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Effects of Biomechanical Risk Factors as Cumulative Trauma on Rotator Cuff Tendinopathy in Workers - A Clinical Survey (2018 - 2019)

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Abstract

Background: Cumulative effects of biomechanical risk factors on rotator cuff tendinopathy have not yet been determined. Accordingly, this study aimed to investigate cumulative effects of biomechanical risk factors on rotator cuff tendinopathy among workers.

Materials & Methods: This descriptive study was conducted on 470 patients suspected of rotator cuff tendinopathy, who referred to the radiology department of Rasool-e-Akram Hospital in Tehran, Iran (July 2018-March 2019). To this end, ergonomic risk factors, including excessive hand raising, repetitive tasks, upper arm flexion, grip force, awkward posture, vibration, abduction, and rotation were evaluated. The subjects were divided into four categories, according to the number of affecting risk factors. Next, univariate and multivariate analyses were performed to identify predictors of rotator cuff tendinopathy. The study data were analyzed by SPSS V24.0.

Results: Risk factors, such as excessive hand raising, repetitive tasks, upper arm flexion, and awkward posture had a significant association with the frequency of rotator cuff tendinopathy ($p < 0.05$). Our study showed that shoulder tendinopathy had a statistically significant association with having at least one affecting risk factor (OR=3.96 95%CI: 2.26-6.96), two affecting risk factors (OR=6.82 95%CI: 4.13-11.26), three affecting risk factors (OR=10.25 95%CI: 4.35-24.14), and four affecting risk factors (OR=12.61 95%CI: 1.69-93.63).

Conclusion: The existence of more than one mechanical risk factor in the workplace is associated with a greater increase in the possibility of rotator cuff tendinopathy. In most workplaces, there is usually more than one mechanical risk factor, so it is necessary to pay attention to cumulative effects of all of them.

Keywords: Shoulder Pain, Posture, Risk Factors, Workplace, Workers.

Introduction

According to research, the lifetime prevalence of shoulder pain in the general population and patients less than 70 years old was 67 and 27%, respectively [1]. In a large-scale population-based survey in Australia in 2010, the prevalence of

shoulder pain was reported to be 22% [2]. Shoulder pain can cause sickness absence, loss of personal ability, as well as reduced work performance and work efficiency [3]. One of the common causes of shoulder pain and upper extremity musculoskeletal disorders (MSDs) in the general population is structure tendinopathy that includes structure tendinitis/tendinosis, subacromial bursitis, and impingement syndrome [4-13]. Shoulder pain improves slowly over time, so the likelihood of recurrence is comparatively high, with about half (40-50%) of patients with shoulder pain suffering from sustained pain or recurrence during the 12-month follow-up period [14, 15]. Successful treatment of structure tendinopathy remains challenging and is especially conservative, with about 40% of patients with structure tendinopathy not responding to such treatments [16-18]. Thus, it is necessary to identify the risk factors and cusses of structure tendinopathy for the purpose of prevention interventions. The etiology of structure tendinopathy is multifactorial, so both intrinsic and extrinsic factors are involved [19]. The major mechanism of structure tendinopathy is the narrowing of the subacromial space and repetitive overhead activities, such as tendon overuse and overload [20]. Several studies show that diabetes mellitus and abdominal obesity are considered intrinsic factors, with work-related factors, such as the frequent handling of loads or handling them with high force, highly repetitive tasks, and works above the shoulder level being considered extrinsic factors leading to tendinopathy [21-23]. Raising the hand above the shoulder level is among the major causes of rotator cuff tendinopathy (RCT) among workers [22, 24-26]. In some studies, heavy manual work [27], repetitive tasks [10, 28], high frequency of work [5, 28, 29], high-force exertion [28, 29], and vibration works [29] have been reported to be related to the increased risk of structure tendinopathy. Similarly, in a recent systematic review and a meta-analysis in 2019, DM, being over age 50, and working at the overhead level were reported to be related to the increased risk of structure tendinopathy [30]. In some studies, doing work with the shoulder placed above 90° was shown to be related to the increased risk of structure tendinopathy among the working population [24, 26, 27]. However, other mechanical workplace factors, except heavy manual works [27], repetitive works [10, 28], high frequency of work [5, 28, 29], high force exertion [29, 31], and vibration work [29,31] have not been clearly associated with the increased risk of structure tendinopathy. In 1997, the National Institute for Occupational Safety and Health published a critical synopsis of evidence-based medical investigations into the relationship between work activities and the development of MSDs. Accordingly, there was clear evidence that definite levels of static contraction, prolonged static loads, and awkward postures involving the neck and shoulder muscles were related to an increased risk of MSDs [32]. In fact, it seems that the effect of cumulative trauma is usually raised in this context, with occupational risk factors being often cumulative over time, possibly increasing the risk of shoulder diseases and injuries. Three mechanisms are introduced to provide explanations for the occurrence of cumulative trauma disorders (CTDs), which include (1) repetitive mechanical irritation, (2) micro ischemia, and (3) accumulation of metabolic products that promote inflammations or interfere with neuromuscular function [33-36]. One or more of the activities, such as excessive force, repetitive movements, awkward postures, prolonged static postures, and vibration have been associated with CTDs and RCT [37]. In most studies, only a limited number of risk factors have been considered for research on occupational risk factors in shoulder injuries. Thus, cumulative effects of these risk factors and their role have not been evaluated. Additionally, most cases of MSDs have been reported by self-reported questionnaires, which can reduce the accuracy of any association between occupational risk factors and the prevalence of MSDs. In this study, radiological findings could confirm the existence of shoulder abnormalities. Therefore, this study aims to investigate cumulative effects of risk factors on RCT among workers.

Materials and Methods

Initial data of this cross-sectional study were extracted from the full archive of the MRI imaging of Rassol-e- Akram Hospital in Tehran, Iran, for the 9-month period from July 2018 to March 2019. Accordingly, the data included MRI images of the referred patients from orthopedic and rheumatology wards to the radiology department, who had neck and shoulder pain and were suspected of rotator cuff tendinopathy (n = 470). The exclusion criteria were patients less than 18 or over 60 years old, patients whose occupation was not determined, professional athletes and patients with a history of multiple trauma, as well as patients with degenerative intervertebral disc disorders, congenital spinal disorders, malignancies, fractures or spinal surgeries in the last six months (n = 64). Finally, 406 patients remained after excluding 64 patients (n = 406).

Next, the included patients were divided into two groups based on their rotator cuff involvement, with the first group being without tendinopathy (n = 112) and the second group being involved with it (n = 294). The study protocol was reviewed and approved by the Ethics Committee of Iran University of Medical Sciences (code: IR.IUMS.FMD.REC 1396.9511308004).

The study participants were interviewed in person. The first part of the interview included general information on the participants' age, sex, education level, marital status, being a smoker or a passive smoker, body mass index, history of underlying diseases, medication use, and shoulder trauma. Besides, the second part of the interview included occupational information on their job title, work experience, employment status, daily and weekly working hours, shift work status, number of monthly shift works, and job satisfaction. Additionally, a question was asked to assess the patients' job satisfaction, and they were asked to rate their job satisfaction on a 1-10 scale.

Ergonomic risk factors were explained to the study participants, and they were asked to mark the risk factors to which they were exposed, including excessive hand raising (an arm above the shoulder > 2h/day), repetitive tasks, upper arm flexion, grip force, awkward postures, vibration, as well as shoulder abduction and rotation.

To determine cumulative effects of biomechanical risk factors altogether, the subjects were divided into several categories according to the number of the affecting biomechanical risk factors. In the first, second, third, and fourth models, people had at least 1, 2, 3, and 4 affecting biomechanical risk factors, respectively.

The study data were analyzed by SPSS V24.0. For quantitative data, mean and standard deviation were used, and for qualitative data, frequency and percentage were used. For the statistical analysis of quantitative and qualitative data, an independent sample t-test and a chi-square test were used, respectively. In addition, univariate and multivariate analyses were performed using the Cox regression model to identify predictors of rotator cuff tendinopathy. Besides, all statistical test results less than 0.05 were considered significant.

Results

This cross-sectional study was performed on 406 patients suspected of rotator cuff tendinopathy, who were referred by orthopedic and rheumatology wards to the radiology department. The majority of the participants were male (n = 308, 75.89% of the persons). In addition, their mean age was 42.02 ± 12.63, their work experience was 8.72 ± 6.81 years, 380 (93.6%) individuals were married, 147 (36.2%) individuals had a high school and diploma, 259 (63.8%) individuals had a higher education, 106 (26.1%) individuals were smokers, 235 (58%) individuals would perform physical work, 137 (33.7%) individuals would do a shift work, 60 (14.8%) individuals were night shift workers, and 228 (56.2%) individuals felt no job satisfaction. According to radiologic findings, 294 (72%) patients had rotator cuff tendinopathy, and 112 (28%) individuals did not have tendinopathy. In patients with tendinopathy, 149 (36.69%) patients had partial width and partial tear, 149 (36.69%) patients had partial width and partial tear, 80 (19.70%) patients had complete thickness tear, 185 (45.56%) patients had tendinosis, 31 (7.63%) patients had complete tear and atrophy, 68 (16.74%) patients had the gap and complete tear, 45 (11.8%) patients had partial width, partial tear, and tendonitis, and 54 (13.3%) patients had full thickness and partial tear.

In this study, 194 (47.8%) patients had excessive hand raising (the arm above the shoulder > 2h/day), 184 (45.3) patients had repetitive tasks, 145 (35.7) patients had upper arm flexion, 112 (27.6) patients had grip force, 190 (46.8) patients had an awkward posture, 38 (9.4) patients experienced vibration, 246 (60.6) patients had shoulder abduction, and 86 (21.2) patients had shoulder rotation. Table 1 shows the participants' demographic and occupational characteristics.

Table 1. Demographic and occupational characteristics of the patients referred from orthopedic and rheumatology wards to the radiology department of Rasool-e-Akram Hospital

Variables		Mean ± SD / Number (%)
Age (year)		42.02± 12.63
Work experience (year)		8.72 ± 6.81
BMI (Kg/M^2)		25.36±2.85
Gender	Female	308 (75.89)
	Male	94 (24.14)
Marital status	Married	380 (93.6)
	Single	126 (6.4)
Smoking	Smoker	106 (26.1)
	Non-smoker	300 (73.9)

Education	High school and diploma	147 (36.2)
	Higher education	259 (63.8)
Job category	Physical	235 (58)
	Non-physical	171 (42)
Shift work	Yes	137 (33.7)
	No	269 (66.3)
Night shift	Yes	60 (14.8)
	No	346 (85.2)
Job satisfaction	Yes	178 (43.8)
	No	228 (56.2)

According to the univariate analysis, being male, being over 40 years old, and physical work significantly affected frequency rotator cuff tendinopathy ($p < 0.05$). In addition, the body mass index (BMI) of over 25 kg/m2, being a smoker, work experience of over 8 years, shift working, night shift working, and job satisfaction had no significant relationship with frequency rotator cuff tendinopathy ($p > 0.05$) (Table 2).

Table 2. Univariate and multivariate analyses of frequency rotator cuff tendinophaty in the study participants

Variables		**Univariate analysis**		**Multivariate analysis**	
		OR (95%CI)	P-value	OR (95%CI)	P-value
Age (year)	**40≥**	1		1	
	40<	2.63 (1.68 to 4.22)	0 < 001	1.12 (0.78 to 1.09)	0.09
Sex	**Female**	1		1	
	Male	0.77 (0.47 to 1.56)	0.03	0.38 (0.28 to 1.04)	0.74
Marital status	**Married**	1			
	Single	0.9 (0.81 to 1.65)	0.37		
BMI	**BMI ≤ 25**	1		1	
	BMI > 25	0.6 (0.22 to 1.49)	0.80	0.94 (1.18 to 2.75)	0.15
Smoking	**Non-smoker**	1			
	Smoker	1.04 (0.64 to 1.71)	0.90		
Work category	**Non-physical**	1		1	
	Physical	1.25 (1.04 to 2.73)	0.02	1.1 2 (1.01 to 2.18)	0.04
Work experience	**8≥**	1		1	
	8<	0.77 (0.49 to 1.22)	0.16	0.58 (0.19 to 3.62)	0.06
Shift working	**Non-shift worker**	1			
	Shift worker	0.53 (0.28 to 2.17)	0.41		
Night shifting	**Non-night shift worker**	1			
	Night shift worker	0.92 (0.22 to 1.31)	0.32		
Job satisfaction	**Yes**	1			
	No	1.01 (0.57 to 1.92)	0.08		

According to the univariate analysis, biomechanical risk factors, such as excessive hand rising (OR=2.73 95%CI: 1.7-4.3), repetitive tasks (OR=4.37 95%CI: 2.68-7.26), upper arm flexion (OR=4.69 95%CI: 2.63-8.35), and awkward postures (OR=2.08 95%CI: 1.3-3.2) had a significant relationship with the frequency of rotator cuff tendinopathy; however, risk factors, including rotation (grip force, vibration, and abduction) had no significant relationship with the frequency of rotator cuff tendinopathy ($p > 0.05$).

According to the multivariate analysis and using the Cox regression model, risk factors, such as excessive hand raising, upper arm flexion, repetitive tasks, and awkward postures had greater effects on rotator cuff tendinopathy than sex ($p = 0.74$), age ($p = 0.09$), BMI ($p = 0.15$), and work experience ($p = 0.2$), which had no significant association. Tables 2 and 3 show the results of the univariate and multivariate analyses using the Cox regression model.

Table 3. Univariate and multivariate analyses of frequency rotator cuff tendionphaty in the study participants

Variables		Univariate analysis		Multivariate analysis	
		OR (95%CI)	P-value	OR (95%CI)	P-value
Excessive hand raising	**No**	1		1	
	Yes	2.73 (1.71 to 4.32)	< 0.001	2.13 (1.92 to 3.64)	0.000
Repetitive tasks	**No**	1		1	
	Yes	4.37 (2.68 to 7.26)	< 0.001	3.18 (1.58 to 3.79)	0.000
Upper arm flexion	**No**	1		1	
	Yes	4.69 (2.63 to 8.35)	< 0.001	2.19 (1.54 to 2.87)	0.000
Grip force	**No**	1			
	Yes	0.78 (0.48 to 1.25)	0.32		
Awkward posture	**No**	1		1	
	Yes	2.08 (1.34 to 3.25)	0.001	1.98 (1.05 to 2.17)	0.000
Vibration	**No**	1			
	Yes	0.80 (0.39 to 1.66)	0.57		
Shoulder abduction	**No**	1			
	Yes	0.54 (0.34 to 0.87)	0.21		
Shoulder rotation	**No**	1			
	Yes	1.33 (0.76 to 2.32)	0.34		

In this study, 15% (n = 61) of the participants were not affected by biomechanical risk factors, 29.8% (n = 121) were affected by one biomechanical risk factor, 27.1% (n = 110) were affected by two biomechanical risk factors, 20.4% (n = 83) were affected by three biomechanical risk factors, and 7.6% (n = 13) were affected by four biomechanical risk factors. Additionally, there was a statistically significant relationship between experiencing at least one affecting risk factor and shoulder tendinopathy (p=0<000 OR=3.96 95%CI: 2.26-6.96, experiencing at least two affecting risk factors and shoulder tendinopathy (p=0<000 OR=6.82 95%CI: 4.13-11.26), experiencing at least three risk factors and shoulder tendinopathy (p=0<000 OR=10.25 95%CI: 4.35-24.14), and experiencing at least four risk factors and shoulder tendinopathy (p=0<000 OR=12.61 95%CI: 1.69-93.63).

Discussion

In this study, conducted on 406 patients suspected of rotator cuff tendinopathy, 72% of the patients had different forms of rotator cuff abnormality.

The results of this study showed that the male sex, being over 40 years old, physical work, and biomechanical risk factors, such as excessive hand raising, repetitive tasks, upper arm flexion, and awkward postures significantly affected frequency rotator cuff tendinopathy. Moreover, rotator cuff tendinopathy had no significant relationship with the participants' body mass index (BMI), smoking, work experience of over 8 years, shift working, night shift working, job satisfaction, and biomechanical risk factors, including rotation, grip force, and vibration.

In this study, RCT was higher in men than in women. Consistent with the present study, RCT was reported to be more in men than in women in some studies [4, 6]; however, there was no difference between sexes in developing rotator cuff in others studies [9, 20, 24]. This gender difference probably reflects differences in work exposure where men usually do more physical work than women. In the present study, job-related factors differed by gender. This gender difference probably reflects differences in exposure to work constraints. According to several studies, job content is different between men and women, even when the job title is the same [29, 34]. RCT has multifactorial causes, with extrinsic and extrinsic factors, or a combination of both involved [19]. Our findings showed that in workers over age 45, RCT was more common; thus, age appears to be a significant factor in the etiology of rotator cuff tendinopathy among the working population, with this being due to age-related degenerative changes [10, 24, 35, and 36].

As a person ages, they will be more likely to be exposed to occupational risk factors, with the prevalence of shoulder involvement increased, as in some studies, RCT increased with age [4, 28]. Decreased ultimate strain, decreased ultimate load, decreased elasticity, and decreased overall tensile strength have been reported in some studies in aging tendons [38, 39]. In addition, microscopic and biochemical pathological changes have led to the degeneration of tenocytes and collagen fibers as well as accumulation of lipids and ground substance (glycosaminoglycans) in aging tendons [35].

However, there is no consensus on whether pathological changes in rotator cuff tendons are primarily due to aging or they are the secondary consequence of excessive mechanical factors and overload [19].

In the present study, no relationship was found between the BMI and rotator cuff involvement. Results from a study [24] were consistent with ours, but they were inconsistent with the results obtained from another study [4].

In this study, excessive hand raising, repetitive tasks, upper arm flexion, and awkward postures were the most important mechanical risk factors for RCT among the workers. These results of our study were consistent with those of a number of other studies. In some studies [22, 24, and 40], hand-up work with the shoulder being over 90° was revealed to be associated with an increased risk of rotator cuff tendinopathy among the working population. In our study, arm abduction had no relationship with rotator cuff tendinopathy, but it had a relationship in a study [24]. In our study, vibration had no association with RCT, but in some studies, the opposite was true [5, 29]. The results of the four models used in the present study showed that the incidence of tendonitis increased with an increase in the number of mechanical risk factors in the workplace. Based on model 1, having at least one affecting risk factor, two affecting risk factors, three affecting risk factors, and four affecting risk factors increased the chances of developing RCT in workers by 3.96, 6.82, 10.25, and 12.61 times, respectively.

In fact, occupational risk factors often become cumulative over time, thereby increasing the danger of shoulder diseases and injuries. In most workplaces, there is usually over one mechanical risk factor, so it is necessary to pay attention to the cumulative effects of all of them.

Several limitations existed in the present study. Firstly, it was a cross-sectional study, so we could not determine the cause-and-effect relationships; secondly, we categorized patients' jobs into physical and non-physical jobs, and perhaps it would have been better to go into more detail; thirdly, we were unable to investigate psychological factors effecting CRT. Therefore, it is suggested that a larger sample size be selected in the form of a cohort study to take into account more details.

This study was one of the first ones conducted in Iran at a major radiological center to investigate cumulative effects of risk factors on RCT among workers, in which, we evaluated ergonomic risk factors along with other individual risk factors.

Conclusion

The results of this study showed that age over 45, excessive hand raising, repetitive tasks, upper arm flexion, and awkward postures were significantly associated with RCT, with the accompanying occupational risk factors increasing the risk of RCT in the workplace. Based on the findings of this study, the existence of over one mechanical risk factor in the workplace can be associated with a higher increase in RCT. In most workplaces, there is usually over one mechanical risk factor, so it is necessary to pay attention to the cumulative effects of all of them.

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