Clin Orthop Relat Res (2022) 480:96-105
DOI 10.1097/CORR.0000000000001949

Clinical Orthopaedics and Related Research®
A Publication of The Association of Bone and Joint Surgeons®

Systematic Review and Meta-analysis

OPEN

What Factors Are Associated with Symptomatic Rotator Cuff Tears: A Meta-analysis

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Received: 26 April 2021 / Accepted: 2 August 2021 / Published online: 23 August 2021

Abstract

Background Rotator cuff tears are common. A previous systematic review reported on factors associated with rotator cuff tears; however, it included relatively few studies and few variables, and in addition, it had considerable heterogeneity. To identify the factors associated with symptomatic rotator cuff tears and to help guide clinicians to potentially modifiable factors, we felt a broader and more inclusive meta-analysis would be useful.

Questions/purposes In this systematic review and meta-analysis, we asked what (1) demographic, (2) disease, and (3) imaging factors are associated with symptomatic rotator cuff tears?

Methods PubMed, Embase, and Web of Science were searched, and the search period were from the inception of each database through February 2021. The keywords included "risk factor," "rotator cuff injury," "rotator cuff tears," and "rotator cuff tendinitis." All comparative studies on symptomatic rotator cuff tears were included. We considered that the diagnosis of rotator cuff tear could be made by any imaging tool (MRI or ultrasound). We

This work was supported by the National Natural Science Foundation of China (No. 81974574 [WYY], No. 81873314 [JL], No. 82004386 [JKP], No. 82004383 [LFZ]), the Project of Administration of Traditional Chinese Medicine of Guangdong Province (No. 20201129 [GHL]), the Project of Guangdong Provincial Department of Finance (No. [2014]157, No. [2018]8 [JL]), the Medical Science Research Foundation of Guangdong Province (No. A2020105, No. B2019091 [GHL]), the Science and Technology Planning Project of Guangdong Province (No. 2020A1414050050 [JL]), the Science and Technology Planning Project of Guangzhou (No. 202102010273 [JL]), and the Science and Technology Research Project of Guangdong Provincial Hospital of Chinese Medicine (No. YN2019ML08, No. YN2015MS15 [JL]).
Each author certifies that there are no funding or commercial associations (consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted article related to the author or any immediate family members.
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considered either partial- or full-thickness tears to be a rotator cuff tear. No language restrictions were applied. Twenty-six articles from 14 countries involving 9809 individuals, consisting of 3164 patients and 6645 controls, were included. The Newcastle-Ottawa Scale and the Agency for Healthcare Research and Quality (AHRQ) scale were used to evaluate the risk of bias of the included studies, and the highest scores were 9 and 11, respectively. The Newcastle-Ottawa Scale was used for retrospective comparative studies, and the AHRQ was used to evaluate prospective comparative studies. The eight retrospective comparative studies we included were scored from 4 to 9. The quality score of the 18 prospective comparative studies ranged from 6 to 9. Publication bias was explored using the Egger test. Heterogeneity was estimated using the I^2 value. If there was no heterogeneity ($I^2 \leq$ 50%), a fixed-effects model was used to determine the overall effect size; if there was heterogeneity ($I^2 >$ 50%), a random-effects model was used to merge the effect values. A meta-analysis was performed with RevMan 5.3, and the risk ratio (RR) and weighted mean difference of related factors were calculated.

Results Our meta-analysis identified the following demographic factors associated with an increased risk of rotator cuff tears: older age (mean difference 3.1 [95% CI 1.4 to 4.8]; p < 0.001), greater BMI (mean difference 0.77 [95% CI 0.37 to 1.17]; p < 0.001), smoking (RR 1.32 [95% CI 1.17 to 1.49]; p < 0.001), dominant arm (RR 1.15 [95% CI 1.06 to 1.24]; p < 0.001), greater height (mean difference 0.9 [95% CI 0.4 to 1.4]; p < 0.001), and heavier weight (mean difference 2.24 [95% CI 0.82 to 3.66]; p = 0.002). Regarding disease factors, we found that traumatic events (RR 1.91 [95% CI 1.40 to 2.54]; p < 0.001) and hypertension (RR 1.50 [95% CI 1.32 to 1.70]; p < 0.001) were associated with symptomatic rotator cuff tears. Regarding imaging factors, we found that the following three factors were associated with symptomatic rotator cuff tears: greater acromion index (mean difference 0.11 [95% CI 0.06 to 0.16]; p < 0.001), greater critical shoulder angle (mean difference 1.9 [95% CI 1.5 to 2.3]; p < 0.001), and smaller glenoid version angle (mean difference -1.3 [95% CI -1.9 to -0.8]; p < 0.001). We found no association between the patient's sex or the presence or absence of thyroid disease and the likelihood of a rotator cuff tear being present.

Conclusion This study identified several factors associated with symptomatic rotator cuff tears, including blood glucose, blood pressure, weight, and smoking. Clinicians may seek to modify these factors, possibly in patients with symptomatic rotator cuff tears, but also in symptomatic patients who have not yet been diagnosed with rotator cuff tears because there would be no harm or risk associated with modifying any of the factors we identified. Future research should further study whether addressing these factors can delay the progression and size of rotator cuff tears.

Level of Evidence Level III, prognostic study.

Introduction

Rotator cuff tears are one of the most common causes of shoulder pain and limited movement [30, 50]. Despite their great frequency, the pathogenesis of cuff tears is not well known [52]. In the past 15 years, the number of rotator cuff tears in Western countries has increased substantially [13]. The costs of the rotator cuff repair are substantial; the annual medical cost in the United States is between USD 1.2 and USD 1.6 billion [13]. Clarifying the factors associated with symptomatic rotator cuff tears and educating patients or the general population about how to control any modifiable factors may help to reduce the occurrence and progression of rotator cuff tears. Identifying risk factors believed to be associated with cuff tears might also help individual clinicians ascertain the likelihood of a rotator cuff injury being present in a particular patient; this could guide the utilization of screening tests.

One systematic review reported several factors associated with rotator cuff tears [54], but it included few studies and evaluated few variables. In addition, heterogeneity was a concern. These shortcomings limit the ability of clinicians to more fully understand the factors associated with symptomatic rotator cuff tears as well as to formulate prevention and treatment strategies. In addition, it would be helpful to include parameters related to shoulder anatomy, such as critical shoulder angle and glenoid version angle [63, 65]. Finally, studies have disagreed to some degree on which factors are or are not associated with rotator cuff tears [2, 7, 25, 54, 57], which suggests that a meta-analysis may be helpful.

We therefore performed a systematic review and meta-analysis, in which we asked: What (1) demographic, (2) disease, and (3) imaging factors are associated with symptomatic rotator cuff tears?

Materials and Methods

Search Strategy

We electronically searched PubMed, Embase, and Web of Science. Combinations of MeSH words and free words were used in the search. Articles published from the establishment of each database through February 2021 were considered potentially eligible. We completed the search in February 2021. The keywords included "risk factor," "rotator cuff injury," "rotator cuff tears," and ""rotator cuff tendinitis" (Supplemental Digital Content 1, http://links.lww.com/CORR/A620).

Inclusion and Exclusion Criteria

We compared patients diagnosed with rotator cuff tears with a group of controls, defined as the study group. We

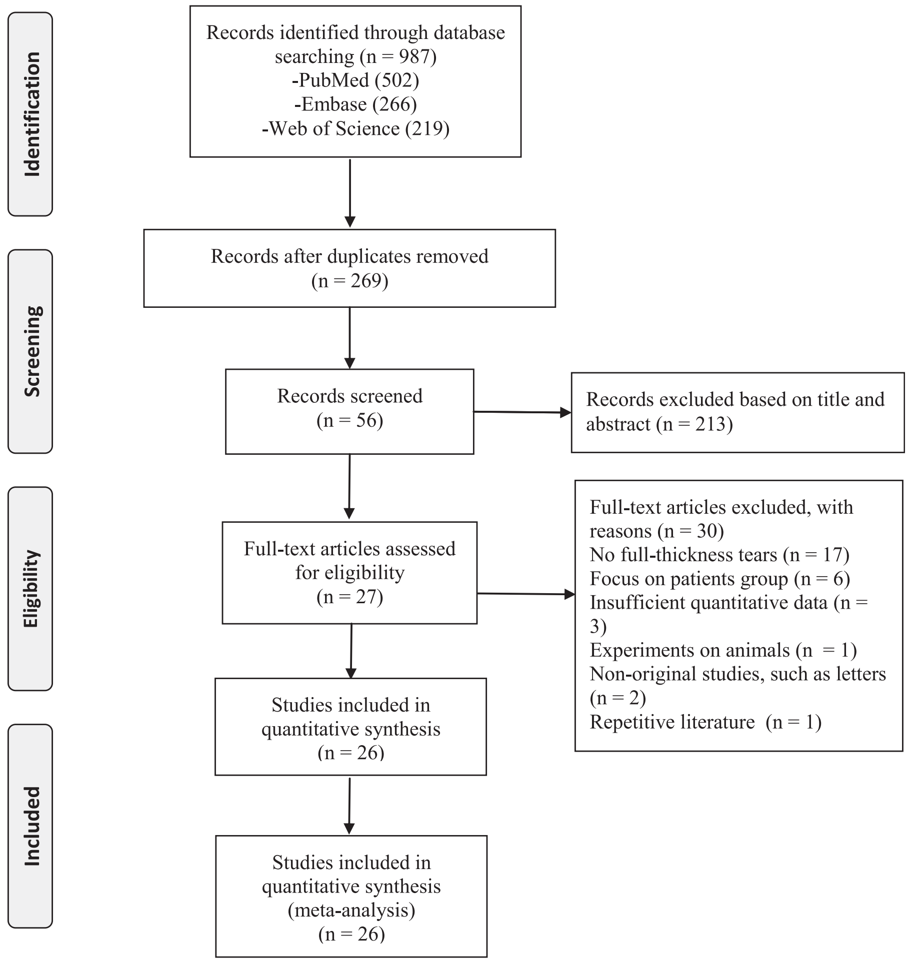

Fig. 1 This flow diagram shows the number of studies identified and included in this meta-analysis.

included studies that involved patients with rotator cuff tears (regardless of rotator cuff tear type) and control groups of patients without rotator cuff tears, as well as studies in which the study and control groups were identified based on tools such as MRI. We also included prospective or retrospective studies with control groups and those that used at least one formal evaluation index that measured demographic, disease, or imaging factors. No language restrictions were implemented.

The exclusion criteria were duplicate studies, grey literature (unpublished studies, abstracts, preprint articles), studies whose data could not be converted and merged, and studies of low quality (Newcastle-Ottawa Scale score < 4 and Agency for Healthcare Research and Quality [AHRQ] score < 4).

Study Screening and Data Extraction

Two researchers (ML, JP) independently screened the studies, extracted data, and cross-checked the data. Disagreements were settled through discussion or negotiation with a third party (JL). After duplicate data were removed from the data retrieved, the abstracts and full texts were read to determine whether the study should be included. If necessary, we contacted the corresponding author of the original study by email or telephone to obtain information that was important for this study. The extracted information comprised basic study information, including the first author, publication date, and study design; baseline characteristics of the participants, including the sampling and imaging methods; key elements of the risk of bias assessment; and relevant outcome indicators and measurement data.

Search Results

We identified 987 studies, and 269 papers remained after we removed duplicates. After reading the title and abstract, we were left with 56 articles. After re-reading the full text, we excluded 30 articles that did not meet the inclusion

Table 1. Characteristics of studies included in this review

Author	Publication year	Country	Design	Ethical approval	Number of patients		Imaging modality	NOS or AHRQ score
					Rotator cuff tear	No Tear		
Abate et al. [1]	2014	Italy	Prospective, comparative study	Yes	27	205	Ultrasound	7[a]
Watanabe et al. [62]	2018	Japan	Retrospective, comparative study	Yes	54	54	MRI	6[b]
Applegate et al. [4]	2016	USA	Prospective, comparative study	Yes	156	1070	MRI	7[a]
Atala et al. [5]	2020	Argentina	Prospective, comparative study	Yes	52	53	MRI	8[a]
Bjarnison et al. [9]	2017	Denmark	Retrospective, comparative study	Yes	95	285	MRI	9[b]
Blonna et al. [10]	2015	Italy	Prospective, comparative study	Yes	40	80	MRI	8[a]
Cunningham et al. [16]	2018	Switzerland	Prospective, comparative study	Yes	33	38	MRI	7[a]
Dogan et al. [17]	2012	Turkey	Retrospective, comparative study	Yes	62	60	MRI	7[b]
Figueiredo et al. [20]	2020	Brazil	Prospective, comparative study	Yes	211	567	MRI	6[a]
Gumina et al. [24]	2013	Italy	Retrospective, comparative study	Yes	215	201	MRI	5[b]
Haveri et al. [27]	2020	India	Prospective, comparative study	Yes	69	31	MRI	8[a]
İncesoy et al. [28]	2020	Turkey	Retrospective, comparative study	Yes	437	433	MRI	8[b]
Jeong et al. [31]	2016	Korea	Prospective, comparative study	Yes	23	355	Ultrasound	6[a]
Jeong et al. [29]	2020	Korea	Retrospective, comparative study	Yes	40	160	MRI	7[b]
van Kampen et al. [61]	2014	Netherlands	Prospective, comparative study	Yes	38	62	MRA	9[a]
Kim et al. [34]	2018	Korea	Prospective, comparative study	Yes	214	109	MRI	7[a]
Lee et al. [37]	2015	China	Prospective, comparative study	Yes	140	176	Ultrasound	6[a]
Longo et al. [40]	2009	UK	Retrospective, comparative study	NR	97	97	Imaging	5[b]
Mehta et al. [41]	2020	USA	Prospective, comparative study	Yes	49	305	Ultrasound	9[a]
Mohamed et al [43]	2014	Egypt	Prospective, comparative study	Yes	56	30	MRI	6[a]
Motta et al. [44]	2014	USA	Prospective, comparative study	Yes	203	207	MRI	6[a]
Park et al. [48]	2018	Korea	Prospective, comparative study	Yes	199	435	MRI	7[a]
Passaretti et al. [49]	2016	Italy	Prospective, comparative study	Yes	249	356	MRI	6[a]
Shinagawa et al. [56]	2018	Japan	Prospective, comparative study	Yes	112	183	MRI or ultrasound	8[a]

Table 1. continued

Author	Publication year	Country	Design	Ethical approval	Number of patients		Imaging modality	NOS or AHRQ score
					Rotator cuff tear	No Tear		
Spiegl et al. [58]	2015	USA	Retrospective, comparative study	Yes	10	10	MRI	4[b]
Yamamoto et al. [64]	2010	Japan	Prospective, comparative study	Yes	283	1083	Ultrasound	8[a]

[a]AHRQ = American Agency for Healthcare Research and Quality (0-11 points).
[b]NOS = Newcastle-Ottawa Scale (0-9 points); for both scales, the higher the score, the better the quality of the study; RCT = rotator cuff tear; NR = not reported.

criteria, and leaving 26 articles [1, 4, 5, 9, 10, 16, 17, 20, 24, 27, 28, 29, 31, 34, 37, 40, 41, 43, 44, 48, 49, 56, 58, 61, 62, 64] in our study (Fig. 1).

Basic Characteristics of the Included Studies

Twenty-six articles from 14 countries were included; 18 were prospective comparative studies and eight were retrospective comparative studies (Table 1). A total of 9809 patients were included in this study, with 3164 in the study group and 6645 in the control group. Seventeen associated factors were identified.

Assessment of Study Quality

The Newcastle-Ottawa Scale was used to evaluate the risk of bias of the retrospective comparative studies included in our review [59]. The following three aspects were assessed: the research participant selection process, level of intergroup comparability, and data measurement process. The total possible score was 9 points, with higher scores indicating better study quality. The prospective comparative studies were evaluated using the risk of bias evaluation standards recommended by the AHRQ [14], with 11 items in total. The response options for each item were yes, no, or not clear. The higher the score, the higher the quality of the study.

In total, eight retrospective comparative studies had quality scores of 4 to 9 (Table 1). The quality score of the 18 prospective comparative studies ranged from 6 to 9. These results suggest that the included studies had a low risk of bias and high methodological quality (Supplemental Digital Content 2, http://links.lww.com/CORR/A621).

This meta-analysis was performed in strict accordance with the requirements of the Meta-analysis of Observational Studies in Epidemiology statement [60] and was registered with the PROSPERO International Prospective Register of Systematic Reviews (registration number: CRD42021239990).

Quantitative Analysis

RevMan 5.3 software (Cochrane Collaboration) was used for the meta-analysis. The weighted mean difference was used to determine the effect size of the measurement data, and the risk ratio (RR) was used to determine the effect size for categorical variables. The 95% confidence interval for each effect size was calculated. A heterogeneity test was used to evaluate the heterogeneity of the included studies. If there was no heterogeneity ($I^2 \leq 50\%$), a fixed-effects model was used to determine the overall effect size; if there was heterogeneity ($I^2 > 50\%$), a random-effects model was used to merge the effect values [11]. According to the heterogeneity test results, the heterogeneity levels of BMI (I^2 = 11%), male sex (I^2 = 50%), smoking (I^2 = 49%), dominant arm (I^2 = 18%), height (I^2 = 0%), weight (I^2 = 0%), traumatic events (I^2 = 35%), hypertension (I^2 = 0%), thyroid disease (I^2 = 0%), critical shoulder angle (I^2 = 23%), and glenoid version angle (I^2 = 0%) were low. The heterogeneity values of age (I^2 = 94%), female sex (I^2 = 51%), diabetes mellitus (I^2 = 86%), acromion index (I^2 = 83%), lateral acromion angle (I^2 = 88%), and acromiohumeral distance (I^2 = 92%) were high (Supplemental Digital Content 3, http://links.lww.com/CORR/A622). For the outcome indicators included in three or more articles, Stata 15.1 software (StataCorp LLC) was used to conduct an Egger test to evaluate publication bias.

The results of the Egger test showed that there was no publication bias related to the outcome indicators of this study with combined data from three or more articles ($p > 0.05$) (Supplemental Digital Content 4, http://links.lww.com/CORR/A623).

Results

Demographic Factors

The results of the meta-analysis showed that older age (mean difference 3.1 [95% CI 1.4 to 4.8]; $p < 0.001$), BMI (mean difference 0.77 [95% CI 0.37 to 1.17]; $p < 0.001$), smoking

(RR 1.32 [95% CI 1.17 to 1.49]; p < 0.001), injured dominant arm (RR 1.15 [95% CI 1.06 to 1.24]; p < 0.001), height (mean difference 0.9 [95% CI 0.4 to 1.4]; p < 0.001), and weight (mean difference 2.24 [95% CI 0.82 to 3.66]; p = 0.002) were factors associated with rotator cuff tears. In addition, our results suggest that sex (RR 0.98 [95% CI 0.92 to 1.05]; p = 0.64 for female versus male) was not a factor associated with rotator cuff tears (Table 2).

Disease Factors

Our meta-analysis revealed that traumatic events (RR 1.91 [95% CI 1.40 to 2.54]; p < 0.001) and hypertension (RR 1.50 [95% CI 1.32 to 1.70]; p < 0.001) were associated with rotator cuff tears; however, diabetes mellitus (RR 1.22 [95% CI 0.72 to 2.07]; p = 0.47) was not. In addition, we found no association between the presence of thyroid disease and the likelihood of a rotator cuff tear being present (RR 0.88 [95% CI 0.45 to 1.73]; p = 0.71) (Table 2).

Imaging Factors

The meta-analysis showed that a greater acromion index (mean difference 0.11 [95% CI 0.06 to 0.16]; p < 0.001), a larger critical shoulder angle (mean difference 1.9 [95% CI 1.5 to 2.3]; p < 0.001), and a smaller glenoid version angle (mean difference -1.3 [95% CI -1.9 to -0.8]; p < 0.001) were factors associated with rotator cuff tears. The lateral acromion angle and acromiohumeral distance had no correlation with symptomatic rotator cuff tears (Table 2).

Discussion

Rotator cuff tears are common, they substantially reduce patients' quality of life, and they impose a heavy economic burden on patients and healthcare systems. Although many studies have evaluated the factors associated with rotator cuff tears, there is a lack of high-quality systematic review articles; such sources can help aggregate data and focus clinicians' attention on the factors that matter most. We collected and assessed the best-available evidence about factors associated with rotator cuff tears, including demographic factors, disease factors, and imaging parameters, and we identified a number of potentially modifiable factors associated with symptomatic rotator cuff tears, including blood glucose control, blood pressure, weight, and cigarette smoking. These findings may help clinicians to intervene to the benefit of patients who have symptoms but who have not yet developed a cuff tear. Future research can further assess whether controlling these associated factors can delay the progression and size of rotator cuff tears.

Limitations

There are some limitations to this study. First, the study population was mainly patients with symptomatic shoulder pain or dyskinesia, so the conclusion of this study is only applicable to patients with symptomatic rotator cuff tears. In addition, our study is about factors associated with rotator cuff tears; the papers included in our analysis could not prove causation. Whether the factors identified in this study can, in fact, influence the progression of rotator cuff tears in patients with shoulder symptoms who are not diagnosed with rotator cuff tears is worthy of further study. Another limitation is the heterogeneity of the included studies, which were of various designs, came from different countries, included patients of a variety of races, and were performed in diverse medical economic environments. In particular, the factors of age, diabetes, acromion index, lateral acromion angle, and acromiohumeral distance were associated with greater heterogeneity, and they should be interpreted accordingly. Future studies including larger sample sizes and less heterogeneity should be considered. However, the fact that the source studies came from diverse environments and included patients of different races and were performed in different settings may offer a measure of generalizability, which may be perceived as advantageous. Finally, the low level of evidence and lack of prospective cohort studies is concerning; however, we restricted inclusion to papers with a Newcastle-Ottawa Scale assessment or AHRQ score of four or more (Supplemental Digital Content 2, http://links.lww.com/CORR/A621), which generally suggests intermediate or better study quality.

Demographic Factors

Older age, greater BMI, smoking, dominant hand, and greater height and weight were factors associated with symptomatic rotator cuff tears; by contrast, sex (male or female) was not associated with symptomatic rotator cuff tears. With increasing age, the incidence of symptomatic rotator cuff tears is higher, which has been recognized by many studies [44, 46, 55]. In older people, the number of microvessels in the tendon is substantially reduced, which makes the rotator cuff tissue more prone to fibrovascular hyperplasia, adiposis, atrophy, and calcification, which may be more likely to be associated with rotator cuff tears [44, 53]. One study found the risk of rotator cuff injury in people older than 60 years was 5.07 times that in people younger than 60 years [54]. Although obviously age is a continuous variable (that is, the difference probably will not be so dramatic between a patient who is 59 and a patient who is 61), the evidence suggests that surgeons certainly can consider older patients as being at higher risk. Increases in BMI are closely related to rotator cuff tendinitis and rotator cuff tears [23]. There is a theory that with

Table 2. Outcomes of the meta-analysis

Risk factor	Number of studies	RR or WMD (95% CI)	p value	I^2, %	Analysis model
Demographic factors					
Age in years	24	WMD 3.1 (1.4-4.8)	< 0.001	94	IV, random
BMI in kg/m^2	5	WMD 0.77 (0.37-1.17)	< 0.001	11	IV, fixed
Female sex	23	RR 0.98 (0.92-1.05)	0.64	51	M-H, random
Male sex	22	RR 1.03 (0.97-1.08)	0.31	50	M-H, fixed
Smoking, yes versus no	9	RR 1.32 (1.17-1.49)	< 0.001	49	M-H, fixed
Dominant arm	7	RR 1.15 (1.06-1.24)	< 0.001	18	M-H, fixed
Height in cm	2	WMD 0.9 (0.4-1.4)	< 0.001	0	IV, fixed
Weight in kg	2	WMD 2.24 (0.82-3.66)	0.002	0	IV, fixed
Underlying disease					
Traumatic events, yes versus no	3	RR 1.91 (1.40-2.54)	< 0.001	35	M-H, fixed
Diabetes mellitus, yes versus no	7	RR 1.22 (0.72-2.07)	0.47	86	M-H, random
Hypertension, yes versus no	5	RR 1.50 (1.32-1.70)	< 0.001	0	M-H, fixed
Thyroid disease, yes versus no	4	RR 0.88 (0.45-1.73)	0.71	0	M-H, fixed
Morphologic parameters					
AI	3	WMD 0.11 (0.06-0.16)	< 0.001	83	IV, random
LAA in °	2	WMD -3.7 (-8.2 to 0.9)	0.11	88	IV, random
CSA in °	6	WMD 1.9 (1.5-2.3)	< 0.001	23	IV, fixed
GVA in °	2	WMD -1.3 (-1.9 to -0.8)	< 0.001	0	IV, fixed
AD in mm	2	WMD -0.8 (-2.4 to 0.8)	0.32	92	IV, random

A forest plot of all risk factors is shown in Supplementary Material 3 (Supplemental Digital Content 3, http://links.lww.com/CORR/A622). RR = relative risk; WMD = weighted mean difference; IV = inverse variance; M-H = Mantel Haenszel test; AI = acromion index; LAA = lateral acromion angle; CSA = critical shoulder angle; GVA = glenoid version angle; AD = acromiohumeral distance.

increasing BMI, there is more serious microvascular damage after a slight rotator cuff injury, which impairs rotator cuff repair and potentiates further subsequent tearing of the rotator cuff [23]. An increase in BMI can also promote inflammation, which may have a negative influence on disease progression and decompensation of rotator cuff tears [33]. Patients with shoulder pain or movement disorders should try to maintain weight control, which may help to prevent the pathological progression of symptomatic rotator cuff tears. Family doctors and surgeons also can provide dietary advice for high-risk groups. We also found cigarette smoking to be associated with rotator cuff tear. Hatta et al. [26] found that nicotine-exposed tendons showed a decrease in gene expression and enzyme activity in a dose-dependent manner. Studies have shown that some components of cigarettes can produce negative influences on the generation, apoptosis, and metabolism of muscle cells in vitro [12, 26]. Smoking cessation is important for many reasons; its effect on the rotator cuff is just one more.

Disease Factors

Our results showed that hypertension and traumatic shoulder events were associated with symptomatic rotator cuff tears but diabetes and thyroid disease were not. There is a lack of research on the relationship between hypertension and the pathogenesis of symptomatic rotator cuff tears; we believe this could be a productive area of future research. Of course, surgeons (and internists) should continue to help patients achieve good blood pressure control, and future studies can explore whether blood pressure control can delay the pathological progression of rotator cuff tears. A history of shoulder trauma has been considered a risk factor for rotator cuff tears [19, 51], as confirmed by our meta-analysis. The number of rotator cuff tears in patients younger than 45 years is increasing because of trauma [6, 38]. Biomechanically, various external forces can lead to overload and overstretching of the rotator cuff tendon, leading to traumatic rotator cuff tears [39]. Diabetes has long been considered an independent risk factor for rotator cuff tears [3, 15], which is not in accordance with our findings. There is a big difference between the susceptible group of diabetes and the susceptible population of rotator cuff tear, so diabetes may not be associated with the rotator cuff tear. Another possible explanation is that the studies we included involved patients who were of different races and from different countries, which could have blunted the apparent association; it is possible that diabetes may have a differential effect on the rotator cuff among people of different races. Future studies might investigate this.

Imaging Factors

Our study showed that a greater critical shoulder angle, a lower glenoid version angle, and a greater acromion index were factors independently associated with rotator cuff tears. The compressive and shear forces of the joint depend on the critical shoulder angle [22, 42]. With an increasing critical shoulder angle, the shear force of the joint increases, which may increase the load on the rotator cuff. A high critical shoulder angle can induce supraspinatus overload and may explain why some rotator cuff tears are associated with a high critical shoulder angle [8, 21]. The critical shoulder angle can be measured on radiographs instead of MRI, and if a patient has shoulder pain and a high critical shoulder angle, one should have a high index of suspicion that the patient may have a rotator cuff tear. Prior studies have disagreed on whether greater glenoid retroversion is associated with rotator cuff tears [18, 28, 32, 36]; our meta-analysis found that it is. Based on this, surgeons might further study the biomechanical effect of glenoid version angle on rotator cuff. Our meta-analysis confirmed that a higher acromion index is associated with the risk of rotator cuff tear. And surgeons might maintain a high index of suspicion for rotator cuff tear in patients with shoulder pain who have a high acromion index (as well as an abnormal critical shoulder angle or excessive glenoid retroversion); this could help guide the judicious use of advanced diagnostic imaging, like MRI and ultrasound, particularly in resource-constrained countries. Previous studies found that patients with a critical shoulder angle greater than 30° to 35° [35, 45], an acromion index greater than 0.6 to 0.64 [28, 47], and abnormal glenoid version angle (less than -2.2°) [28] were at greater risk of developing rotator cuff tears. The critical shoulder angle, glenoid version angle, and the acromion index are anatomical parameters of the shoulder that are nonmodifiable other than, perhaps, with surgery. When a patient is diagnosed with a rotator cuff tear and surgical treatment is considered, in addition to repairing the rotator cuff tear, the surgeon may consider addressing the above three factors in the hope of reducing the risk of retear. Further research might seek to evaluate approaches to addressing those anatomic factors through surgery, to determine whether this will have a protective effect on the rotator cuff after surgery.

Conclusion

This study identified a number of potentially modifiable factors associated with symptomatic rotator cuff tears, including blood glucose, blood pressure, weight, and smoking. Clinicians may help patients with shoulder pain who do not yet have a cuff tear to modify these factors, as such interventions may help prevent a tear; furthermore, there is no risk to modifying those factors because doing so would also improve patients' overall health. The radiographic factors we identified, including the acromion index, critical shoulder angle, and glenoid version angle, may help surgeons determine which patients with symptoms suggestive of a cuff tear are more or less likely to actually have a tear. Future research can further study whether controlling these factors may delay the progression and size of rotator cuff tears. In addition, future studies can continue to explore whether changing the anatomical parameters of the shoulder during surgery, such as the critical shoulder angle, glenoid version angle, and the acromion index, will help to protect the rotator cuff from retear after surgery. Finally, we should further explore whether there are differences in risk factors for rotator cuff tears among patients of different ages and ethnic groups.

Acknowledgments We thank American Journal Experts for linguistic assistance during the preparation of this manuscript.

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