中国临床研究 Chin J Clin Res, July 2024, Vol.37, No.7

Cite as: Zhang XY, Wang LH Ren ML, Cao XM.Association of skeletal muscle mass index with non-traumatic rotator cuff tear in patients with type 2 diabetes mellitus [J]. Chin J Clin Res, 2024, 37(7):1066-1069,1074.
DOI: 10.13429/j.cnki.cjcr.2024.07.016

Association of skeletal muscle mass index with non-traumatic rotator cuff tear in patients with type 2 diabetes mellitus

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Abstract: Objective To investigate the relationship between skeletal muscle mass index (SMI) and non-traumatic rotator cuff tears(RCTs) in patients with type 2 diabetes mellitus (T2DM). **Methods** The clinical data of 180 T2DM patients who were hospitalized in the Department of Endocrinology and Orthopedics, the Third People's Hospital of Jinzhong from June 2020 to December 2022 were retrospectively analyzed. According to the results of MRI and medical history, the patients were divided into (T2DM+RCT) group (n=80) and [T2DM+ non-rotator cuff tear(non-RCT)] group (n=100). The general data, body fat ratio, skeletal muscle mass, duration of diabetes, glycosylated hemoglobin (HbA1c) and other factors were compared between the two groups. Binary logistic regression was used to analyze the risk factors for non-traumatic RCTs in T2DM patients. The receiver operating characteristic (ROC) curve was used to analyze the predictive value of various factors for non-traumatic RCTs in T2DM patients. **Results** The proportion of female, body weight, body mass index(BMI), duration of diabetes, body fat ratio and HbA1c level in (T2DM+RCT) group were higher than those in (T2DM+non-RCT) group (P<0.05). The SMI was lower than that of the (T2DM+non-RCT) group [6.10 (5.50,7.18) kg/m^2 vs 5.40 (4.50,6.10) kg/m^2, Z=4.443, P<0.01]. Binary logistic regression analysis showed that SMI, BMI, duration of diabetes and HbA1c were risk factors for RCTs. The ROC curve showed that the optimal cut-off value of SMI in diagnosing RCTs in T2DM patients was 5.15 kg/m^2, with a sensitivity of 48.80% and a specificity of 82.00%, and AUC=0.693 (*95%CI:* 0.614-0.771). The combination of SMI, BMI, duration of diabetes and HbA1c had the highest diagnostic value, with a sensitivity of 81.30% and a specificity of 91.00%, and AUC =0.926 (*95%CI:* 0.885-0.966). **Conclusion** There is a correlation between SMI and non-traumatic RCTs in diabetic patients, which has a particular predictive value for non-traumatic RCTs.

Keywords: Type 2 diabetes mellitus; Skeletal muscle mass index; Rotator cuff tear; Non-traumatic rotator cuff tears; Duration of diabetes

Fund program: Research Project Supported by Shanxi Scholarship Council of China (2023-095) ; General Project Supported by Natural Science Foundation of Shanxi Province (201901D111185)

The rotator cuff is a dynamic stabilizing structure of the shoulder joint and consists of the supraspinatus, infraspinatus, subscapularis and teres minor muscles. Rotator cuff injuries are a common cause of shoulder pain and dysfunction and can be classified as traumatic or non-traumatic injuries[1]. Non-traumatic rotator cuff injuries have been shown to be significantly associated with type 2 diabetes mellitus (T2DM)[2]. Compared to non-diabetic individuals, those with T2DM are four times more likely to develop tendinopathy and five times more likely to develop tendon injuries[3]. Therefore, it is significant to classify and identify different individuals and develop early individualized intervention programs to reduce the incidence of rotator cuff injuries in diabetic patients. However, there is still a lack of clarity regarding the underlying mechanisms of non-traumatic injury in diabetic patients. Reduced skeletal muscle mass has been shown to be associated with cardiometabolic risk factors such as T2DM in normal weight or overweight individuals[4]. Skeletal muscle mass plays a key role in the regulation of glucose and lipid metabolism and the release of a variety of endocrine and autocrine activators, which may protect against metabolic deterioration in patients with hypertension, diabetes, and other conditions[5]. Decreased skeletal muscle mass may be an important cause of non-traumatic injury in diabetic patients. In this study, we investigated the relationship between skeletal muscle mass and the development of non-traumatic rotator cuff injuries in patients with T2DM to provide a basis for the early detection and prevention of musculoskeletal complications in patients with T2DM.

1 Material and methods

1.1 *General information*

The clinical data of 180 T2DM patients, including 73 males and 107 females, who were hospitalized in the Department of Endocrinology and Orthopaedics of the Third People's Hospital of Jinzhong from June 2020 to December 2022 were retrospectively analyzed. They were divided into (T2DM+RCT) group (n=80) and (T2DM+non-RCT) group (n=100) according to

magnetic resonance imaging (MRI) findings and patients' medical history.

Inclusion criteria: (1) diagnosis of T2DM according to the 1999 WHO criteria; (2) confirmed diagnosis of rotator cuff injury by MRI examination and clinical symptoms and signs; (3) medical history of more than 2 months without clear history of trauma.

Exclusion criteria: (1) type 1 diabetes mellitus and special type of diabetes mellitus; (2) acute complications such as hyperosmolar hyperglycemic state; (3) infections, tumors, and other consumptive diseases; (4) diseases of the musculoskeletal system and diseases affecting limb movement; (5) taking hormones and other drugs affecting muscle function and bone metabolism within 1 year; (6) engaging in heavy manual labor and fitness business for many years; (7) combining with neurovascular diseases of the shoulder; (8) medical history of fracture or surgery of the affected shoulder joint; (9) severe organ dysfunction,clouding of consciousness or mental illness. The study was approved by the Medical Ethics Committee of the hospital (approval number: 2023005), and the subjects signed an informed consent form.

Data on patients' gender, age, height, weight, history of hypertension, history of smoking, duration of diabetes mellitus, and body mass index (BMI) were collected.

1.2 Research methods

1.2.1 Body composition measurement

In this study, we used the InBody 770 body composition and body water analyzer to perform bioelectrical impedance analysis (BIA). The subjects wore light clothing and went barefoot, and made full contact with the foot-shaped electrodes on the panel of the device, held the handle with both hands, making sure that all five fingers fully contacted the electrodes, and maintained a quiet standing posture for 3-5 minutes, and recorded the values of skeletal muscle mass, and body fat mass. Skeletal muscle mass index (SMI)=skeletal muscle mass (kg)/[height (m)]^2; body fat percentage(BFP)=body fat amount (kg)/body weight (kg)×100%.

1.2.2 Glycated hemoglobin (HbA1c) level

A total of 5 mL of venous blood was collected from fasted subjects in the early morning to measure HbA1c.

1.3 Statistical methods

SPSS 22.0 software was used for statistical analysis. Normally distributed measurement data were expressed as $\bar{x} \pm s$, and independent sample *t*-test was used for comparison. Non-normally distributed measurement data were expressed as M (P_{25} , P_{75}). Non-parametric rank-sum test was used for comparison. Count data were expressed as case (%), and the chi-square test was used for comparison. Binary logistic regression was used to analyze the risk factors for non-traumatic rotator cuff injuries. The receiver operating characteristic (ROC) curves of the subjects after correction for confounders were plotted and the area under the curve (AUC) was calculated. $P < 0.05$ was considered statistically significant.

2 Results

2.1 Comparison of general information, biochemical indexes and SMI between the two groups

The proportion of female patients, body weight, BMI, duration of diabetes, BFP and HbA1c level in the (T2DM+RCT) group were higher than that in the (T2DM+non-RCT) group (P<0.05). SMI was lower than that in the T2DM group (P<0.05); and the difference in terms of age, height, history of smoking, and history of hypertension between the two groups was not statistical significance ($P > 0.05$). **[Table 1]**

Tab. 1 Comparison of general data, biochemical indexes and SMI between the two groups

Item	(T2DM+RCT) group (n=100)	(T2DM+non-RCT) group (n=80)	χ^2 /Z/ t value	P value
Gender (female/male, case)	51/49	56/24	6.655	0.010
History of hypertension [cases (%)]	48 (48.00)	43 (53.75)	0.588	0.443
History of smoking [cases (%)]	33 (33.00)	19 (23.75)	1.851	0.174
Age (years)[a]	67.00 (58.00,75.00)	64.00 (56.00, 71.00)	1.819	0.069
Height (m)[b]	1.67±0.08	1.65±0.08	1.897	0.059
Weight (kg)[a]	63.20 (52.53, 70.30)	72.90 (63.15, 84.1)	4.918	<0.001
BMI (kg/m^2) [a]	22.10 (19.40, 25.30)	26.30 (23.95, 29.85)	6.933	<0.001
SMI (kg/m^2) [a]	6.10 (5.50, 7.18)	5.40 (4.50, 6.10)	4.443	<0.001
Duration of diabetes (years)[a]	5(5,6)	7(5,10)	4.804	<0.001
BFP (%)[a]	31.90 (20.90, 36.25)	38.39 (35.13, 43.79)	6.579	<0.001
HbA1c level (%)[a]	6.65 (5.43, 7.90)	8.40 (6.40, 10.43)	4.692	<0.001
Skeletal muscle mass (kg)[a]	16.93 (14.66, 20.80)	13.96 (12.00,17.53)	4.137	<0.001
Total body fat (kg)[a]	20.30 (15.05, 25.33)	28.10 (22.89, 33.48)	6.967	<0.001

Note:[a] $M(P_{25}, P_{75})$; [b] $\bar{x} \pm s$.

2.2 Binary logistic regression analysis of risk factors for non-traumatic rotator cuff injuries in patients with T2DM

A binary logistic regression model was performed with combined non-traumatic rotator cuff injuries as the dependent variable, and gender, weight, BMI, SMI,

duration of diabetes, BFP, and HbA1c level as independent variables. The results showed that gender, weight, and BFP were not risk factors for the development of non-traumatic rotator cuff injuries (*P*>0.05). BMI, duration of diabetes, and HbA1c level correlated with non-traumatic rotator cuff injuries (P<0.05). BMI, duration of diabetes, and HbA1c level were associated with non-traumatic rotator cuff injuries (*P*<0.05). After correcting for gender, weight, BMI, duration of diabetes, BFP, and HbA1c level, skeletal muscle mass was still a risk factor for the development of non-traumatic rotator cuff injury in patients with T2DM [*OR*=0.233, *95%CI* (0.108-0.500), *P*<0.001]. **[Table 2]**

Tab.2 Binary logistic regression analysis of risk factors for developing non-traumatic RCTs in T2DM patients

Item	*B*	*SE*	*Walds*	*P* value	*OR* value	95% *CI*
Gender (female/male case)	-1.349	1.484	0.827	0.363	0.259	0.014-4.754
Weight	-0.011	0.039	0.079	0.779	0.989	0.915-1.069
BMI	0.377	0.187	4.057	0.044	1.458	1.010-2.104
SMI	-1.458	0.390	13.941	<0.001	0.233	0.108-0.500
Duration of diabetes	0.350	0.099	12.632	<0.001	1.419	1.170-1.722
BFP	0.061	0.109	0.319	0.572	1.063	0.859-1.316
HbA1c	0.455	0.123	13.690	<0.001	1.576	1.239-2.005

2.3 ROC curve for predicting the development of non-traumatic rotator cuff injury in patients with T2DM

The results showed that the combined use of SMI, BMI, duration of diabetes, and HbA1c had the highest predictive value for the development of non-traumatic rotator cuff injuries in patients with T2DM, with a sensitivity of 81.30%, a specificity of 91.00%, and an AUC of 0.926 (0.885-0.966). **[Table 3 & Figure 1]**

Tab.3 Predictive value of risk factors for diagnosing non-traumatic rotator cuff tears in T2DM patients

Item	Cut-off value	Sensitivity (%)	Specificity (%)	AUC (95% *CI*)	*P* value
SMI	5.15 kg/m ^{2}	48.80	82.00	0.693 (0.614-0.771)	<0.001
BMI	22.45 kg/m^2	90.00	55.00	0.801 (0.739-0.863)	<0.001
Duration of diabetes	7.50 years	46.30	98.00	0.706 (0.620-0.793)	<0.001
HbA1c	9.25%	48.80	100.00	0.704 (0.623-0.785)	<0.001
Combination		81.30	91.00	0.926 (0.885-0.966)	<0.001

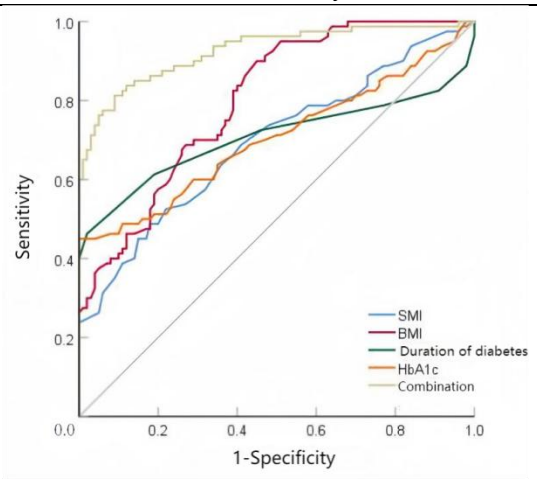

Fig.1 The ROC curves of risk factors for diagnosing non-traumatic rotator cuff tear in T2DM patients

3 Discussion

Rotator cuff injury is a common shoulder disease, affecting between 6.8% and 22.4% of people over the age of 40, many of whom have no history of significant trauma. The incidence of RCTs increases with age and rotator cuff size, and size of RCT is significantly and positively correlated with age[6]. These data suggest that non-traumatic rotator cuff injury is an age-related process[7]. Skeletal sarcopenia has long been associated with aging and the elderly, but it is now recognized that the development of skeletal sarcopenia often begins early in life, and that skeletal sarcopenia can be caused by a number of causative factors in addition to aging[8-9], and in recent years studies have shown that T2DM is strongly associated with sarcopenia[10]. Thus, in this paper, we consider that there may be a close association between the development of non-traumatic rotator cuff injuries and the decline in skeletal muscle mass in patients with T2DM.

Numerous studies have shown that diabetes is a risk factor for rotator cuff injury[2,10-11], but the mechanism has not been clarified. One study found that hypertension, older age, male, higher BMI and diagnosis of carpal tunnel syndrome were risk factors significantly associated with increased risk of RCT, while smoking was not associated with RCT [12-13]. A study by Abate *et al.*[14] found that BMI and BFP were strongly associated with the incidence and severity of RCTs. The present study showed that diabetes mellitus with rotator cuff injury group had a higher percentage of female patients, weight, BMI, and BFP than the non-rotator cuff injury group. There was no significant difference in age, smoking and hypertension status between the two groups. This result is partially consistent with the findings of Abate et al. The difference may be due to the fact that this study was based only on diabetic patients and the limitations of the sample size. Also, for gender, the higher percentage of female patients may be related to postmenopausal estrogen changes affecting skeletal muscle protein metabolism and indirectly affecting skeletal muscle mass and function[15].

In addition, our team also found that the duration of diabetes and HbA1c levels in the diabetes combined with rotator cuff injury group were higher than those in the non-rotator cuff injury group, suggesting that a sustained high-glucose environment may increase the risk of rotator cuff injuries in diabetic patients. Longo *et al.*[16] also found that even if glucose levels are at the high limit of the normal range, it may be a risk factor for rotator cuff injuries. This finding may indicate that rational glycemic control in diabetic patients is important for the prevention of rotator cuff injury.

In this study, through logistic regression, decreased SMI in diabetic patients was verified to be an independent risk factor for non-traumatic rotator cuff injuries. However, Atala *et al.*[17] concluded that reduced skeletal muscle mass could not be an independent risk factor for rotator cuff injury, the differences need to be further explored.

Altered mitochondrial function and impaired glucose homeostasis are common in diabetic individuals[18]. Impaired mitochondrial oxidative capacity may produce reactive oxygen species (ROS), leading to increased oxidative stress, a central feature that may promote skeletal muscle tissue damage[19]. Skeletal muscle is the largest insulin target organ in the body and is the primary site of insulin-stimulated glucose uptake, but when insulin resistance occurs in diabetic patients insulin-related signaling pathways are inhibited, leading to a decrease in protein synthesis and an increase in catabolism, resulting in a reduction in skeletal muscle mass[20]. Insulin resistance also promotes gluconeogenesis, which causes upregulation of sterol regulatory element-binding protein 1c, inhibition of β-oxidation, and increased release of free fatty acids, which in turn shifts the triglyceride metabolism, ultimately leading to accumulation of triglycerides in skeletal muscle[21]. These indications suggest that diabetes may accelerate the steatosis of rotator cuff muscle tissue. In addition, in diabetic patients, persistent hyperglycemia accelerates the formation of advanced glycosylation end products (AGEs), the accumulation of which affects muscle mass by increasing intramuscular protein cross-linking, interfering with muscle contractility, up-regulating inflammatory responses, triggering oxidative stress, and impairing endothelial function[9]. Changes in tendon properties and tissue and cellular molecules caused by the above mechanisms may make diabetics more susceptible to tendon injury.

The ROC curve in this study found that the optimal SMI cut-off value for the development of non-traumatic rotator cuff injury in patients with T2DM was 5.15, with a sensitivity of 48.80% and a specificity of 82.00%. T2DM patients with SMI below this cut-off value were more likely to develop non-traumatic rotator cuff injuries in T2DM patients. This suggests that lower SMI has a predictive effect on the development of non-traumatic rotator cuff injuries, which needs to be confirmed by a large-sample, multi-center study in the later phase of the study.

In conclusion, reduced skeletal muscle mass is an independent risk factor for non-traumatic rotator cuff injuries in patients with T2DM, which is important for early clinical detection and prevention of musculoskeletal complications in patients with T2DM. Meanwhile, this study still has some limitations. First, only diabetic patients were collected, and there was a lack of normal population controls; second, different lifestyle of patients, such as diet, work and rest, and exercise status, may affect the results. Future multi-center and large-sample studies are needed for further validation in different populations.

Conflict of interest None

Reference

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Submission received: 2023-08-28/**Revised:** 2023-11-24

·论　著·

2 型糖尿病患者骨骼肌质量指数与非创伤性肩袖损伤的相关性

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摘要：目的　探讨 2 型糖尿病(T2DM)患者骨骼肌质量指数(SMI)与发生非创伤性肩袖损伤(RCT)的关系。**方法**　回顾性分析 2020 年 6 月至 2022 年 12 月于晋中市第三人民医院内分泌及骨科住院的 180 例 T2DM 患者的临床资料，按照磁共振检查结果及病史分为 T2DM 合并非创伤性 RCT 组(T2DM+RCT 组，$n=80$)与 T2DM 未合并肩袖损伤组(T2DM+non-RCT 组，$n=100$)。比较两组患者一般资料、体脂率、骨骼肌质量、糖尿病病程、糖化血红蛋白(HbA1c)等的差异。使用二元 logistic 回归分析 T2DM 患者发生非创伤性 RCT 的危险因素。绘制受试者工作特征(ROC)曲线分析各因素对 T2DM 患者发生非创伤性 RCT 的预测价值。**结果**　T2DM+RCT 组女性患者比例、体重、身体质量指数(BMI)、糖尿病病程、体脂率及 HbA1c 水平均高于 T2DM+non-RCT 组($P<0.05$)；SMI 低于 T2DM+non-RCT 组[6.10 (5.50,7.18) kg/m^2 *vs* 5.40 (4.50,6.10) kg/m^2，$Z=4.443$，$P<0.01$]。二元 logistic 回归分析显示，SMI、BMI、糖尿病病程及 HbA1c 水平是 RCT 的影响因素($P<0.05$)。ROC 曲线显示，SMI 诊断 T2DM 患者合并 RCT 的最佳截断值为 5.15 kg/m^2，灵敏度为 48.80%，特异度为 82.00%，AUC = 0.693(95%*CI*：0.614～0.771)。SMI、BMI、糖尿病病程及 HbA1c 四者联合诊断价值最高，灵敏度为 81.30%，特异度为 91.00%，AUC = 0.926(95%*CI*：0.885～0.966)。**结论**　T2DM 患者非创伤性 RCT 的发生与 SMI 存在相关性，对非创伤性 RCT 形成有一定预测价值。

关键词： 2 型糖尿病；骨骼肌质量指数；肩袖损伤；非创伤性肩袖损伤；糖尿病病程

中图分类号： R685.4　**文献标识码：** A　**文章编号：** 1674-8182(2024)07-1066-05

Association of skeletal muscle mass index with non-traumatic rotator cuff tear in patients with type 2 diabetes mellitus

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Abstract: Objective　To investigate the relationship between skeletal muscle mass index (SMI) and non-traumatic rotator cuff tear(RCT) in patients with type 2 diabetes mellitus (T2DM). **Methods**　The clinical data of 180 T2DM patients who were hospitalized in the Department of Endocrinology and Orthopedics, the Third People's Hospital of Jinzhong from June 2020 to December 2022 were retrospectively analyzed. According to the results of MRI and medical history, the patients were divided into T2DM+RCT group ($n=80$) and T2DM+ non-RCT group ($n=100$). The general data, body fat ratio, skeletal muscle mass, duration of diabetes, glycosylated hemoglobin (HbA1c) and other factors were compared between the two groups. Binary logistic regression was used to analyze the risk factors for non-traumatic RCT in T2DM patients. The receiver operating characteristic (ROC) curve was used to analyze the predictive value of various factors for non-traumatic RCT in T2DM patients. **Results**　The proportion of female, body weight, body mass

DOI: 10.13429/j.cnki.cjcr.2024.07.016

基金项目： 山西省回国留学人员科研资助基金(2023-095)；山西省自然科学基金面上项目(201901D111185)

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出版日期： 2024-07-20

QR code for English version

index(BMI), duration of diabetes, body fat ratio and HbA1c level in T2DM+RCT group were higher than those in T2DM+ non-RCT group ($P < 0.05$). The SMI was lower than that of the T2DM+ non-RCT group [6.10 (5.50, 7.18) kg/m^2 *vs* 5.40 (4.50,6.10) kg/m^2, $Z=4.443$, $P<0.01$]. Binary logistic regression analysis showed that SMI, BMI, duration of diabetes and HbA1c were influencing factors for RCT. The ROC curve showed that the optimal cut-off value of SMI in diagnosing RCT in T2DM patients was 5.15 kg/m^2, with a sensitivity of 48.80% and a specificity of 82.00%, and AUC=0.693 (95%*CI*: 0.614-0.771). The combination of SMI, BMI, duration of diabetes and HbA1c had the highest diagnostic value, with a sensitivity of 81.30% and a specificity of 91.00%, and AUC=0.926 (95%*CI*: 0.885-0.966). **Conclusion** There is a correlation between SMI and non-traumatic RCT in diabetic patients, which has a particular predictive value for non-traumatic RCT.

Keywords: Type 2 diabetes mellitus; Skeletal muscle mass index; Rotator cuff tear; Non-traumatic rotator cuff tear; Duration of diabetes

Fund program: Research Project Supported by Shanxi Scholarship Council of China (2023-095); General Project Supported by Natural Science Foundation of Shanxi Province (201901D111185)

肩袖是肩关节动态稳定结构,由冈上肌、冈下肌、肩胛下肌和小圆肌组成。肩袖损伤是肩关节疼痛和功能障碍的常见原因,可分为创伤性或非创伤性损伤[1]。有研究表明,非外伤性肩袖损伤与 2 型糖尿病(T2DM)显著相关[2]。与 T2DM 患者发生肌腱病变的可能性是非糖尿病患者的 4 倍,发生肌腱损伤的可能性是其 5 倍[3]。因此,对不同个体及时进行分类与识别,尽早开发个体化干预方案,对于降低糖尿病患者肩袖损伤的发生率具有重要意义。然而,关于糖尿病患者发生非创伤性损伤的潜在机制仍不明确。有研究表明,在正常体重或超重人群中,骨骼肌质量降低与 T2DM 等心脏代谢危险因素存在关系[4],且骨骼肌质量在调节葡萄糖和脂质代谢及释放多种内分泌和自分泌活性物质方面起着关键作用,可能对高血压、糖尿病等患者代谢恶化起到保护作用[5]。笔者考虑,骨骼肌质量下降可能是导致糖尿病患者发生非创伤性损伤的重要原因。本研究通过探讨 T2DM 患者骨骼肌质量与非创伤性肩袖损伤形成的关系,为早期发现并预防 T2DM 患者肌肉骨骼的并发症提供依据。

1　资料与方法

1.1　一般资料　回顾性分析 2020 年 6 月至 2022 年 12 月于晋中市第三人民医院内分泌科及骨科住院的 180 例(男性 73 例,女性 107 例)T2DM 患者的临床资料。按照核磁共振成像(MRI)检查结果及患者病史分为 T2DM 合并非创伤性肩袖损伤组(T2DM+RCT 组,$n=80$)和 T2DM 未合并肩袖损伤组(T2DM + non-RCT 组, $n = 100$)。纳入标准:(1) 根据 1999 年 WHO 标准明确诊断为 T2DM;(2) 经 MRI 检查及临床症状、体征确诊为肩袖损伤;(3) 病史 2 个月以上,无明确外伤史。排除标准:(1) 1 型糖尿病及特殊类型糖尿病;(2) 高渗高血糖综合征等急性并发症;(3) 感染、肿瘤及其他消耗性疾病;(4) 运动系统疾病及影响肢体活动疾病;(5) 1 年内服用激素等影响肌肉功能及骨代谢药物;(6) 常年从事重体力劳动及健身行业;(7) 患肩合并神经血管疾病;(8) 患侧肩关节既往存在过骨折等损伤或手术史;(9) 伴严重脏器功能异常,意识模糊或有精神疾病者。本研究通过医院医学伦理委员会审批(批号:2023005)。研究对象均签署知情同意书。

1.2　*研究方法*

1.2.1　基础资料　收集患者性别、年龄、身高、体重、高血压史、吸烟史、糖尿病病程、身体质量指数(BMI)等资料。

1.2.2　人体成分测量　本研究使用生物电阻测量法(BIA)人体成分分析仪(InBody770),受试者着轻便服装并赤脚,与仪器面板足形电极充分接触,双手握住手柄,确保五指充分接触电极,保持安静姿势 3~5 min,记录骨骼肌质量、身体脂肪量数值。计算骨骼肌质量指数(skeletal muscle mass index, SMI)= 骨骼肌质量(kg)/[身高(m)]^2;体脂率 = 身体脂肪量(kg)/体重(kg)×100%。

1.2.3　糖化血红蛋白(HbA1c)水平　清晨采集空腹受试者静脉血 5 mL,测定血清 HbA1c。

1.3　*统计学方法*　采用 SPSS 22.0 软件进行统计分析。正态分布的计量资料以 $\bar{x}\pm s$ 表示,采用独立样本 t 检验;非正态分布的计量资料以 $M(P_{25}, P_{75})$ 表示,比较采用非参数秩和检验。计数资料以例(%)表示,比较采用 χ^2 检验;使用二元 logistic 回归分析非创伤性肩袖损伤的危险因素。绘制校正混杂因素后的

受试者工作特征曲线(ROC)并计算曲线下面积(AUC)。P<0.05 为差异有统计学意义。

2　结　果

2.1　两组患者的一般资料、生化指标及 SMI 比较　T2DM+RCT 组女性患者比例、体重、BMI、糖尿病病程、体脂率及 HbA1c 水平均高于 T2DM+non-RCT 组(P<0.05);SMI 低于 T2DM+non-RCT 组(P<0.01);两组的年龄、身高、吸烟史、高血压史比较,差异无统计学意义(P>0.05)。见表 1。

2.2　二元 logistic 回归分析 T2DM 患者发生非创伤性肩袖损伤的危险因素　以合并非创伤性肩袖损伤为因变量,以性别、体重、BMI、SMI、糖尿病病程、体脂率、HbA1c 水平为自变量,行二元 logistic 回归分析,结果显示,性别、体重及体脂率不是合并非创伤性肩袖损伤的危险因素(P>0.05);BMI、糖尿病病程及 HbA1c 水平与合并非创伤性肩袖损伤有相关性(P<0.05);校正性别、体重、BMI、糖尿病病程、体脂率、HbA1c 水平后,低 SMI 仍是 T2DM 患者发生非创伤性肩袖损伤的危险因素[OR=0.233, 95%CI(0.108~0.500), P<0.01]。见表 2。

2.3　预测 T2DM 患者发生非创伤性肩袖损伤的 ROC 曲线　结果显示,SMI、BMI、糖尿病病程、HbA1c 联合检测对 T2DM 患者发生非创伤性肩袖损伤的预测价值最高,灵敏度为 81.30%,特异度为 91.00%,AUC 为 0.926(0.885~0.966)。见表 3、图 1。

表 1　两组一般资料、生化指标及 SMI 比较

Tab. 1　Comparison of general data, biochemical indexes and SMI between the two groups

指标	T2DM+non-RCT 组(n=100)	T2DM+RCT 组(n=80)	χ^2/Z/t 值	P 值
性别(女/男,例)	51/49	56/24	6.655	0.010
高血压史[例(%)]	48(48.00)	43(53.75)	0.588	0.443
吸烟史[例(%)]	33(33.00)	19(23.75)	1.851	0.174
年龄(岁)[a]	67.00(58.00, 75.00)	64.00(56.00, 71.00)	1.819	0.069
身高(m)[b]	1.67±0.08	1.65±0.08	1.897	0.059
体重(kg)[a]	63.20(52.53, 70.30)	72.90(63.15, 84.1)	4.918	<0.001
BMI(kg/m^2)[a]	22.10(19.40, 25.30)	26.30(23.95, 29.85)	6.933	<0.001
SMI(kg/m^2)[a]	6.10(5.50, 7.18)	5.40(4.50, 6.10)	4.443	<0.001
糖尿病病程(年)[a]	5(5,6)	7(5,10)	4.804	<0.001
体脂率(%)[a]	31.90(20.90, 36.25)	38.39(35.13, 43.79)	6.579	<0.001
HbA1c 水平(%)[a]	6.65(5.43, 7.90)	8.40(6.40, 10.43)	4.692	<0.001
骨骼肌质量(kg)[a]	16.93(14.66, 20.80)	13.96(12.00, 17.53)	4.137	<0.001
身体脂肪总量(kg)[a]	20.30(15.05, 25.33)	28.10(22.89, 33.48)	6.967	<0.001

注:[a] 表示数据为 $M(P_{25}, P_{75})$;[b] 表示数据为 $\bar{x}\pm s$。

表 2　T2DM 患者发生非创伤性肩袖损伤危险因素的二元 logistic 回归分析

Tab.2　Binary logistic regression analysis of risk factors for developing non-traumatic rotator cuff tears in T2DM patients

指标	β	SE	$Walds$	P 值	OR 值	95%CI
性别	−1.349	1.484	0.827	0.363	0.259	0.014~4.754
体重	−0.011	0.039	0.079	0.779	0.989	0.915~1.069
BMI	0.377	0.187	4.057	0.044	1.458	1.010~2.104
SMI	−1.458	0.390	13.941	<0.001	0.233	0.108~0.500
糖尿病病程	0.350	0.099	12.632	<0.001	1.419	1.170~1.722
体脂率	0.061	0.109	0.319	0.572	1.063	0.859~1.316
HbA1c	0.455	0.123	13.690	<0.001	1.576	1.239~2.005

表 3　各危险因素诊断 T2DM 患者非创伤性肩袖损伤的预测价值

Tab.3　Predictive value of risk factors for diagnosing non-traumatic rotator cuff tears in T2DM patients

变量	截断值	灵敏度(%)	特异度(%)	AUC(95%CI)	P 值
SMI	5.15 kg/m^2	48.80	82.00	0.693(0.614~0.771)	<0.001
BMI	22.45 kg/m^2	90.00	55.00	0.801(0.739~0.863)	<0.001
糖尿病病程	7.50 年	46.30	98.00	0.706(0.620~0.793)	<0.001
HbA1c	9.25%	48.80	100.00	0.704(0.623~0.785)	<0.001
联合检测		81.30	91.00	0.926(0.885~0.966)	<0.001

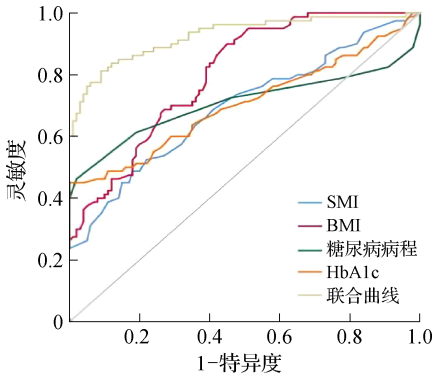

图 1　各危险因素诊断 T2DM 患者非创伤性肩袖损伤的 ROC 曲线

Fig.1　The ROC curves of risk factors for diagnosing non-traumatic rotator cuff tear in T2DM patients

3　讨　论

肩袖损伤是一种常见的肩部疾病,40 岁以上人群中有 6.8%~22.4%的人患肩袖损伤,其中,很多患者并无明显外伤。肩袖撕裂的发生率随着年龄和肩袖大小的增加而增加,且肩袖撕裂的大小与年龄显著正相关[6]。这些数据提示,非创伤性肩袖损伤是一个与衰老相关的过程[7]。骨骼肌减少症长期以来都与衰老和老年人有关,但现在人们认识到骨骼肌减少症的发展往往开始于生命的早期,骨骼肌减少症的原因除了衰老之外还有许多致病因素[8-9]。近年来研究表明,T2DM 与骨骼肌减少症关系密切[10]。由此,笔者考虑 T2DM 患者非创伤性肩袖损伤的发生与骨

骼肌质量的下降可能存在密切联系。

众多研究表明糖尿病是肩袖损伤的危险因素[2,10-11],但是其机制尚未明确。有研究发现,高血压、高龄、男性、较高的 BMI 和诊断为腕管综合征是与肩袖撕裂风险增加显著相关的危险因素,而吸烟与肩袖撕裂无关[12-13]。Abate 等[14]的研究发现 BMI 和体脂率与肩袖撕裂的发生率和严重程度密切相关。本研究显示,T2DM 合并肩袖损伤患者女性比例、体重、BMI、体脂率高于非肩袖损伤患者。两组的年龄、吸烟和高血压状况无明显差异。这一结果与 Abate 等[14]研究结果部分相符,其差异可能是因为本研究仅基于糖尿病患者及样本量存在局限。另外,女性患者比例较高可能与绝经后雌激素改变影响骨骼肌蛋白代谢,间接影响骨骼肌质量和功能有关[15]。此外,本团队还发现糖尿病合并肩袖损伤患者糖尿病病程及 HbA1c 水平均高于非肩袖损伤患者,提示持续的高糖环境可能会增加糖尿病患者肩袖损伤风险。Longo 等[16]也发现即使血糖水平处于正常范围的高限,可能是导致肩袖损伤的一个危险因素。这一结论可说明糖尿病患者合理控制血糖对预防肩袖损伤有重要意义。

Atala 等[17]的研究认为骨骼肌质量减少不能作为肩袖损伤的独立危险因素,但本研究 logistic 分析示 T2DM 患者 SMI 降低可能是非创伤性肩袖损伤的独立危险因素。其差异需要进一步探究。

糖尿病个体表现出线粒体功能改变和葡萄糖稳态受损[18]。线粒体氧化能力受损可能会促进活性氧的产生,导致氧化应激增加,这可能是促进骨骼肌组织损伤的核心特征[19]。骨骼肌是人体最大的胰岛素靶器官,是胰岛素刺激下葡萄糖摄取的主要部位,但是当糖尿病患者出现胰岛素抵抗时,胰岛素相关信号通路受到抑制,导致蛋白质合成减少、分解增加,引起骨骼肌质量减小[20]。胰岛素抵抗还会促进糖异生的发生,从而引起固醇调节元素结合蛋白 1c 的上调、β-氧化的抑制及游离脂肪酸的释放增加,进而转变三酰甘油转运途径,最终导致三酰甘油在骨骼肌中的积累[21],提示糖尿病可能加速了肩袖肌组织的脂肪变性。另外,糖尿病患者持续高血糖会加快晚期糖基化终产物(AGEs)的形成,AGEs 的积累通过增加肌肉内蛋白交联、干扰肌肉收缩力、上调炎症反应、引发氧化应激和损害内皮功能进而影响肌肉质量[9]。以上机制引起的肌腱特性及组织、细胞分子的改变,可使糖尿病患者更易发生肌腱损伤。

本研究 ROC 曲线发现,SMI 诊断 T2DM 患者发生非创伤性肩袖损伤的最佳截断值为 5.15,灵敏度为 48.80%,特异度为 82.00%。即 T2DM 患者 SMI 低于该临界值时,其发生非创伤性肩袖损伤的可能性较大,表明 SMI 降低对非创伤性肩袖损伤发生有一定预测作用,后期尚需大样本、多中心研究加以证实。

综上所述,骨骼肌质量降低是 T2DM 患者发生非创伤性肩袖损伤的独立危险因素,对临床早期发现并预防 T2DM 患者运动系统并发症有重要意义。同时,本研究有一定的局限性。首先,仅收集糖尿病患者,缺少正常人群对照;其次,患者的饮食、作息、运动情况等不同生活习惯可能影响结果。未来仍需开展多中心、大样本研究,在不同人群中进一步验证。

利益冲突　无

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收稿日期:2024-05-20　**修回日期**:2024-06-03　**编辑**:王海琴

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收稿日期:2023-08-28　**修回日期**:2023-11-24　**编辑**:叶小舟