

Risk of anterior cruciate ligament injury in population with elevated body mass index

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ABSTRACT

Aim Anterior cruciate ligament (ACL) injury is among the most common orthopaedic injuries. The elevated body mass index (BMI) can contribute to non-contact ACL injury. This study aims to assess the risk of ACL injury among elevated BMI population people (BMI ≥ 25 Kg/m²).

Methods This is a cross sectional study that was conducted in a tertiary care centre in the Kingdom of Saudi Arabia. A total of 302 patients, who had an ACL reconstruction surgery in a ten-year-period (January 2008 to December 2018) were included.

Results Sport related injury is significantly higher among the overweight and obese groups ($p=0.002$). Moreover, the combined ACL tear was higher among the overweight and obese groups ($p=0.001$). In univariate regression analysis for the selected baseline characteristics, it was found that individuals with higher BMI have chance to develop combined (ACL) injury 2 times higher when compared to those with isolated ACL injury ($p=0.003$). Also, the ACL type, mode of injury, types of injury and type of sports were statistically significant in univariate regression analysis. However, only the mode of injury was statistically significant after controlling the confounding factors. Other selected variables like type of sport, type of injury and ACL type were not significant.

Conclusion Elevated BMI was associated with a higher risk of developing combined ACL tear as well as reinjured individuals.

Key words: anterior cruciate ligament reconstruction, BMI, knee injury, obesity, sport injury

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INTRODUCTION

Anterior cruciate ligament (ACL) tear is among the most common orthopaedic injuries (1,2). The annual ACL injury rate in the United States is reported to be between 100000 – 200000 (3). Many factors have been associated with ACL injury including modifiable and non-modifiable risk factors. In fact, understanding the modifiable risk factors is crucial in employing preventative measures (4,5). One of the modifiable risk factors is an elevated body mass index (BMI), which can contribute to the development of non-contact ACL injury and associated with articular injuries in the presence of ACL tear (6). Reportedly, elevated BMI in both genders is associated with increasing the rate of knee injuries (7,8). Noyes et al. found that 75% of ACL injuries were due to non-contact mechanism (9).

Limited studies assessed the association between BMI and the risk of ACL injury (10). World Health Organization (WHO) considers obesity as a worldwide health issue which is associated with many chronic disorders. WHO classified the BMI between 25 - 30 kg/m² as an overweight and more than 30 kg/m² as obesity (11). In the Kingdom of Saudi Arabia (KSA), the prevalence of overweight population is 30.7% in males and 28.4% in females. Moreover, the prevalence of obesity is more in females, accounting for 23.6% compared with 14.2% in the male population (12). Although obesity is an emerging health issue in the KSA and ACL injury is one of the most common injuries faced by orthopaedic surgeons, there is only one national study, up to authors' knowledge, which assessed the association between these variables (1,12).

The aim of this study is to evaluate the risk of ACL injury in a population with an elevated BMI (BMI \geq 25 Kg/m²) in a tertiary care centre in Al-Khobar city, KSA.

PATIENTS AND METHODS

For this cross-sectional study, which was conducted in a tertiary care centre in Al Khobar, KSA, data were collected in a ten-year period (January 2008 to December 2018). The study included all patients who underwent ACL reconstruction using either semitendinosus (semi-T) or bone-tendon bone (BTB) autograft/allograft. Patients' demographics and other variables related to the injury and surgery were obtained via an electronic file system. Three

hundred and two patients were included, and 13 patients were excluded due to missing data, so the total cohort was 289. An institutional review board approval was granted for the study.

Methods

The rate of isolated anterior cruciate ligament tear, multi-ligamentous tears and associated meniscal injuries were compared between normal BMI and elevated BMI groups in conjunction with baseline variables. Multi-ligamentous tears were defined as an ACL tear plus one or more of the following: medial collateral ligament, the lateral collateral ligament and posterior cruciate ligament tears. The collected data included the date of admission, duration of injury and date of surgery, along with height (m) and weight (kg) represented by the BMI.

The sample was categorized into three main categories, based on WHO classification of BMI, the normal BMI group (17.9-24.9), overweight (25-29.9) and obese group. The obese group included the three main classes: Class I for BMI between (30- 34.9), Class II BMI between (35- 39.9) and Class III for BMI of 40 and above. Mechanisms of injury involving the type of sport, either contact sports (e.g., football and basketball), non-contact sports (e.g., jogging and jumping) or non-sport injuries (e.g., falls) were considered. The presence or absence of surgical revision was documented.

Statistical analysis

The data were described using numbers and percentages for all categorical variables. The relationship between the BMI level and baseline characteristics of patients was conducted using the χ^2 test. The $p < 0.05$ was accepted as the significant level for all statistical tests. Univariate and multivariate regression analysis had been conducted as well to predict the likelihood effect of the BMI \geq 25 kg/m² against the significant variables drawn from the cross tabulation where the unadjusted and adjusted odds ratio (OR) as well as 95% confidence interval (CI) were also being reported.

RESULTS

The age range of 289 patients was 12-55 years old (mean 28.3 \pm 7.5). Nearly all patients were males, 284 (98.3%). Injuries were mostly due to sport activities, 201 (69.6%), while 88 (30.4%) were due to

non-sport. The mean BMI was 27.6 (SD 4.8). Based on BMI classification, 86 (29.8%) patients had normal BMI, 116 (40.1%) were overweight and the 87 (30.1%) were obese. Three out of four patients had the ACL injury for the first time. Most patients had an isolated ACL injury, 110 (38.1%). Combined ACL with medial meniscus injury accounted for 97 (33.6%) patients. The ACL with lateral meniscus injury accounted for 26 (9%), and ACL with both menisci were 32 (11%). The relationship between the level of BMI and baseline characteristics of patients showed that the mode of injury ($p=0.018$) isolated ACL injury ($p=0.003$), and ACL injury type ($p=0.007$) significantly influence the level of BMI (Table 1).

Table 1. Relationship between the level of body mass index (BMI) and clinical characteristics of 289 patients with anterior cruciate ligament (ACL) injury

Variable	N (%) of patients			p
	Total (n=289)	Elevated BMI (≥ 25 kg/m ²) (n=203)	Normal BMI (<25 kg/m ²) (n=86)	
Age group				
≤30 years	193 (66.7)	128 (63.1)	65 (75.6)	0.039
>30 years	96 (33.2)	75 (36.9)	21 (24.4)	
Gender				
Male	284 (98.3)	198 (97.5)	86 (100)	0.142
Female	5 (1.7)	05 (02.5)	0	
Type of sports				
Football	190 (65.7)	121 (59.6)	69 (80.2)	0.001
Non-football	99 (34.2)	82 (40.4)	17 (19.8)	
Leg injured				
Left	129 (44.6)	92 (45.3)	37 (43.0)	0.595
Right	158 (54.7)	109 (53.7)	49 (57.0)	
Both	2 (0.70)	02 (01.0)	0	
Isolated				
Isolated	113 (39.1)	68 (33.5)	45 (52.3)	0.003
Combined	176 (60.9)	135 (66.5)	41 (47.7)	
Type of injury				
Sport	201 (69.6)	130 (64.0)	71 (82.6)	0.002
Non-sport	88 (30.4)	73 (36.0)	15 (17.4)	
Classification of injury				
Contact	97 (33.6)	65 (32.0)	32 (37.2)	0.393
Non-contact	192 (66.4)	138 (68.0)	54 (62.8)	
Mechanism of injury				
Fall	37 (12.8)	31 (15.3)	06 (07.0)	0.146
Twisting	163 (56.4)	110 (54.2)	53 (61.6)	
Trauma	89 (30.8)	62 (30.5)	27 (31.4)	
Type of graft				
Semi-T	269 (93)	189 (94.0)	80 (93.0)	0.747
BTB	20 (6.9)	14 (06.0)	06 (07.0)	
Source of graft				
Autograft	284 (98.2)	198 (98.5)	86 (100)	0.255
Allograft	05 (1.7)	05 (01.5)	0	
Mode of injury				
Reinjured	74 (25.6)	60 (29.6)	14 (16.3)	0.018
Non-reinjured	215 (74.4)	143 (70.4)	72 (83.7)	
ACL type				
Isolated ACL	110 (38.1)	67 (33.0)	43 (50.0)	0.007
Non-isolated ACL	179 (61.9)	136 (67.0)	43 (50.0)	

BMI, body mass index; Semi-T, semitendinosus; BTB, bone-tendon bone; ACL, anterior cruciate ligament

The results of univariate analysis predicted that those who had reinjured ACL were 2.16 times more likely in the elevated BMI group (UOR=2.16; 95% CI=1.13–4.12; $p=0.020$). After conducting multivariate for the latter, the risk decreased to 1.97 (AOR=1.97; 95% CI=1.00–3.85; $p=0.049$). For ACL type, the risk of injury in elevated BMI group in the non-isolated ACL group was 2.03 times higher than those with isolated ACL (UOR=2.03; 95% CI=1.21–3.39; $p=0.007$) (Table 2).

Table 2. Univariate and multivariate regression analysis to determine independent significant factors associated with body mass index (BMI ≥ 25 kg/m²) in 289 patients with anterior cruciate ligament injury

Variable	UOR (95% CI)	p	AOR (95% CI)	p
Age group				
≤30 years	Ref		Ref	
>30 years	1.81 (1.03–3.20)	0.040	1.61 (0.89–2.92)	0.115
Type of sports				
Football	0.36 (0.19–0.66)	0.001	1.92 (0.69–5.26)	0.206
Non-football	Ref		Ref	
Isolated				
Isolated	Ref		Ref	
Combined	2.18 (1.30–3.64)	0.003	1.66 (0.67–4.12)	0.271
Type of Injury				
Sport	2.66 (1.42–4.97)	0.002	0.74 (0.26–2.12)	0.575
Non-sport	Ref		Ref	
Mode of injury				
Reinjured	2.16 (1.13–4.12)	0.020	1.97 (1.00–3.85)	0.049
Non-reinjured	Ref		Ref	
ACL type				
Isolated ACL	Ref		Ref	
Non-isolated ACL	2.03 (1.21–3.39)	0.007	1.33 (0.54–3.32)	0.535

UOR, unadjusted Odds Ratio; AOR, adjusted Odds Ratio; CI, Confidence Interval, Ref, reference category

DISCUSSION

Our study focused on addressing the association between elevated BMI and ACL injury. Understanding the association between these variables in this study is crucial. Obesity is a major public health problem that causes burden on the patient and the society affecting a large number of countries worldwide (13). The overall world prevalence of obesity and overweight in the KSA was 35.6% and 36.9%, respectively, that makes 72.5% of the population falling in either overweight or obese category (11). Surprisingly, in our study obese and overweight patients were 30.1% and 40.1% of the study's population respectively, which accounted for 70.2 % of the total number.

Thein et al. reported that increased BMI in both genders is associated with an elevated prevalence of knee injuries, but it was more significant in females in terms of having more associated meniscal and ligamentous injuries (8). In our study,

most of the patients were male accounting for 98.3%; that makes it difficult to draw a statistical conclusion because the sample is not representative for the gender.

In our study, the patients with high BMI were more prone to develop non-isolated ACL injuries than isolated ACL compared to patients with normal BMI (<25 kg/m²). Also, there was a significant difference in the reinjury rate, which was significantly less in the group with normal BMI. This was the only significant finding after adjustment to confounders. The risk of ACL tears and particularly combined ACL tears were significantly higher across the high BMI group.

A recent systematic review showed that the non-contact injuries in the patients with normal BMI account for 49%, while in the elevated BMI, the non-contact injuries reach 40% indicating no significant difference between the two groups (6). Al Jassir et al. have found that the BMI was not counted as a risk factor of injury; their study did not include ACL cases with traumatic injuries, partial tear, revision ligament surgery, multi-ligamentous injury and patients with current or old hamstring injuries (14). In contrary, all first and reinjured patients with contact and non-contact injuries were included in our study. In a study by Ballal et al. on the functional outcome of primary ACL reconstruction with hamstring graft, there was no significant difference between the patients with normal and high BMI in terms of mean age, postoperative length of stay or injury mechanism (15).

Our research focused on the role of elevated BMI and its relationship to ACL injury. As BMI is one of the modifiable factors, understanding the relationship between these variables will give us a clue to improve the prevention strategies of ACL injuries. In Bojicic et al. study, sagittal magnetic resonance (MRI) images had been collected and specific radiological measurements had been quantified in addition to patients' demographic data suggesting that high BMI was associated with a risk of developing ACL injury in presen-

ce of increased value of lateral posterior tibial slope (16). Derraik et al. reported an association between patients with elevated BMI and the progressive decrease in physical functions, therefore, such a deficit can include patients who suffer from orthopaedic diseases such as ACL injuries (17). Identifying and understanding the risk factors and the mechanism of ACL injury are of great importance for the patients and clinicians as it helps to design neuromuscular training programs for athletes (18).

ACL injury can cause knee joint instability leading ultimately to cartilage damage and the development of knee osteoarthritis (19,20).

Our study showed that the patients with an elevated BMI had a higher risk for developing isolated as well as non-isolated ACL tear.

A limitation of our study is that BMI was only measured at the time of hospital admission and may not indicate the true BMI measure at the time of injury. The study did not differentiate between partial or complete ACL injuries. Also, the sampling design of this study was non-probability sampling based on the patients who visited the medical centre. Moreover, both partial and complete tears were considered and submitted together.

In conclusion, understanding the association between an elevated BMI and ACL injury is important in the implementation of appropriate preventive measures. Recent literature suggests having an elevated BMI is a modifiable risk factor for ACL injury. Many questions remain unanswered, including the type of body fat mass versus the lean and how much is the hazardous amount of weight gain, all these questions could be the target of future research.

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TRANSPARENCY DECLARATION

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