Is Diabetes Associated with Shoulder Pain or Stiffness? Results from a Population Based Study

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ABSTRACT. ***Objectives.*** To assess the association of shoulder pain and/or stiffness and diabetes mellitus in a population based cohort.

Methods. Participants were randomly recruited from the North West Adelaide Health Study, a longitudinal, population based study. In the second stage, 3128 participants were assessed for diabetes mellitus and shoulder complaints via questionnaires, the Shoulder Pain and Disability Index (SPADI), physical assessment, blood sampling for fasting plasma glucose, and HbA1c levels.

Results. Overall, 682 (21.8%) participants experienced shoulder pain and/or stiffness and 221 participants (7.1%) fulfilled criteria for diabetes mellitus. Those with diabetes had a higher prevalence of shoulder pain and/or stiffness (27.9% vs 21.3%; $p = 0.025$), and poorer SPADI disability subscore ($p = 0.01$) and total SPADI score ($p = 0.02$). After controlling for age, sex, obesity, and current smoking, the prevalence of shoulder pain and/or stiffness did not differ significantly between those with diabetes and those without (OR 1.05, 95% CI 0.76–1.45), nor were there significant differences in the SPADI disability subscore ($p = 0.39$) or total SPADI score ($p = 0.32$) between the 2 groups. After adjustment for covariates, there was no association between higher levels of HbA1c and shoulder pain and/or stiffness ($p > 0.8$). Range of shoulder movement was significantly reduced in those with diabetes ($p < 0.05$).

Conclusions. There is a higher prevalence of shoulder pain and/or stiffness in people with diabetes mellitus. The differences observed between those with diabetes and those without can largely be explained by the confounding factors of age, sex, obesity, and current smoking. (First Release Nov 15 2008; J Rheumatol 2009;36:371–7; doi:10.3899/jrheum.080349)

Key Indexing Terms:
SHOULDER PAIN DIABETES MELLITUS RANGE OF MOVEMENT PAIN

Shoulder pain is a common musculoskeletal condition with a tendency for chronicity. Prevalence rates in the literature vary. A systematic review of 18 studies reported 1-year prevalence rates of shoulder pain in the general population ranging from 19% to 31% and a lifetime prevalence from 7% to 67%. The prevalence increased with age and female gender[1]. A population based study of workers found the prevalence of rotator cuff tendinitis and nonspecific shoulder pain to be 2% and 12%, respectively[2].

Chronic shoulder pain has the potential to adversely affect quality of life and ability to perform daily activities and work duties. As many as 54% of participants in one population based cohort study still reported shoulder pain at 3 years' followup, and 90% also reported disability with significant influence on daily activities[3]. Studies based in the primary care setting have also found that shoulder symptoms tend to be chronic or recurrent, with as many as 40% to 60% of patients still experiencing symptoms at 12 to 18 months[4-6].

It is known that having one area of chronic pain is associated with an increased risk of having another regional pain syndrome, and it has been hypothesized that there may be an underlying propensity for chronic pain and/or risk factors that make an individual more likely to experience pain[7]. Some musculoskeletal conditions are reported to be particularly common in people with diabetes mellitus. These include diabetic cheiropathy, flexor tenosynovitis, Dupuytren's contracture, carpal tunnel syndrome, adhesive capsulitis and calcific periarthritis of the shoulder, reflex sympathetic dystrophy, diabetic osteoarthropathy, diabetic muscle infarction, and diffuse idiopathic skeletal hyperosto-

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sis[8]. Research on the associations between shoulder pain and diabetes has generally been conducted with clinical samples from tertiary outpatient clinics and primary care settings[9-15]. These studies have reported a higher prevalence of shoulder symptoms in people with diabetes, with a prevalence ranging from 11% to 35% compared with 2% to 17% in control groups[9-13,15]. A recent study, based in a tertiary care setting, found both shoulder pain and disability to be worse among those with diabetes than in controls[9].

There is a paucity of data from population based studies specifically investigating the association between diabetes and shoulder symptoms. One study looking at the differences in determinants of a specific shoulder disorder versus nonspecific shoulder pain did show an association between diabetes mellitus and chronic rotator cuff tendinitis, but it did not find a similar association with nonspecific shoulder pain[2]. A study of Finnish workers, however, found no significant association between diabetes or raised plasma glucose levels and chronic shoulder disorders[16]. Another study, also involving participants from the Mini Finland Health Survey, found that diabetes was associated with shoulder impairment, with an OR of 1.6 (95% CI 1.2–2.1) after adjustment for age and sex[17].

As shoulder pain tends to be chronic and carries a significant burden of disease, it is important to identify associated conditions and thus potential risk factors in order to implement strategies to help prevent shoulder pain from developing. Data from clinic studies support an association between shoulder pain and diabetes, and several studies have shown an association between musculoskeletal pain and the duration of diabetes[9,10,12-15]. It is well known that poor glycemic control or chronic hyperglycemia is associated with an increased risk of developing microvascular and macrovascular complications from diabetes mellitus[18,19]. Clinical studies have not, however, found a significant correlation between poor diabetic control (as measured by HbA1c levels) and musculoskeletal symptoms in people with diabetes mellitus[9,12-14]. This may suggest that other factors are responsible for the apparent association between shoulder pain and/or stiffness and diabetes.

The aim of our study was to assess the association between shoulder pain and/or stiffness and diabetes mellitus in the general population and to test the association between poor glycemic control and shoulder symptoms in a population based sample.

MATERIALS AND METHODS

Data were obtained from the North West Adelaide Health Study (NWAHS), a population based biomedical cohort study established in 2000. This study involves people living in the northwest region of Adelaide, South Australia, and covers a broad range of socioeconomic areas. It was designed to investigate the prevalence of chronic conditions and health related risk factors and to monitor progression of diseases over time to help plan healthcare provision in South Australia. The methodology has been described in detail[20]. Briefly, Stage 1 was conducted between 2000 and 2003; households were selected randomly via the electronic telephone directory, and the last person in the household to have had their birthday and be 18 years of age or older was interviewed over the telephone and invited to attend a clinic for baseline clinical assessment. Data collected included information relating to demographics, chronic conditions (in particular asthma, diabetes mellitus, chronic obstructive pulmonary disease, and cardiovascular disease), risk factors, health service utilization, and quality of life. The initial eligible sample comprised 8213 people. Of these, 5850 were interviewed (215 not contactable, 2148 refused interview) and 4060 attended the clinic.

Stage 2 was conducted between 2004 and 2006. Participants from Stage 1 were recontacted and invited to complete a Computer Assisted Telephone Interview (CATI) and a self-completed questionnaire, and to attend a further physical assessment (which for the first time included musculoskeletal assessment). Participants completed all or a combination of these assessments, depending on their capabilities. In all, 3566 participants completed all, or combination of, these assessments: 3146 completed the interview and questionnaire and attended clinic; 46 completed the questionnaire and attended clinic; 14 completed the interview and attended clinic; 49 completed the interview and the questionnaire but did not attend clinic; 19 completed the questionnaire only, and 292 completed the interview only. The overall response rate was 3566/3960 (90.1%). Of the 3146 participants who completed the musculoskeletal assessment (telephone interview, questionnaire, and clinic assessment), 3128 also had assessment for diabetes mellitus.

Information relating to musculoskeletal conditions, including prevalence of shoulder pain and stiffness, was collected as part of the CATI survey. Participants were asked, "Have you ever had pain or aching in your shoulder at rest or when moving, on most days for at least a month?" and "Have you ever had stiffness in your shoulder when getting out of bed in the morning on most days for at least a month?". Participants who answered positively to either of these questions were also asked to complete the Shoulder Pain and Disability Index (SPADI), a tool designed to measure the effects of shoulder pathology in terms of pain and disability[21]. The SPADI consists of 13 questions grouped into 2 subscales of pain and function. Scores range from 0 to 100, with higher scores indicating greater impairment. It has been shown to have acceptable test-retest reliability[14]. Although initially used as a self-administered clinical index utilizing the visual analog scale (VAS), a numerically scaled SPADI has been found to be highly correlated to the VAS version and suitable for telephone administration[22]. The numerical version was used in this study.

Information relating to smoking status was collected using the self-completed questionnaire. Participants were asked if they currently smoked and if they had ever smoked regularly.

Physical assessment included height and weight measurements using a wall stadiometer and calibrated scales, respectively. Measurements were then used to calculate body mass index [BMI; weight (kg)/height (m^2)]. Those classified as obese (BMI $\geq$ 30 kg/m^2) were defined using the World Health Organization classification[23]. Fasting blood was taken to measure fasting plasma glucose level (FPG) and glycosylated hemoglobin (HbA1c). People with diabetes mellitus were defined as either those who had FPG of at least 7.0 mmol/l[24], or those who self-reported having been told by a doctor that they had diabetes. Participants with diabetes were categorized according to HbA1c levels: < 6.0%: normal; 6.0%–7.0%: good glycemic control; > 7.0%: poor glycemic control.

Range of movement of both the right and left shoulders was assessed for flexion and abduction by clinic staff using a Plurimeter V inclinometer. The range of external rotation of both shoulders was estimated from visual assessment.

The outcome of our study was the prevalence of people who had shoulder pain and/or stiffness in combination with diabetes mellitus. The other outcome measures were: prevalence of shoulder pain/stiffness stratified according to HbA1c levels; SPADI scores in those with diabetes mellitus; SPADI scores stratified into HbA1c levels; and degree of shoulder restriction in people with diabetes mellitus.

All data were weighted by age and sex to the estimated residential population aged 20 years and over of the northwest suburbs of Adelaide[25]. Data were analyzed using Excel and the Statistical Package for the Social

Sciences (SPSS version 15.0). Chi-square tests were used to determine statistically significant differences ($p < 0.05$) in the prevalence of shoulder pain and/or stiffness between participants who had diabetes and those who did not, and between different HbA1c categories. From univariate analysis on this cohort, it was found that shoulder pain was associated with age > 50 years, female sex, BMI ≥ 30, and current smoking. Therefore, we adjusted for these variables in the following analyses. Due to the potential confounding influence of BMI on glucose balance and diabetes, the association between diabetes and shoulder symptoms was analyzed separately for obese and nonobese participants. These results were then adjusted for age and sex.

Odds ratios for shoulder pain and/or stiffness according to presence of diabetes and HbA1c level were determined using logistic regression analyses and adjusted for age, sex, obesity, and current smoking using logistic regression analysis. Unadjusted statistically significant differences ($p < 0.05$) between continuous variables (SPADI scores, degrees of range of movement) for those with shoulder pain and/or stiffness according to diabetes status and HbA1c levels were determined using t tests and analysis of variance as appropriate. Adjusted statistically significant differences ($p < 0.05$) between continuous variables for those with shoulder pain and/or stiffness according to diabetes status and HbA1c levels were then determined using multiple analyses of variance controlling for age, sex, obesity, and current smoking.

RESULTS

In Stage 2, 3206 participants completed the clinical assessment. Overall, 49.1% were male. There was a broad age range (20–95 years, median 45 yrs): 38.2% were 20 to 39 years of age, 36.5% were 40 to 59 years, and 25.2% were over 60 years. The only age group that had a significant difference in proportion of males and females was the group aged ≥ 60 years: in this group the proportion of females was 54.6% ($p = 0.03$). Mean BMI was in the overweight range for males (28.0 kg/m^2; SD 5.0) and females (27.7 kg/m^2; SD 6.3); and 19.3% were current smokers (18.4% of females smoked, 21.1% of males). The following results are for those participants in Stage 2 who provided information relating to shoulder pain and stiffness, underwent assessment of their shoulder range of movement, and provided sufficient information (via self-report or FPG test) to determine diabetes status.

Overall, 3128 participants provided information relating to shoulder problems and diabetes status (self-reported diabetes status or via FPG). Shoulder pain and/or stiffness was reported in 21.8% (95% CI 20.4–23.3; n = 682), and 7.1% (95% CI 6.2–8.0; n = 221) had diabetes mellitus. Those with diabetes had a statistically significant higher prevalence of shoulder pain and/or stiffness compared to those without diabetes (27.9% compared to 21.3%; $p = 0.02$; Table 1). There was a higher prevalence of shoulder pain and/or stiffness in the groups with higher HbA1c levels (Table 1).

Subjects with diabetes were significantly more likely to have shoulder pain and/or stiffness; however, after adjustment for age, sex, obesity, and current smoking, there were no statistically significant differences between those with and without diabetes. This was also true of poorer glycemic control, with no significant increase in the likelihood of shoulder pain and/or stiffness with higher HbA1c levels (Table 1).

Of the participants who had shoulder pain and/or stiffness, 37.1% were obese. Among nonobese participants there was no significant difference in prevalence of shoulder symptoms between those with diabetes and those without (Table 2). Shoulder symptoms were significantly increased in obese individuals even if they did not have diabetes (OR 1.47, 95% CI 1.21–1.77). Among those who were obese there was no significant difference in the prevalence of shoulder symptoms in those with diabetes versus those without (37% and 26.1%, respectively). After adjustment for age and sex, these differences between obese and nonobese participants were still evident (Table 2).

Among subjects with shoulder pain and/or stiffness, the SPADI pain subscore was not significantly different between those with and those without diabetes; however, there was a significant increase in the SPADI disability subscore and in the total SPADI score among those with diabetes (Table 3). HbA1c levels > 6.0% were associated with higher SPADI disability subscores, while HbA1c levels > 7.0% were associated with statistically significantly higher total SPADI scores (Table 3). When adjusted for age, sex, obesity, and current smoking, there was no statistically significant difference in SPADI subscores or in total SPADI

Table 1. Prevalence of shoulder pain/stiffness and odds ratios of shoulder pain and/or stiffness: unadjusted and adjusted for age, sex, body mass index, and current smoking.

	Prevalence, n/N	% (95% CI)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Diabetes				
No diabetes	620/2907	21.3 (19.9–22.9)	1.00 (ref)	1.00 (ref)
Diabetes (diagnosed and undiagnosed)	62/221	27.9 (22.3–34.1)*	1.42 (1.05–1.93)	1.05 (0.76–1.45)
HbA1c				
Normal , 6.0%	531/2584	20.6 (19.0–22.2)	1.00 (ref)	1.00 (ref)
6% to 7%	119/439	27.2 (23.2–31.5)**	1.44 (1.14–1.81)	0.97 (0.76–1.26)
> 7.0%	32/110	29.0 (21.4–38.1)**	1.58 (1.04–2.41)	1.01 (0.64–1.59)

* Statistically significantly different between prevalence of shoulder pain and no diabetes. Chi-square test = 5.06, $p = 0.02$. ** Statistically significantly different between prevalence of shoulder pain in these categories compared to HbA1c < 6.0%. Chi-square test = 13.08, $p = 0.001$.

Table 2. Prevalence of shoulder pain and/or stiffness according to body mass index and diabetes status.

	Prevalence, n/N	Unadjusted OR (95% CI)	Adjusted OR (age and sex) (95% CI)
Not obese and no diabetes	407/2090 (19.5%)	1.00	1.00
Not obese and diabetes	22/113 (19.5%)	0.99 (0.61–1.59)	0.77 (0.47–1.26)
Obese and no diabetes	213/816 (26.1%)	1.47 (1.21–1.77)	1.43 (1.18–1.74)
Obese and diabetes	40/108 (37.0%)	2.41 (1.60–3.61)	1.94 (1.28–2.94)

Table 3. SPADI score; unadjusted and adjusted for age, sex, body mass index, and current smoking.

	SPADI Pain Subscore (95% CI)		SPADI Disability Subscore (95% CI)		Total SPADI score (95% CI)	
	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted
Diabetes	26.8	27.1	16.1	16.6	20.4	20.8
No diabetes	(24.9–28.8)	(25.2–29.1)	(14.5–17.8)*	(15.0–18.2)	(18.7–22.1)#	(19.2–22.4)
Diabetes (diagnosed and undiagnosed)	32.9	30.7	23.4	18.7	27.2	23.3
	(26.5–39.4)	(24.2–37.1)	(17.4–29.3)*	(13.5–23.9)	(21.5–32.9)#	(18.0–28.5)
HbA1c						
Normal, < 6.0%	27.1	27.9	15.1	16.3	19.7	20.8
	(25.0–29.3)	(25.7–30.0)	(13.3–16.8)†	(14.6–18.1)	(18.0–21.5)***	(19.1–22.6)
6% to 7%	27.4	25.4	22.1	18.0	24.7	21.3
	(22.5–32.2)	(20.7–30.1)	(17.8–26.4)**	(14.2–21.8)	(20.4–28.9)	(17.4–25.1)
> 7.0%	32.7	28.7	26.8	19.8	29.2	23.0
	(25.5–39.9)	(19.5–37.9)	(18.9–34.8)†	(12.4–27.2)	(22.1–36.2)***	(15.6–30.5)

* Statistically significantly different, no diabetes vs diabetes, t = –2.52; p = 0.012. # Statistically significantly different, no diabetes vs diabetes, t = –2.39; p = 0.017. ** Statistically significantly difference, normal vs 6% to 7% (p = 0.004), and † statistically significant difference normal vs > 7% (p = 0.007). ANOVA test F = 8.97, p < 0.001, Bonferroni correction. *** Statistically significant difference, normal vs > 7% (p = 0.045). ANOVA test F = 5.05, p = 0.007, Bonferroni correction. In adjusted analysis, no statistically significant differences between SPADI scores between diabetes and HbA1c categories.

score for those with and without diabetes, or between different HbA1c levels (Table 3).

The mean range of shoulder movement in participants with shoulder pain and/or stiffness was significantly reduced in those with diabetes versus those without, with a mean reduction of 10° to 17° in shoulder flexion, abduction, and external rotation. The mean range of shoulder flexion and abduction remained significantly reduced in those with diabetes, even after adjustment for age, sex, obesity, and current smoking, with mean differences in range of movement of 4° to 10° (Table 4). In addition, there was a reduction in the range of some shoulder movements with increased levels of HbA1c (Table 5).

As expected, range of shoulder movement in participants without reported shoulder pain and/or stiffness was increased in all planes compared to participants with a history of shoulder symptoms (Tables 4-7). In participants without shoulder pain and/or stiffness the range of shoulder movement was reduced (even after adjusting for age, sex, BMI, smoking) in those with diabetes versus those without, by 3° to 6° (Table 6). Poor glycemic control in participants without shoulder pain and/or stiffness was associated with small, but statistically significant, reductions in range of shoulder movement (Table 7).

DISCUSSION

Our population based study found that over one-quarter of people with diabetes mellitus in the community had shoulder pain and/or stiffness. This represents a higher prevalence than in those without diabetes and is consistent with previous studies reporting higher prevalence of shoulder pain among those with diabetes (14%–35%) compared to controls (2%–17%)[9-13]. For respondents reporting shoulder pain, people with diabetes mellitus had significantly worse shoulder-specific physical disability compared with those without diabetes.

However, we found that the differences in prevalence of shoulder pain and/or stiffness and in SPADI scores between those with diabetes and the group without diabetes were no longer significant after adjustment for other factors known to be associated with shoulder pain (increased age, female sex, obesity, and current smoking). In addition, although participants with poorer glycemic control were more likely to have shoulder pain and/or stiffness, this association was also no longer significant after adjustments for these risk factors. Previous studies have also failed to show any significant association between poor glycemic control and shoulder symptoms but have made no adjustments for confounding factors[9,13,14].

Table 4. Mean shoulder range of movement for those with shoulder pain/stiffness, adjusted for age, sex, body mass index, and current smoking.

	No Diabetes Mean Range (95% CI)	Diabetes Mean Range (95% CI)	p
Flexion			
Right	148.4 (146.4–150.5)	138.5 (131.8–145.2)	0.004
Left	149.5 (147.7–151.2)	141.9 (136.3–147.6)	0.011
Abduction			
Right	135.6 (133.2–138.0)	126.5 (118.6–134.3)	0.025
Left	136.8 (134.8–138.9)	129.8 (123.2–136.5)	0.043
External rotation			
Right	52.4 (51.0–53.9)	47.6 (42.9–52.2)	0.045
Left	51.3 (49.9–52.7)	47.5 (42.3–52.0)	0.104

t test $p < 0.05$.

Table 5. Mean shoulder range of movement among those with shoulder pain/stiffness stratified by HbA1c level and adjusted for age, sex, body mass index, and current smoking.

	HbA1c < 6.0% (95% CI)	HbA1c 6.0% to 7.0% (95% CI)	HbA1c > 7.0% (95% CI)
Flexion			
Right	148.7 (146.4–150.9)	144.4 (139.5–149.3)	139.3 (129.7–148.9)
Left	150.0 (148.0–151.9)*	146.4 (142.3–150.5)	137.6 (129.5–145.7)*
Abduction			
Right	135.9 (133.3–138.6)	132.0 (126.3–137.7)	125.7 (114.5–136.8)
Left	137.3 (135.1–139.6)†	133.5 (128.6–138.3)	125.4 (115.9–134.9)†
External rotation			
Right	52.6 (51.1–54.2)	50.4 (47.0–53.8)	46.5 (39.8–53.1)
Left	51.4 (49.9–52.9)	49.4 (46.1–52.7)	48.4 (41.9–54.8)

* Statistically significantly different, $p = 0.003$. † Statistically significantly different, $p = 0.013$.

Table 6. Mean shoulder range of movement for those without shoulder pain/stiffness, adjusted for age, sex, body mass index, and current smoking.

	No Diabetes Mean Range (95% CI)	Diabetes Mean Range (95% CI)	p
Flexion			
Right	160.1 (159.4–160.8)	156.3 (153.5–159.1)	0.007
Left	158.6 (158.0–159.3)	154.6 (151.9–157.2)	0.002
Abduction			
Right	150.8 (150.0–151.6)	145.1 (142.1–148.1)	< 0.001
Left	148.8 (148.1–149.6)	144.1 (141.2–147.1)	0.002
External rotation			
Right	58.7 (58.0–59.4)	55.8 (53.1–58.5)	0.035
Left	56.6 (55.9–57.3)	53.7 (51.0–56.4)	0.032

t test $p < 0.05$.

Croft, *et al*[7] suggest that there may be an underlying vulnerability for chronic pain in certain individuals. The association between shoulder pain and/or stiffness and diabetes mellitus found in our study may represent one such underlying condition. This association between diabetes and shoulder pain was, however, no longer significant after adjustment for age, sex, obesity, and current smoking. It is well known that obesity and increased age are risk factors for type 2 diabetes mellitus. Univariate analysis on our participants also showed an association between age and obesity and shoulder pain, findings consistent with previous studies[3,14,16]. This suggests that these 2 shared risk factors (increased age and obesity) may be responsible for the apparent association between diabetes and shoulder pain. Although smoking and female gender were also shown to be associated with shoulder pain in univariate analysis, the association was weaker.

When the association between diabetes and shoulder

Table 7. Mean shoulder range of movement for those without shoulder pain/stiffness stratified by HbA1c level and adjusted for age, sex, body mass index, and current smoking.

	HbA1c < 6.0% (95% CI)	HbA1c 6.0% to 7.0% (95% CI)	HbA1c > 7.0% (95% CI)
Flexion			
Right	160.5 (159.7–161.3)*†	156.9 (154.9–158.9)*	155.2 (151.3–159.2)†
Left	159.2 (158.5–159.9)*†	154.6 (152.7–156.5)*	153.7 (150.0–157.4)†
Abduction			
Right	151.2 (150.4–152.0)*†	147.2 (145.0–149.4)*	143.4 (139.2–147.7)†
Left	149.4 (148.6–150.2)*†	144.9 (142.7–147.0)*	144.0 (137.9–146.1)†
External rotation			
Right	58.8 (58.1–59.6)	57.1 (55.1–59.0)	56.2 (52.4–60.0)
Left	56.8 (56.0–57.5)†	55.6 (53.6–57.5)	51.8 (48.0–55.6)†

* Statistically significantly different, p = 0.001 for each. † Statistically significantly different, p < 0.05 for each.

symptoms was analyzed in nonobese participants, we found that there was an equal prevalence of shoulder symptoms among those with and without diabetes (19.5% in both groups). In obese participants the odds of having shoulder symptoms was significantly increased compared to the nonobese group, regardless of whether diabetes was also present. This remained true after adjusting for age and sex. Among obese participants there was a nonsignificant increase in the risk of shoulder symptoms in those with diabetes compared to those without. Combined with our previous results showing no association between diabetes and shoulder symptoms after adjustment for age, sex, BMI, and current smoking, this suggests that obesity rather than abnormal glucose balance (which may be a secondary effect from increased BMI) is a major factor in the development of shoulder pain and/or stiffness.

In those participants with shoulder pain and/or stiffness, the only outcome shown to be significantly different after adjustment for covariates, between those with and those without diabetes, was measured range of shoulder flexion and abduction. The presence of diabetes influenced shoulder range of movement even in those participants without a history of shoulder pain and/or stiffness: those with diabetes had significant reductions in range of movement compared to those without diabetes. It is not clear whether these differences in range of movement have an influence on physical functioning; however, participants with shoulder pain and diabetes did have worse SPADI functional scores than without diabetes.

A limitation of our study was that, due to small numbers of patients with high levels of HbA1c, the cutoff for the highest HbA1c category was relatively low at > 7.0% (normal range < 6.0%). In those with diabetes, this would in fact reflect adequate glycemic control; therefore, any differences in shoulder symptoms or function due to poor glycemic control may have been underestimated in this study. Further, a single HbA1c evaluation is not an adequate marker of longterm glycemic control, reflecting plasma glucose levels only over preceding months. Thus to evaluate the effect of glycemic control on shoulder symptoms, several HbA1c evaluations over time would be required. The definition of diabetes was broad to encompass subjects with both diagnosed and undiagnosed diabetes as this is one of the overall aims of the NWAHS. We calculated that the prevalence of diabetes in our cohort was 7.1%, which is comparable to another study of prevalence of diabetes mellitus in Australia of 7.4%[26].

We chose a relatively "narrow" definition of shoulder pain and or stiffness (participants requiring at least shoulder pain or stiffness for most days for at least a month) as we wanted to exclude those people with transient muscle or ligamentous pain that would quickly resolve without causing significant effects on well-being or function for prolonged periods. This could possibly have led to an underestimation of participants with shoulder pain and or stiffness and therefore a reduced chance of finding an association with these symptoms and diabetes mellitus.

Our study is subject to potential biases. It is unlikely that selection bias played a large role as our study involved a large random sample. Subjects with chronic medical conditions, however, may be more likely to participate in such a study rather than those who are asymptomatic. Like most epidemiological studies this study involved recall bias, that is, we asked participants to recall pain experiences over their lifetime. This may have resulted in an underestimate of the prevalence of shoulder pain and/or stiffness and therefore may have reduced the chance of finding any association with diabetes mellitus. Our prevalence rates of shoulder pain were, however, found to be consistent with those reported in the literature.

The strength of our study is that the participants were randomly selected from the community, so it is a truly representative population sample. Other studies that have recruited participants from hospital or primary clinic settings are subject to selection bias. Moreover, all our participants underwent testing for diabetes, so that we were able to recognize both doctor-diagnosed and undiagnosed diabetes and assess glycemic control.

In conclusion, shoulder pain and/or stiffness is common in the community, particularly in people with diabetes mellitus. The combination of shoulder pain and/or stiffness and diabetes mellitus has significant efffects on physical functioning. However, after controlling for age, sex, obesity, and current smoking, there was no difference in prevalence of shoulder pain and/or stiffness, or in the SPADI scores in those with diabetes versus those without. In this population based study there was a small, but significant, reduction in measured range of shoulder movement in those with diabetes versus those without, even after adjustment for covariates. In our study, poor glycemic control was not associated with increased prevalence of reported shoulder pain and/or stiffness after adjustment for age, sex, obesity, and smoking. Although shoulder pain and stiffness represent a significant burden of disease among those with diabetes, the increased prevalence of shoulder pain may largely be explained by other risk factors such as age, sex, smoking, and particularly obesity.

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