eligible for inclusion if they were registered with National Health Service (NHS) Scotland both pre- and post-service. The cohort, which comprises a 100% sample of all eligible veterans identified from the NHS Scotland central database, is an extension of the Scottish Veterans Health Study, which used similar methodology and is fully described elsewhere.(11) Demographic data obtained from electronic NHS registration records were linked at an individual level to routine hospital admissions data (Scottish Morbidity Record SMR01), including the Office of Population Censuses and Statistics (OPCS) surgical procedure codes, to provide information on all recorded occurrences of hip or knee replacement. Individual-level prescribing data were obtained from the NHS Prescribing Information System for a limited range of drugs including analgesics. Dates of entering and leaving the Service, for veterans, were obtained from the Scottish NHS registration record; subtracting date of joining from date of leaving provided data on length of service. The maximum period of follow-up was from 1 January 1981 (or date of leaving the Armed Forces, for veterans, if later) to 31 December 2017. The data extract was pseudo-anonymised and approval for the study was granted by the Public Benefit and Privacy Panel of the Information Services Division of NHS Scotland. As this was a secondary data study, individual consent was not required.

Socio-economic status

An area-measure of socio-economic status (SES) was provided by the Scottish Index of Multiple Deprivation (SIMD), which is based on 6,505 datazones with a mean population of 800, derived from postcode of residence. Deprivation status is calculated from information on income, employment, health, education (including skills and training), housing, crime, and access to services. The SIMD has been used to derive quintiles of SES for the Scottish population; ranging from 1 (most deprived) to 5 (least deprived).(12) The cohort participants were categorised according to these quintiles using their postcode of residence.

Statistical methods

For the purposes of the study, hip replacement was defined as the occurrence of any of the OPCS-4 codes for primary total hip replacement (W37-W39 or W93-W95 and their subcodes), or OPCS-3 code 810 (total hip replacement), and knee replacement was defined as the occurrence of any of the OPCS-4 codes for primary total knee replacement (O18 or W40-W42 and their subcodes), or OPCS-3 code 812 (arthroplasty of knee). Only the first recorded replacement of hip or knee joint was included in the study in order to avoid double counting in cases of revision or bilateral replacement. Cox proportional hazard models were used to examine the association between veteran status and cumulative risk of hip and knee replacement, overall and by subgroup, using age as the time dependent variable, age at first record of joint replacement as the failure time, and death (if no joint replacement) as the censor time. A landmark age of 45 years was used to maximise the likelihood of capturing joint replacement due to osteoarthritis, in line with the National Institute for Health and Care Excellence (NICE) diagnostic criteria for osteoarthritis. Hazard ratios and p values were calculated and the *a priori* rejection level was set at 0.05. Proportionality was tested using

methodology based on Schoenfeld residuals.(13) The models were run univariably and then repeated adjusting for the potential confounding effect of SES. The analyses were repeated stratifying by 5-year bands of birth year, to examine birth cohort effects, and stratifying by length of service in categories reflecting common lengths of military engagement. The use of prescribed analgesic medication prior to undergoing surgery was examined using odds ratios. The likelihood ratio test was used to examine potential interactions. All analyses were performed using Stata® v.16 (StataCorp LLC).

RESULTS

After data cleansing to remove incomplete and invalid records, 78,157 (99.7%) veterans and 252,637 (100.0%) non-veterans were included in the analysis. The dataset included 7,573 (9.7%) women veterans, reflecting the gender balance of the Armed Forces, and 28,983 (11.5%) non-veteran women. Health outcome data were available for a total of 10,643,252 person-years of follow-up.

Overall

Hip replacement

During the period of follow-up, 877 (1.12%) veterans and 3089 (1.22%) non-veterans underwent a first hip replacement. Veterans were statistically significantly less likely to undergo hip replacement than non-veterans, Cox proportional hazard ratio (HR) 0.87, 95% confidence intervals (CI) 0.80-0.95, p<0.001 (Figure 1a) based on a landmark age of 45 years. The hazard ratio was unchanged after adjusting for SES.

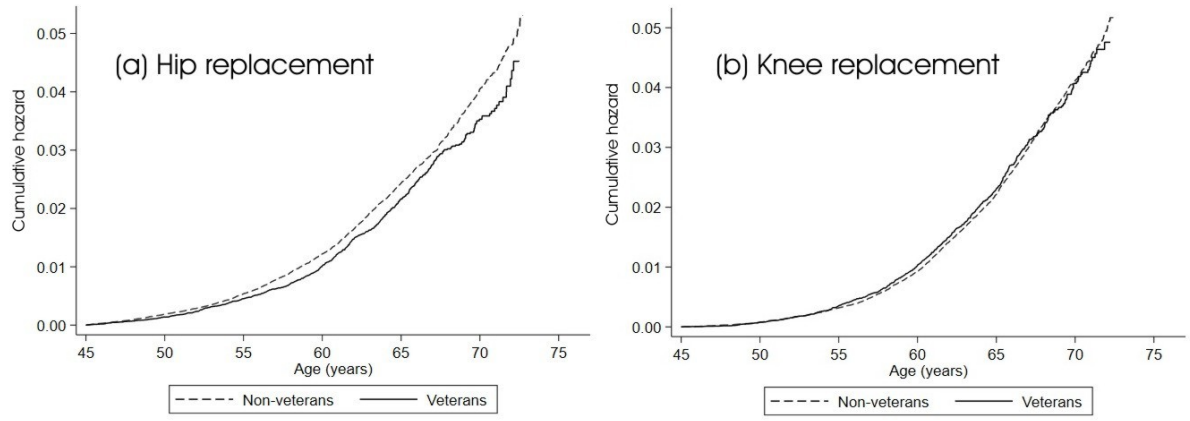

Figure 1. Nelson-Aalen cumulative hazard plot of risk of hip and knee replacement by age, landmark age 45 years, veterans compared with non-veterans

Knee replacement

A first knee replacement was recorded in 759 (0.97%) veterans and 2190 (0.87%) non-veterans; there was no significant difference between veterans and non-veterans in the unadjusted model HR 1.02, 95% CI 0.94-1.11, p=0.643 for a landmark age of 45 years (Figure 1b). The findings were unchanged after adjusting for SES.

Sex

Hip replacement

When analysed by sex, testing for interaction was non-significant, p=0.784. A total of 793 (1.12%) male veterans underwent hip replacement compared with 2686 (1.20%) male non-veterans. The corresponding figures for women were 84 (1.10%) in veterans and 403 (1.39%) in non-veterans. Both male and female veterans were less likely than non-veterans to undergo hip replacement, although non-significantly so for women, HR 0.88, 95% CI 0.80-0.96, p=0.006 for men and HR 0.84, 95% CI 0.65-1.10, p=0.207 for women. For both veterans and non-veterans, women were more likely than men to undergo hip replacement, HR 1.36, 95% CI 0.1.06-1.74, p=0.017 for female veterans compared with male veterans, and HR 1.41, 95% CI 1.26-1.59, p<0.001 for non-veteran women compared with non-veteran men.

Knee replacement

Interaction was also non-significant in respect of sex when knee replacement was examined, p=0.689. A total of 694 (0.98%) male veterans and 1922 (0.86%) male non-veterans underwent knee replacement, compared with 65 (0.86%) female veterans and 268 (0.92%) female non-veterans. There was no significant difference between the veterans and non-

veterans in the likelihood of knee replacement either for men, HR 1.03, 95% CI 0.94-1.13, p=0.505, or for women, HR 0.98, 95% CI 0.75-1.29. p=0.900. Female non-veterans were significantly more likely to undergo knee replacement than male non-veterans, HR 1.24, 95% CI 1.09-1.41, p=0.001; for veterans, the increased risk in women compared with men was non-significant, HR 1.18, 95% CI 0.91-1.53, p=0.213.

Age

Age at first joint replacement did not differ significantly between veterans and non-veterans, for men or women, for either hip or knee (Table 1). The median age for knee replacement was around 4-5 years higher than for hip replacement, in all groups.

Table 1. Median age at first hip and knee replacement, veterans and non-veterans

	Veterans n=78,157		**Non-veterans n=252,637**		
	Median age (years)	**IQR**	**Median age (years)**	**IQR**	**p value**
Hip replacement Men	56.6	46.9-62.1	55.8	45.2-61.9	0.102
Hip replacement Women	55.9	47.8-62.0	56.6	46.9-63.0	0.920
Knee replacement Men	60.0	55.2-63.9	60.6	55.8-64.7	0.062
Knee replacement Women	59.2	53.6-64.3	60.3	56.3-64.5	0.270

p values for Wilcoxon rank-sum test

Birth cohort

There was no significant difference in risk between veterans and non-veterans in any birth cohort, for either hip or knee replacement, apart from a reduction in risk of hip replacement in veterans for the 1955-1959 birth cohort (Figure 2).

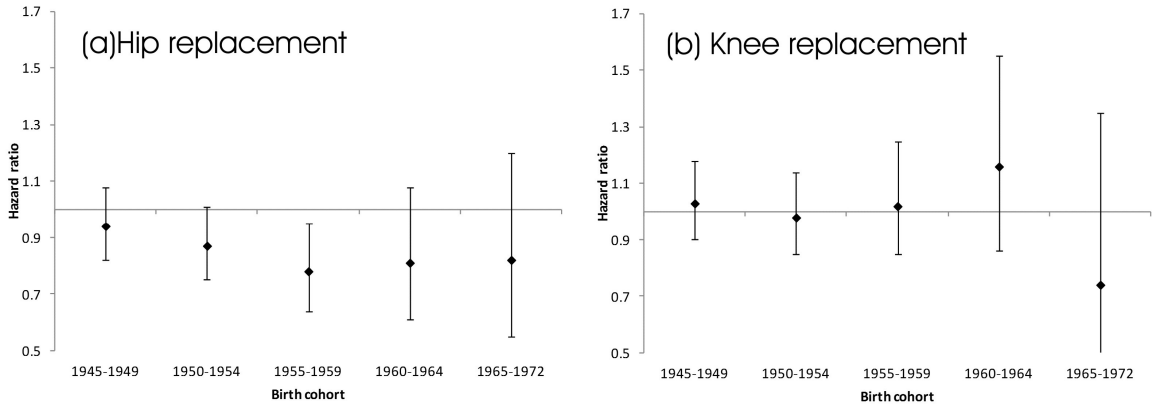

Figure 2. Hazard ratios for risk of hip and knee replacement by birth cohort, veterans compared with non-veterans

Length of service

When veterans were compared against a baseline of all non-veterans, no consistent overall pattern was evident in the risk of undergoing a hip or knee replacement for any length of service (Figure 3).

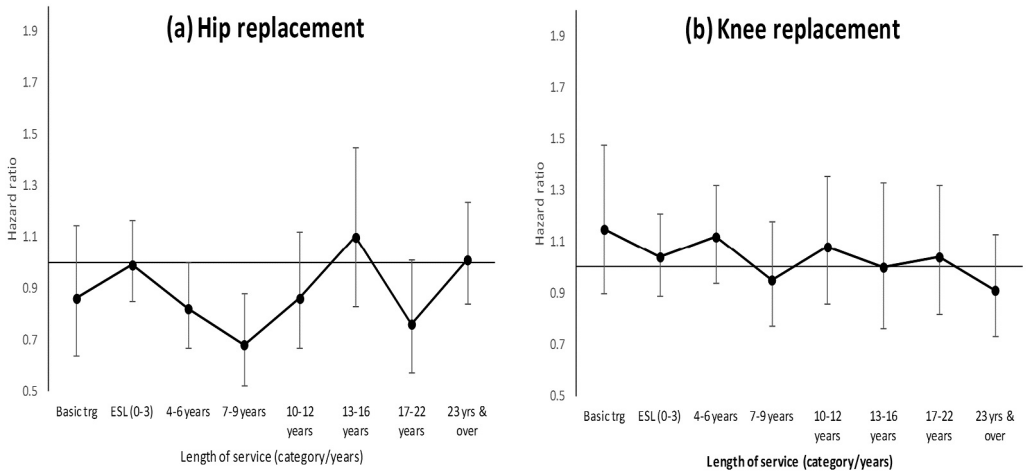

Figure 3. Hazard ratios for risk of hip and knee replacement in veterans by length of service, compared with all non-veterans. Intervals correspond to common lengths of military engagement

Prescribing

Analgesia

We found no difference between veterans and non-veterans in the likelihood of having encashed a prescription for analgesics prior to hip replacement, odds ratio (OR) 1.02, 95% CI 0.96-1.10, p=0.483. Similarly, there was no difference in respect of knee replacement, OR 0.96, 95% CI 0.91-1.02, p=0.142. However, both veterans and non-veterans were more likely to have received prescribed analgesia prior to knee surgery than hip, 67.5% vs. 53.6% for veterans and 70.3% vs. 52.2% for non-veterans.

DISCUSSION

Main findings

Despite the number of veterans who have left the Armed Forces as a result of medical discharge for lower limb injuries and disorders, reassuringly we find no evidence to suggest that they are at increased risk of osteoarthritis of sufficient severity to warrant hip or knee replacement in later life. Indeed, in respect of hip replacement, the converse is true with veterans less likely to undergo hip replacement than non-veterans, although this was only statistically significant for men. In particular, there was no increase in risk associated with longer service, which would have been expected if osteoarthritis was a consequence of service-related physical exercise or trauma, as longer service is associated with a longer period of exposure to these risk factors. Nor was there any statistically significant difference in risk in veterans born from 1960 onwards, who experienced a greater emphasis on running, mainly on roads and initially wearing boots, in consequence of the 'Fit to Fight' cardiorespiratory fitness initiative introduced in 1978.(14) For both veterans and non-veterans, women were more likely to undergo both hip and knee replacement than men; this is consistent with findings of the analysis of Clinical Practice Research Datalink (CPRD) data by Culliford et al. (15).

Risk factors for osteoarthritis include obesity, biomechanics, bone density and dietary factors.(7) Traumatic injury can be a predisposing factor.(8) There is good evidence for a genetic component, which may contribute up to 60% of the risk for hip and knee osteoarthritis;(9) this may contribute to explaining the similarity of risk which we found between veterans and non-veterans, and could be explored in other studies.

The incidence starts to become clinically apparent in early middle age, earlier for knee than for hip, and reaches a peak in the 70s. Osteoarthritis of the knee is more common in women, whereas hip osteoarthritis is more common in men.(7) A systematic review of osteoarthritis in former elite athletes, who may be regarded as a valid civilian comparator for the intense physical training of military personnel, found an overall higher prevalence of lower limb osteoarthritis in athletes.(16) It might therefore be expected that the incidence in veterans would be higher, but our data do not support this. Few previous studies have compared the risk of arthritis in veterans with people who have never served; two US studies based on self-reported data from large national questionnaire surveys found conflicting results.(5, 6) Our study is based on objective data from NHS records and therefore eliminates the recall bias which may have influenced these findings.

An alternative explanation for our findings might be that veterans were less likely to access joint replacement surgery even if experiencing symptoms. An Australian study found that the odds ratio for hip and knee replacement in veterans compared with non-veterans was lower in the 64-74 year age group, but that there was an increase in knee replacements in veterans above age 85 years, which the authors interpreted as veterans delaying treatment for knee replacement.(17) This finding is consistent with our finding in respect of hip replacement, all the veterans in our study being under age 74 years, but not knee replacement where our rates were similar. As we have no data for the older age-groups, we have no basis on which to conclude that veterans were delaying treatment, but there is no plausible reason why that should be the case for hip replacement but not knee replacement. Furthermore, it might be expected that previously active veterans would be motivated to seek treatment if mobility was becoming impaired. NHS Scotland operates a priority

treatment scheme for veterans for conditions arising in connection with military service.(18) It is therefore possible that the lower risk of hip replacement in veteran men reflects a real reduction in incidence of osteoarthritis.

We have made the assumption that all hip and knee replacements were for osteoarthritis. Whilst this may be true for the majority of veterans, it is possible that some cases in the non-veterans were due to congenital or other hip disease which would have precluded military service. We mitigated this by using a landmark age of 45 years, but any such cases over the age of 45 years could still have led to under-estimation of any excess risk in veterans. Some joint replacements may have taken place as a result of acute trauma, reported by NHS Scotland to account for 7% of all hip replacements and less than 1% of knee replacements (Table 2);(19) we have made the assumption that the incidence of these conditions does not differ between veterans and non-veterans.

Table 2. Principal indications for hip and knee replacement, Scottish national data 2017(19)

Diagnosis	Hip replacement %	Knee replacement %
Osteoarthritis	87.1	97.2
Fracture	7.1	0.6
Secondary osteoarthritis	1.8	~
Osteonecrosis	1.6	~
Inflammatory arthritis	1.2	1.2
Other	1.1	1.0

~ no cases

We know of no studies assessing obesity in a broad sample of UK veterans, although a study on serving military personnel based on data collected 2007 showed a similar prevalence of obesity to the general population in personnel aged 35-44 years.(20) However in a treatment-seeking group of veterans with mental health conditions, 63% were overweight or obese, two to four times higher than the general population.(21)

The mean ages for hip and knee replacements in our study are lower than those reported by NHS Scotland for 2017 (67.3 years and 68.2 years respectively).(19) However the NHS data include patients of all ages whereas our dataset was capped at 73 years of age (people born in 1945) and thus cannot be compared directly.

We found no difference between veterans and non-veterans in the likelihood of receiving prescribed analgesics prior to the date of surgery for either hip or knee replacement, which further provides no indication that veterans delayed surgery until their symptoms were more severe, at least in the age group covered by our study. However, both groups were more likely to receive analgesics prior to a knee replacement compared with hip, suggesting that osteoarthritis of the knee may be associated with a greater level of pain. This is consistent with the older age at knee replacement, for both veterans and non-veterans, and may reflect surgery being delayed for longer in all these patients. This is at variance with the study by Salaffi et al. which found no difference in non-steroidal anti-inflammatory prescribing between patients with hip and knee osteoarthritis.(22)

Strengths and Limitations

The main strength of this study is that we had access to data on over 78,000 veterans and 253,000 non-veterans aged up to 73 years. Outcomes were recorded on NHS data systems and were, therefore, not reliant on individual recall.

Joint replacements taking place in non-NHS facilities would not have been captured, although the number missed in this way is likely to be small in Scotland. We had no data on the prevalence of obesity in the veterans, or of nutrition-related risk. We had no data on the Service to which each veteran belonged (Naval Service, Army or Royal Air Force), nor their trade, and it is likely that some veterans, such as those who served in the infantry or Royal Marines, or who undertook parachuting activities, will have experienced more physical exertion and lower limb trauma than those in less physically active trades.

The absence of statistical significance in the figures for knee replacement in women veterans in comparison with non-veterans is likely to be a consequence of the relatively small number of women veterans who have undergone this procedure, despite the size of our dataset and length of follow-up. This will have limited the statistical power, but as we used a 100% sample of all veterans meeting eligibility criteria, we had no scope to increase the power.

CONCLUSION

Despite the large number of people discharged from military service for musculoskeletal disorders of the lower limb, using joint replacement as a proxy outcome measure there is no evidence of an increased risk of osteoarthritis of the hip or knee in later life in comparison with people who have never served. It is therefore valid to use data from the wider community in planning care and welfare services for veterans with lower limb osteoarthritis.

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Declaration of interests

BPB is a military veteran and Honorary Civilian Consultant Advisor (Army) in Veterans' Health and Epidemiology. Neither the Army nor the Ministry of Defence had any input to this paper, and the views and opinions expressed are solely those of the authors. No other interests are declared by the authors.

Author contributions

BPB conceived the idea and designed the study, with advice from JPP and DFM. BPB carried out the data analysis, which was overseen by DFM, and interpreted the findings. BPB wrote the first draft of the report, which was critically reviewed and edited by all authors. BPB revised the article in response to the Reviewers' feedback, and all authors approved the final article.

Ethical Approval

Approval for the study was granted by the Public Benefit and Privacy Panel of the Information Services Division of NHS Scotland approval number 1718-0133. As a pseudo-anonymised secondary data study, individual consent was not required.

Data sharing

The study remains in progress and the data are not currently available for sharing.