Factors Associated with Atraumatic Posterosuperior Rotator Cuff Tears

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Background: Certain metabolic factors have been proposed as risk factors for a posterosuperior rotator cuff tear. Although metabolic syndrome is of increasing concern in industrialized societies, little information exists regarding its association with posterosuperior rotator cuff tears. The purpose of this study was to determine the risk factors for an atraumatic posterosuperior rotator cuff tear, including metabolic factors and metabolic syndrome.

Methods: This study involved 634 subjects (634 shoulders) drawn from a cohort of rural residents. Posterosuperior rotator cuff tear diagnoses were based on magnetic resonance imaging (MRI) findings. Logistic regression analysis was used to determine the odds ratios (ORs) and 95% confidence intervals (CIs) for various demographic, physical, and social factors, including age, sex, dominant-side involvement, body mass index (BMI), and participation in manual labor; the comorbidities of diabetes, hypertension, dyslipidemia, thyroid dysfunction, ipsilateral carpal tunnel syndrome, and metabolic syndrome; and the serum metabolic parameters of serum lipid profile, glycosylated hemoglobin A1c, and level of thyroid hormone. Two multivariable analyses were performed: the first excluded metabolic syndrome while including diabetes, hypertension, BMI, and hypo-high-density lipoproteinemia (hypo-HDLemia), and the second included metabolic syndrome while excluding the formerly included variables.

Results: Age, BMI, waist circumference, dominant-side involvement, manual labor, diabetes, hypertension, metabolic syndrome, ipsilateral carpel tunnel syndrome, HDL (high-density lipoprotein), and hypo-HDLemia were significantly associated with posterosuperior rotator cuff tears in univariate analyses ($p \leq 0.035$). In the first multivariable analysis, age (OR. 1.86 [95% CI, 1.47 to 2.35]), BMI (OR, 1.09 [95% CI, 1.02 to 1.18]), dominant-side involvement (OR, 2.04 [95% CI, 1.38 to 3.01]), manual labor (OR, 9.48 [95% CI, 5.13 to 17.51]), diabetes (OR, 3.38 [95% CI, 1.98 to 5.77]), and hypo-HDLemia (OR, 2.07 [95% CI, 1.30 to 3.29]) were significantly associated with posterosuperior rotator cuff tears ($p \leq 0.019$). In the second multivariable analysis, age (OR, 1.85 [95% CI, 1.48 to 2.31]), dominant-side involvement (OR, 1.83 [95% CI, 1.26 to 2.67]), manual labor (OR, 7.71 [95% CI, 4.33 to 13.73]), and metabolic syndrome (OR, 1.98 [95% CI, 1.35 to 2.91]) were significantly associated with posterosuperior rotator cuff tears ($p \leq 0.002$).

Conclusions: The metabolic factors of diabetes, BMI, hypo-HDLemia, and metabolic syndrome were significant independent factors associated with the development of posterosuperior rotator cuff tears.

Level of Evidence: Prognostic Level III. See Instructions for Authors for a complete description of levels of evidence.

Rotator cuff tears are the most common disease entity in the shoulder and a notable source of shoulder disability. The posterosuperior rotator cuff, composed of the supraspinatus and the infraspinatus tendons, is the most common site of a rotator cuff tear. Extrinsic and intrinsic causes have been proposed to explain rotator cuff tears. However, the causes of posterosuperior rotator cuff tears are multifactorial and have not yet been clearly elucidated[1,2]. Most of

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the subjects in previous relevant studies, including most of the control groups, have been patients of clinics or hospitals rather than subjects recruited from the general population. Some recent studies have proposed age[2], activity[3], and genetics[4] as well as the following metabolic factors, among others, as risk factors for rotator cuff tear: obesity[5,6], dyslipidemia[7,8], hyperglycemia[9], thyroid functional abnormalities[10], and diabetes[11]. Many of these metabolic factors remain unconfirmed or controversial as posterosuperior rotator cuff tear risk factors[7,8,12]. Additionally, little information exists regarding any association of those metabolic factors with posterosuperior rotator cuff tears in the general population.

Metabolic syndrome is a clustering of medical conditions including dyslipidemia (hypertriglyceridemia [hyper-TGmia] or hypo-high-density lipoproteinemia [hypo-HDLemia]), hypertension, hyperglycemia, and abdominal obesity. This syndrome is related to various chronic degenerative diseases, including cardiovascular disease, stroke, diabetes, and osteoarthritis[13]. Metabolic syndrome is of growing concern in industrialized societies because of its high prevalence and the serious morbidity associated with the syndrome; however, there have been few studies that have investigated associations between metabolic syndrome and musculoskeletal disorders. One study reported metabolic syndrome as a risk factor for shoulder pain without confirming rotator cuff integrity with diagnostic imaging or arthroscopy[14]. Therefore, it is not clear whether metabolic syndrome is a risk factor for rotator cuff tears.

The purpose of the current study was to investigate the strengths of the associations between atraumatic posterosuperior rotator cuff tears and various factors, including metabolic factors and metabolic syndrome, in a general population.

Materials and Methods

This study received institutional review board approval. A total of 1,149 volunteers, all of whom lived in the studied rural region, were recruited and enrolled; they constituted this study's cohort. The volunteer participants completed a questionnaire and underwent physical examination of both shoulders by an orthopaedic surgeon (J.-Y.G.), fasting blood testing, radiographic evaluation of both shoulders (true anteroposterior, axillary lateral, and outlet views), bilateral shoulder magnetic resonance imaging (MRI), and bilateral upper-extremity electrophysiological assessment.

Inclusion criteria required subjects to sign an informed consent document and to have a complete clinical evaluation as described above. MRI evaluations were performed using a 1.5-T scanner (Siemens Medical Systems). Four sequences (each with a slice thickness of 3 mm, a field of view from 15.9 to 18.0 cm, and 1 excitation) were obtained, as follows: (1) oblique sagittal T1-weighted spin-echo (TR/TE [repetition time/echo time] = 452/11 ms, matrix size of 192 × 320); (2) oblique sagittal T2-weighted turbo-spin-echo (TSE) with fat saturation (TR/TE = 2,800/56 ms, matrix size of 269 × 448); (3) oblique coronal T2-weighted TSE with fat saturation (TR/TE = 2,800/56 ms, matrix size of 269 × 448); and (4) axial T2-weighted TSE with fat saturation (TR/TE = 2,800/56 ms, matrix size of 267 × 384).

Five hundred and fifteen subjects were excluded for the following reasons: the absence of a complete MRI study (17 subjects, 33 shoulders); history of shoulder trauma or surgery, osteoarthritis, calcific tendinitis, frozen shoulder, or subscapularis tendon tear (380 subjects, 760 shoulders); and current medication

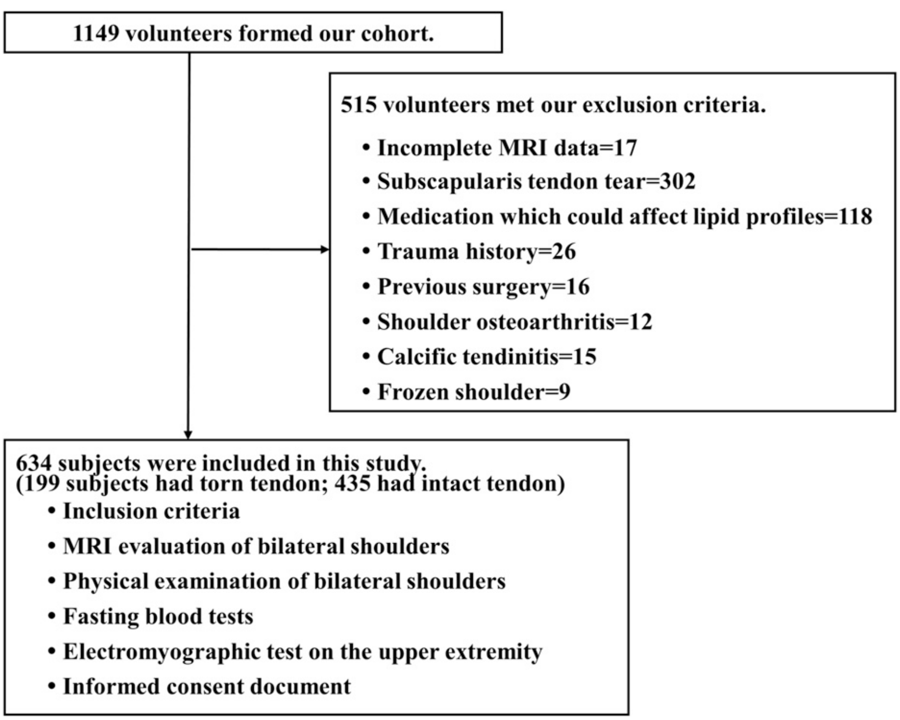

Fig. 1

Flowchart showing exclusion and inclusion criteria for this study. All 634 subjects met our inclusion criteria.

TABLE I Data on Age and Sex According to Occupation of Enrolled Subjects*

	No. (%)	Mean Age ± SD *(yr)*
Total enrolled	634 (100%)	59.1 ± 8.6
Male	307 (48.4%)	59.9 ± 8.9
Female	327 (51.6%)	58.3 ± 8.3
Agricultural worker	456 (71.9%)	58.8 ± 8.9
Male	216 (47.4%)	59.4 ± 9.1
Female	240 (52.6%)	58.2 ± 8.7
Office worker	178 (28.1%)	59.8 ± 7.9
Male	91 (51.1%)	61.1 ± 8.5
Female	87 (48.9%)	58.4 ± 6.9

*For the values for male and female, the percentage is of the given group (total enrolled, agricultural worker, or office worker). SD = standard deviation.

that might have affected serum lipid levels (118 subjects, 236 shoulders) (Fig. 1). Only 1 shoulder per subject was included in our analysis. In cases with either bilateral posterosuperior rotator cuff tears or no posterosuperior rotator cuff tear, 1 shoulder was randomly excluded (using random number generation). For subjects with a unilateral posterosuperior rotator cuff tear, only the involved shoulder was included. Therefore, the total number of subjects included in our analysis was 634 (634 shoulders).

We diagnosed a posterosuperior rotator cuff tear as either a partial-thickness or full-thickness tear, on the basis of MRI findings. High signal intensity within the cuff tendon that extended to the bursal or articular surface indicated a partial-thickness tendon tear. High signal intensity passing through the entire thickness of the tendon indicated a full-thickness tear[15]. The radiologist (J.B.N.) who diagnosed the tear was blinded to patients' laboratory and other clinical data.

The demographic factors that were evaluated were sex and age. The physical factors that were evaluated included height, weight, body mass index (BMI), waist circumference, and dominant-side involvement. The social factors that were considered were smoking, alcohol consumption, and participation in labor according to the volunteer's occupation. To facilitate interpretation and to clarify the association between increasing age and higher rotator cuff tear prevalence, we divided age into 5 categories: <40, 40 to 49, 50 to 59, 60 to 69, and ≥70 years of age. The investigated medical comorbidities were diabetes, hypertension, metabolic syndrome, hyper- and hypothyroidism, and ipsilateral carpal tunnel syndrome. We accepted prior diagnoses of diabetes, and we diagnosed new cases of diabetes on the basis of the finding of a serum glycosylated hemoglobin A1c (HbA1c) level of >6.4%. Hypertension was diagnosed according to previous medical history or the detection of a blood pressure level of >140 mm Hg for systolic or >90 mm Hg for diastolic pressure[16]. Clinical identification of metabolic syndrome was based on a subject's meeting 3 of the following 5 criteria: (1) a fasting plasma glucose level of ≥100 mg/dL or taking antidiabetic medication; (2) systolic blood pressure of ≥130 mm Hg, diastolic blood pressure of ≥85 mm Hg, or taking antihypertensive medication; (3) a serum triglyceride (TG) level of ≥150 mg/dL; (4) a serum high-density lipoprotein (HDL) level of <40 mg/dL for men or <50 mg/dL for women; and (5) a waist circumference of ≥90 cm for men or ≥85 cm for women[17,18]. The waist circumference criteria for obesity were adjusted according to Korean norms[19]. We also accepted prior diagnoses of hyper- and hypothyroidism as well as diagnosed additional cases of hyper- and hypothyroidism according to the results of thyroid function tests for which a serum free thyroxine (T4) level of >1.70 ng/dL indicated hyperthyroidism and a level of <0.93 ng/dL indicated hypothyroidism[20].

Prior studies have noted that carpal tunnel syndrome is associated with rotator cuff tears[11,21]. Therefore, we included the results of our carpal tunnel syndrome evaluations of all enrolled subjects. Carpal tunnel syndrome was diagnosed according to electrophysiological findings, after consideration of symptoms and findings on physical examination. Electrophysiological diagnosis was based on established criteria: a median nerve distal motor latency of >4.0 ms, distal sensory latency of >3.6 ms, or a distal sensory latency delay of >0.5 ms as compared with conduction measurements of the median nerve and the ulnar nerve in the fourth digit[22].

Serum lipid profiles were evaluated as scale and categorical variables. The scale variables were total cholesterol, low-density lipoprotein (LDL), TG, HDL, and non-HDL levels. The categorical variables included the following dyslipidemias: hypercholesterolemia (total cholesterol of ≥200 mg/dL), hyper-LDLemia (LDL of ≥100 mg/dL), hyper-TGmia (TG of ≥150 mg/dL), hypo-HDLemia (HDL of <40 mg/dL for men and <50 mg/dL for women), and hyper-non-HDLemia (non-HDL of ≥130 mg/dL). High-sensitivity C-reactive protein (hs-CRP) was also evaluated.

TABLE II Prevalence of Posterosuperior Rotator Cuff Tear (PSRCT)*

	Subjects with Complete MRI Study	Subjects Meeting All Inclusion Criteria
PSRCT	46.7% (529)	31.4% (199)
Full-thickness	17.4% (197)	11.2% (71)
Partial-thickness	29.3% (332)	20.2% (128)
Symptomatic PSRCT†	27.9% (316)	22.6% (143)
Full-thickness	12.0% (136)	10.7% (68)
Partial-thickness	15.9% (180)	11.8% (75)
Bilateral PSRCT	22.1% (250)	14.5% (92)‡

*A total of 1,132 subjects had complete MRI studies, and 634 met all inclusion criteria. The values are given as the percentage, with the number of subjects in parentheses. †Subjects with symptomatic PSRCT were identified using the criteria of Moosmayer et al.[24]. ‡The bilateral percentage came from data compiled before we excluded 1 shoulder for each of the 634 subjects.

TABLE III Summary of Demographic Data and Values (Prevalence, Mean, or Median) for Studied Variables*

Studied Variable	All Included	PSRCT Group	Intact Group
Male sex	307 (48.4%)	107 (53.8%)	200 (46.0%)
Age† *(yr)*	59.1 ± 8.6	61.9 ± 7.6	57.7 ± 8.8
No. (%) by age by category			
<40 yr	8 (1.3%)	0 (0.0%)	8 (1.8%)
40 to 49 yr	66 (10.4%)	11 (5.5%)	55 (12.6%)
50 to 59 yr	265 (41.8%)	66 (33.2%)	199 (45.7%)
60 to 69 yr	218 (34.4%)	86 (43.2%)	132 (30.3%)
≥70 yr	77 (12.1%)	36 (18.1%)	41 (9.4%)
Height‡ *(cm)*	161 (155-168)	162 (155-167)	161 (155-168)
Weight† *(kg)*	63 ± 9	64 ± 10	62 ± 9
BMI† *(kg/m²)*	24 ± 3	25 ± 3	24 ± 3
Waist circumference† *(cm)*	84 ± 8	86 ± 8	84 ± 8
No (%) by higher categories of waist circumference			
85-89.9 cm (women), 90-94.9 cm (men)	128 (20.2%)	35 (17.6%)	93 (21.4%)
90-94.9 cm (women), 95-99.9 cm (men)	93 (14.7%)	36 (18.1%)	57 (13.1%)
≥95 cm (women), ≥100 cm (men)	33 (5.2%)	14 (7.0%)	19 (4.4%)
Dominant-side involvement	314 (49.5%)	122 (61.3%)	192 (44.1%)
Smoking	211 (33.3%)	76 (38.2%)	135 (31.0%)
Alcohol consumption	424 (66.9%)	123 (61.8%)	301 (69.2%)
Manual labor	456 (71.9%)	183 (92.0%)	273 (62.8%)
Diabetes	92 (14.5%)	51 (25.6%)	41 (9.4%)
Hypertension	174 (27.4%)	66 (33.2%)	108 (24.8%)
Metabolic syndrome	210 (33.1%)	89 (44.8%)	121 (27.8%)
Hyperthyroidism	10 (1.6%)	3 (1.5%)	7 (1.6%)
Hypothyroidism	17 (2.7%)	5 (2.5%)	12 (2.8%)
Ipsilateral carpal tunnel syndrome	142 (22.4%)	55 (27.6%)	87 (20.0%)
Serum lipid levels *(mg/dL)*			
Total cholesterol†	198 ± 37	200 ± 35	198 ± 37
LDL†	132 ± 34	133 ± 33	131 ± 34
TG‡	107 (79-152)	109 (83-160)	104 (78-150)
HDL‡	55 (46-66)	54 (45-63)	57 (46-67)
Non-HDL†	141 ± 36	145 ± 35	140 ± 37
Dyslipidemia			
Hypercholesterolemia	292 (46.1%)	95 (47.7%)	197 (45.3%)
Hyper-LDLemia	525 (82.8%)	170 (85.4%)	355 (81.6%)
Hyper-TGmia	176 (27.8%)	65 (32.7%)	111 (25.5%)
Hypo-HDLemia	137 (21.6%)	62 (31.2%)	75 (17.2%)
Hyper-non-HDLemia	396 (62.5%)	131 (65.8%)	265 (60.9%)
hs-CRP‡ *(mg/L)*	1 (0-1)	1 (0-1)	1 (0-1)

*A total of 634 subjects were included, including 199 in the posterosuperior rotator cuff tear (PSRCT) group and 435 in the intact group. The values are given as the number, with the percentage in parentheses, or as otherwise noted. †The values are given as the mean and standard deviation. ‡The values are given as the median, with the interquartile range in parentheses.

Statistical Analysis

The associations between posterosuperior rotator cuff tears and specific factors, including general physical factors, social factors, comorbidities, and serum lipid profiles, were evaluated by calculating the odds ratios (ORs) with 95% confidence intervals (CIs) using logistic regression analyses. Univariate logistic regression analyses were performed for all variables; multiple logistic regression analyses were then performed on

TABLE IV Strengths of Associations Between Studied Variables and Posterosuperior Rotator Cuff Tear in Univariate Analyses

Studied Variable	OR (95% CI)	P Value
Male sex	1.37 (0.98-1.91)	0.069
Age	1.75 (1.43-2.14)	<0.001*
BMI (kg/m^2)	1.10 (1.04-1.18)	0.002*
Waist circumference	1.03 (1.01-1.06)	0.003*
Dominant-side involvement	2.01 (1.42-2.82)	<0.001*
Smoking	1.37 (0.97-1.95)	0.076
Alcohol consumption	0.72 (0.51-1.02)	0.067
Manual labor	6.79 (3.93-11.73)	<0.001*
Diabetes	3.31 (2.11-5.21)	<0.001*
Hypertension	1.50 (1.04-2.17)	0.030*
Metabolic syndrome	2.10 (1.48-2.98)	<0.001*
Hyperthyroidism	0.94 (0.24-3.66)	0.924
Hypothyroidism	0.91 (0.32-2.61)	0.859
Ipsilateral carpal tunnel syndrome	1.53 (1.04-2.26)	0.033*
Total cholesterol (mg/dL)	1.00 (1.00-1.01)	0.531
LDL (mg/dL)	1.00 (1.00-1.01)	0.469
TG (mg/dL)	1.00 (1.00-1.00)	0.339
HDL (mg/dL)	0.99 (0.98-1.00)	0.035*
Non-HDL (mg/dL)	1.00 (1.00-1.01)	0.133
Hypercholesterolemia	1.10 (0.79-1.55)	0.566
Hyper-LDLemia	1.32 (0.83-2.10)	0.238
Hyper-TGmia	1.42 (0.98-2.04)	0.063
Hypo-HDLemia	2.17 (1.47-3.21)	<0.001*
Hyper-non-HDLemia	1.24 (0.87-1.76)	0.236
hs-CRP (mg/L)	1.04 (0.98-1.11)	0.185

*Significant.

variables demonstrating significant associations. Because metabolic syndrome possibly has multicollinearity with BMI, diabetes, hypertension, and hypo-HDLemia, we performed 2 different multivariable analyses after assessment of multicollinearity, using factors with a variance inflation factor (VIF) and a conditional index. Multicollinearity was considered absent when both the VIF and conditional index were <10[23]. Goodness of fit for the multivariable logistic regression model was determined by the Hosmer-Lemeshow test. All statistical analyses were performed using SPSS software (version 21.0; IBM). Significance for the logistic analyses was set at the level of $p < 0.05$. Significance for the Hosmer-Lemeshow test was set at $p > 0.05$.

Results

The 634 subjects had a mean age (and standard deviation) of 59.1 ± 8.6 years. Among the 327 female participants (51.6%), the mean age was 58.3 ± 8.3 years, and among the 307 male participants (48.4%), it was 59.9 ± 8.9 years. Age-related data are summarized in Table I.

The prevalence of posterosuperior rotator cuff tears was 31.4% (199 of 634). Of the 634 subjects, 11.2% (71) had a full-thickness posterosuperior rotator cuff tear and 20.2% (128) had a partial-thickness tear. The prevalence of symptomatic posterosuperior rotator cuff tears, according to the criteria of Moosmayer et al.[24], was 22.6% (143 of 634). The prevalence data for all participants with a complete MRI study and for the subjects who were ultimately included in our analysis are summarized in Table II.

Demographic data and the prevalence, mean, or median for each of the studied variables are summarized in Table III.

In univariate analyses, age, BMI, waist circumference, dominant-side involvement, manual labor, diabetes, hypertension, metabolic syndrome, ipsilateral carpal tunnel syndrome, HDL, and hypo-HDLemia were significant variables. The ORs for all variables, with 95% CIs, are presented in Table IV.

For the first multivariable analysis, we excluded metabolic syndrome and included BMI, diabetes, hypertension, and hypo-HDLemia as well as age, dominant-side involvement, manual labor, and ipsilateral carpal tunnel syndrome; no multicollinearity among the 8 studied variables was shown. Age (OR, 1.86 [95% CI, 1.47 to 2.35]; $p < 0.001$), BMI (OR, 1.09 [95% CI, 1.02 to 1.18]; $p = 0.019$), dominant-side involvement (OR, 2.04 [95% CI, 1.38 to 3.01]; $p < 0.001$), manual labor (OR, 9.48 [95% CI, 5.13 to 17.51]; $p < 0.001$), diabetes (OR, 3.38 [95% CI, 1.98 to 5.77]; $p < 0.001$), and hypo-HDLemia (OR, 2.07 [95% CI, 1.30 to 3.29]; $p = 0.002$) were significantly associated with posterosuperior rotator cuff tears. The VIF, conditional index, and ORs with 95% CIs for all of the variables are summarized in Table V. The p value of the Hosmer-Lemeshow test was 0.775, indicating a good fit.

The second multivariable analysis included age, dominant-side involvement, manual labor, metabolic syndrome, and

TABLE V Strengths of Associations Between Studied Variables and Posterosuperior Rotator Cuff Tear on Multivariable Analysis: Metabolic Syndrome Excluded*

Studied Variable	OR (95% CI)	P Value
Age	1.86 (1.47-2.35)	<0.001†
BMI (kg/m^2)	1.09 (1.02-1.18)	0.019†
Dominant-side involvement	2.04 (1.38-3.01)	<0.001†
Manual labor	9.48 (5.13-17.51)	<0.001†
Diabetes	3.38 (1.98-5.77)	<0.001†
Hypertension	1.05 (0.68-1.62)	0.824
Ipsilateral carpal tunnel syndrome	0.78 (0.50-1.22)	0.276
Hypo-HDLemia	2.07 (1.30-3.29)	0.002†

*The variance inflation factor (VIF) and the conditional index were 1.136 and 5.088, respectively; the p value of the Hosmer-Lemeshow test was 0.775. †Significant.

TABLE VI Strengths of Associations Between Studied Variables and Posterosuperior Rotator Cuff Tear on Multivariable Analysis: BMI, Diabetes, Hypertension, and Hypo-HDLemia Excluded*

Studied Variable	OR (95% CI)	P Value
Age	1.85 (1.48-2.31)	<0.001†
Dominant-side involvement	1.83 (1.26-2.67)	0.002†
Manual labor	7.71 (4.33-13.73)	<0.001†
Metabolic syndrome	1.98 (1.35-2.91)	<0.001†
Ipsilateral carpal tunnel syndrome	0.88 (0.57-1.35)	0.555

*The variance inflation factor (VIF) and the conditional index were 1.093 and 4.563, respectively; the p value of the Hosmer-Lemeshow test was 0.615. †Significant.

ipsilateral carpal tunnel syndrome. There was no multicollinearity among the 5 variables. Age (OR, 1.85 [95% CI, 1.48 to 2.31]; $p < 0.001$), dominant-side involvement (OR, 1.83 [95% CI, 1.26 to 2.67]; $p = 0.002$), manual labor (OR, 7.71 [95% CI, 4.33 to 13.73]; $p < 0.001$), and metabolic syndrome (OR, 1.98 [95% CI, 1.35 to 2.91]; $p < 0.001$) were significantly associated with posterosuperior rotator cuff tears. The VIF, conditional index, and ORs with 95% CIs for all of the variables are summarized in Table VI. The p value of the Hosmer-Lemeshow test was 0.615, indicating a good fit.

Discussion

This study demonstrated that, in a general population from rural South Korea, atraumatic posterosuperior rotator cuff tears were significantly associated with age, dominant-side involvement, manual labor, diabetes, BMI, hypo-HDLemia, and metabolic syndrome. The ORs of these factors, with the exception of BMI, suggest substantial clinical relevance.

Previous studies indicated that the prevalence of posterosuperior rotator cuff tears increases with age and that age is a risk factor for posterosuperior rotator cuff tears[2,25-34]. Our study further establishes that age is an independent risk factor for a posterosuperior rotator cuff tear, supporting the consensus that an atraumatic posterosuperior rotator cuff tear is a result of the degenerative process that accompanies aging[28,30].

Controversy exists as to whether a posterosuperior rotator cuff tear more commonly affects the dominant upper extremity. Milgrom et al. found no relation between hand dominance and asymptomatic rotator cuff tears[30]. Keener et al. reported that hand dominance is related to symptomatic rotator cuff tears, especially tears involving shoulder pain[35]. In the present study, which included participants with asymptomatic and symptomatic posterosuperior rotator cuff tears, we found atraumatic posterosuperior rotator cuff tears to be more prevalent in the dominant upper extremity[34]. In a general-population study similar to ours, Yamamoto et al. reported a similar association between posterosuperior rotator cuff tears and the dominant upper extremity[2]. Our finding that manual labor was significantly associated with posterosuperior rotator cuff tears is consistent with the expectation that the dominant upper extremity has greater exposure to repetitive and overuse activities.

The finding that the manual labor involved in agricultural work is significantly associated with posterosuperior rotator cuff tears is consistent with other epidemiologic studies indicating a high prevalence of rotator cuff tears among manual laborers, including agricultural workers[3,27,36,37]. Additionally, our results support those of previous biomechanical studies that suggested that manual labor activities, including sustained or repeated arm abduction, heavy lifting or carrying, high task repetitiveness, and physical exertion, are associated with posterosuperior rotator cuff tears[36,38,39].

The finding that diabetes is strongly associated with posterosuperior rotator cuff tears is consistent with the findings of several previous studies noting diabetes as a risk factor for a rotator cuff tear and for a retear after rotator cuff repair[26,34,40]. It was recently reported that even plasma glucose levels at the high end of the normal range may be a risk factor for a rotator cuff tear[9]. Other authors reported a significant association between hyperglycemia and Achilles tendon tendinopathy and considered insulin resistance, an aspect of metabolic syndrome, as a possible cause[41]. Our study also found that metabolic syndrome, which is strongly related to insulin resistance and hyperglycemia[13], was associated with posterosuperior rotator cuff tears. On the molecular level, hyperglycemia induces oxidative stress and cytokine production, which lead to inflammation and result in damage in various tissues[42-45]. Hyperglycemia alters collagen structure through a glycation process[46,47] and also reduces proteoglycan levels through decreased synthesis or sulfation of glycosaminoglycans[48]. These molecular mechanisms may affect rotator cuff tendon degeneration.

Our finding of a significant association between BMI and posterosuperior rotator cuff tears is consistent with previous studies noting that both BMI and percentage of body fat are strongly associated with the prevalence and severity of rotator cuff tears[6,8]. One proposed mechanism of the effect of obesity on tendon degeneration is cellular inflammation through the disturbed production of adipokines in adipose tissue; decreased production of adiponectin and increased leptin resistance induce intracellular reactive oxygen species, which induce inflammation and apoptosis of cells[49,50]. In obesity, oxidative stress on tendons may be accelerated by increased proinflammatory cytokines, including plasminogen activator inhibitor, tumor necrosis factor (TNF)-α, angiotensinogen, and interleukins 6, 8, 10, and 18[50]. The present study did not evaluate an association between obesity and adipokines but did confirm that obesity, a factor of metabolic syndrome, is significantly associated with posterosuperior rotator cuff tears. However, the strength of association between BMI and a posterosuperior rotator cuff tear was low compared with that of the other studied metabolic parameters. Therefore, the clinical relevance of obesity may not be substantial.

The relationship between serum lipids and rotator cuff tears remains unclear[7,8,51]. In the current study, we found that hypo-HDLemia was significantly associated with posterosuperior rotator cuff tears. Abboud and Kim reported that serum levels of total cholesterol, TG, and LDL were higher and of HDL were lower among patients with a rotator cuff tear compared with a control group[51]. Djerbi et al. reported that the prevalence of rotator cuff tears was greater among patients with dyslipidemia[7]. Abate et al. reported that lower levels of HDL and higher levels of TG were significantly more prevalent among women with a rotator cuff tear[8]. However, Longo et al. reported no association between rotator cuff tears and either serum TG concentration or serum total cholesterol concentration[12].

Metabolic syndrome is a well-known risk factor for various degenerative diseases, including cardiovascular disease, stroke, and diabetes as well as osteoarthritis and Achilles enthesopathy[13,52-54]. We found that metabolic syndrome was significantly associated with posterosuperior rotator cuff tears. The authors of a previous study reported metabolic syndrome as a possible risk factor for shoulder pain in men but were unable to demonstrate a significant association between metabolic syndrome and rotator cuff tears because rotator cuff integrity was not evaluated[14]. Our univariate analysis showed that a number of components of metabolic syndrome were significantly associated with posterosuperior rotator cuff tears. The associations between posterosuperior rotator cuff tears and several factors, including obesity, diabetes, and dyslipidemia, suggest a molecular link between posterosuperior rotator cuff tears and metabolic syndrome. This finding strongly suggests that metabolic syndrome is a risk factor for a posterosuperior rotator cuff tear, although the molecular mechanism and the pathophysiology of that association have not been determined.

This investigation had several limitations. Although this was a cohort study, we were only able to include subjects who volunteered, and they may not be representative of the entire population. Agricultural workers made up a major portion of this investigation's population, and their characteristics may not be generalizable to populations in other locations. Because labor activity was significantly associated with posterosuperior rotator cuff tears, the rates of cuff tear may be higher in this cohort than in the general population. It is also possible that a dietary difference exists between this study's cohort and an urban population and this could affect metabolic parameters. However, the American and European heart associations do not accept rural residence as a conventional cardiovascular risk factor[55,56]. Although this cross-sectional study did demonstrate a significant association between diabetes and posterosuperior rotator cuff tears and between hypo-HDLemia and posterosuperior rotator cuff tears, we could not evaluate the cumulative effects of serum lipid abnormalities on posterosuperior rotator cuff tears and any association between the duration or severity of diabetes and posterosuperior rotator cuff tears. We evaluated the association between labor and rotator cuff tears, but we did not evaluate according to the specific type of occupation or sports activity, or the cumulative effect of labor. While the importance of the significantly associated factors is not affected by these limitations, the relevance to other populations may be limited.

The present study also had strengths. Posterosuperior rotator cuff tears were diagnosed using MRI findings. In the previous general-population studies[2,27], the existence of a rotator cuff tear was determined by ultrasound instead of MRI, which has higher interobserver reliability[57]. In addition, MRI findings are also more useful for diagnosing subscapularis tendon tears, so in the current study, we were able to exclude subscapularis tendon tears[58]. Lastly, the inclusion and study of a general population likely provides information about the pathogenesis of rotator cuff tears that is less biased than that of studies of cohorts with symptomatic rotator cuff tears.

In summary, the metabolic factors of diabetes, BMI, hypo-HDLemia, and metabolic syndrome were significant independent factors associated with the development of a posterosuperior rotator cuff tear. ■

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