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Original article

Is recovery from ankle sprains negatively affected by obesity?

I.A. Bielska [a,*], R. Brison [a,b], B. Brouwer [c,d], I. Janssen [a,d], A.P. Johnson [a], A.G. Day [e], W. Pickett [a,b]

[a] Department of Public Health Sciences, Queen's University, K7L 3N6 Kingston, ON, Canada
[b] Department of Emergency Medicine, Queen's University, K7L 3N6 Kingston, ON, Canada
[c] School of Rehabilitation Therapy, Queen's University, K7L 3N6 Kingston, ON, Canada
[d] Department of Kinesiology and Health Studies, Queen's University, K7L 3N6 Kingston, ON, Canada
[e] Kingston General Hospital Research Institute, K7L 2V7 Kingston, ON, Canada

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ABSTRACT

Objective: Ankle sprains are common injuries that may lead to long-term morbidity. Individuals with obesity are at increased risk for ankle sprains; however, prognostic associations between body mass index (BMI) and recovery are less well understood. This study investigated whether BMI status affects recovery from ankle sprains.
Methods: We included individuals ≥ 16 years old with grade 1 or 2 ankle sprains who sought emergency department treatment in Kingston, Ontario, Canada. Height in centimeters and weight in kilograms were measured at baseline by using a height rod and a standard medical column scale, respectively. BMI was calculated and categorized as non-overweight, < 25.0 kg/m^2; overweight, 25.0–29.9 kg/m^2; and obese, ≥ 30 kg/m^2. Recovery was assessed at 1, 3 and 6 months post-injury by the Foot and Ankle Outcome Score (FAOS). Continuous FAOS and binary recovery status were compared by BMI group at each assessment using a repeated measures linear mixed effects model and logistic regression, respectively.
Results: In total, 504 individuals were recruited and 6-month follow-up data were collected for 80%. We observed no significant differences in recovery at 1 and 3 months post-injury. At 6 months, between 53% and 66% of the participants were considered to have recovered according to the FAOS. The mean difference in unadjusted FAOS between participants classified as obese and non-overweight was −23.02 (95% confidence interval, −38.99 to −7.05) but decreased after adjusting for confounders. The odds ratio for recovery was 0.60 (0.37–0.97) before adjustment and 0.74 (0.43–1.29) after adjustment. Six-month recovery was significantly lower for participants with obesity than non-overweight participants on the FAOS Pain and Function in Daily Living subscales but were not clinically meaningful.
Conclusions: All BMI groups showed improvements from ankle sprain over time. However, at 6 months, a sizeable proportion of the participants had not fully recovered particularly among individuals classified as obese. The findings suggest that individuals with obesity may benefit from specialized interventions focused on symptom management and functional activity.

1. Introduction

Ankle sprains are soft-tissue injuries representing partial or complete tears to one or more of the ankle joint ligaments [1]. Patients with ankle sprains commonly seek emergency room treatment, where they account for up to 5% of visits [2,3]. One half to three quarters of patients with ankle sprains report mobility problems, recurrent sprains, or residual symptoms of pain and swelling 6 to 18 months post-injury [4,5]. Several factors affect the recovery time from ankle sprains, most notably patient age and severity of injury [6–8].

Numerous studies have shown that individuals with body mass index (BMI) indicative of being overweight or obese are at increased risk of ankle sprains [8,10] and recurrent sprains [7]. However, we have little information on the potential prognostic effects of BMI on recovery from ankle sprains. A prospective cohort study of US children found that those classified as overweight or obese based on BMI were almost twice more likely to experience persistent symptoms half a year following the ankle sprain injury than children in the healthy BMI range

* Corresponding author.
E-mail address: iwona.bielska@queensu.ca (I.A. Bielska).

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[11]. However, a second study of adults with ankle sprains from the United Kingdom ($n = 85$) did not find a relation between BMI and recovery at 4 and 16 weeks post-injury [12].

Mechanistically, increased BMI has a direct effect on the ankle joint because of abnormally high joint loading. The ankle joint supports the body's weight and can experience compressive forces that exceed 8 times the body's weight [13]. The high ground reaction forces and ankle joint loading associated with running and jumping render the ankle joint susceptible to injury due to improper stepping or altered foot strike pattern [13,14]. Increased BMI is also related to reduced balance control, postural instability, and mobility problems, which may contribute to increased risk of falling among individuals with obesity [15–17]. Indirectly, BMI may influence ankle joint function and health because of poor physical condition [10]. Therefore, excess weight may negatively affect ankle joint healing post-injury [18].

Approximately 16 million (or 60%) of Canadian adults are living with overweight or obesity [9], so knowledge about the effect of BMI on recovery from the common injury of ankle sprains is especially important. The objective of this study was to investigate the impact of BMI as a prognostic factor for recovery from medically attended ankle injuries among adult Canadians recruited from a tertiary-care hospital setting.

2. Materials and methods

2.1. Study design

This was a prospective study of individuals $\geq$ 16 years old with a diagnosis of acute grade 1 or 2 ankle sprain at one of 2 hospital-based emergency departments in Kingston, Ontario, Canada, between September 2009 and April 2013. The study was part of a randomized controlled trial of a physical therapy treatment protocol for ankle sprains [19]. Participants were randomized to receive usual care in the emergency department (including instructions on PRICE — protection, rest, ice, compression, elevation) or a physical therapy regimen in addition to usual care and followed clinically for 6 months. All study participants provided consent, and ethics approval was obtained from the Queen's University Health Sciences Research Ethics Board. This research was performed in adherence to the principles of the Declaration of Helsinki.

2.2. Study inclusion and exclusion criteria

Ankle sprain severity was evaluated according to the West Point Ankle Grading System by the attending emergency physician during the initial emergency department presentation [20]. Individuals with grade 1 or 2 ankle sprain were included in the trial if they were $\geq$ 16 years old and presented for treatment within 72 hr of the acute ankle sprain, could communicate in English, were mentally competent, and agreed to participate in the follow-up motor performance laboratory (MPL) testing and telephone interviews. We excluded individuals with grade 3 ankle sprains, fractures, or conditions requiring immobilization or surgery as assessed by the attending emergency physician and ruled out by imaging, when appropriate. Patients with other soft-tissue injuries or multiple injuries that could affect ankle sprain recovery were also excluded after a medical examination in the emergency department. Additionally, individuals who had sprained their ankle in the preceding 6 months, scored $\geq$ 450/500 on the Foot and Ankle Outcome Score (FAOS) questionnaire at recruitment, had arranged for physiotherapy, or had other health conditions that limited mobility, such as arthritis or neurological diseases, were excluded.

2.3. Data collection

Demographic and injury information were collected at a baseline MPL visit within 1 week post-injury. Height in centimeters (to the nearest 0.1 cm) and weight in kilograms (to the nearest 0.1 kg) were measured at baseline by a trained research assistant who used a height rod and a standard medical column scale, respectively. BMI was calculated as kg/m^2 and classified according to the World Health Organization BMI Classification: non-overweight, < 25.0 kg/m^2; overweight, 25.0–29.9 kg/m^2; and obese, ≥ 30 kg/m^2 [21]. For participants who were 16 and 17 years old, BMI was classified by using the International Obesity Task Force age- and sex-specific BMI cutoffs that are linked to the adult BMI cutoffs [22].

Prognostic data on recovery were collected prospectively at 1, 3, and 6 months after the initial emergency department visit. The baseline FAOS was used as a measure of functional status at the time of the injury, and recovery from ankle sprains was assessed by using the 1-, 3-, and 6-month FAOS. The FAOS instrument is a 42-item interviewer-administered questionnaire that provides self-perception of the symptoms and limitations related to the ankle joint [23]. The FAOS questionnaire has 5 subscales: Symptoms subscale (SS), Pain subscale (PS), Function in Daily Living subscale (ADLS), Function in Sport and Recreation subscale (SPS), and Foot and Ankle-Related Quality of Life subscale (QOLS) [23,24]. A score of 0 (extreme symptoms) to 100 (no symptoms) was estimated for each of the 5 subscales. The FAOS questionnaire has been validated in patients with ankle ligament reconstruction [24]. The content validity of FAOS items was assessed to be relevant and important by patients, and its construct validity was moderately correlated with the Karlsson score of ankle function ($r = 0.58$ to 0.67) [24,25]. The FAOS questionnaire has high test–retest reliability (Spearman's correlation coefficient $\geq$ 0.85 on all 5 subscales) and high internal consistency (Cronbach alpha $\geq$ 0.88 on all 5 subscales) [24,25]. A clinically significant difference in FAOS has been reported to be 8 to 10 points for the subscale scores [2]. Excellent recovery was defined as scoring 90% or greater on the FAOS questionnaire, which corresponds to a total score of 450/500 overall or 90/100 on the subscales [26–29].

Additional prognostic factors for recovery from ankle sprains and other musculoskeletal injuries that could confound the relationship of interest were selected from the existing biomedical literature and assessed for inclusion in the statistical models. These factors included sex, age, injury severity, injured dominant lower limb (as measured by which foot was used to kick a ball), self-reported level of preinjury physical activity (days per week with at least 60 min of activity per day), and income category [12,30–33]. Self-reported employment status and income were used to assess socioeconomic status with the following categories:

- unemployed, full-time student, or retired;
- annual earnings of $<$ \$19,999;
- \$20,000–39,999;
- or $\geq$ \$40,000 Canadian.

The income categories were created to correspond with Canada's low-income cut-off and the lowest federal tax rate bracket [34,35].

2.4. Statistical analysis

Baseline participant data are presented by BMI group by using cross-tabulations for categorical predictor variables and means (with SD) for continuous predictor variables. A linear repeated measures mixed-effects model allowing for unstructured within-patient correlation was estimated by restricted maximum likelihood to model the association between BMI group exposure and the continuous representation of the FAOS outcome while controlling for covariates and accounting for the repeated measures at 1, 3, and 6 months post-randomization. In model 1, a backward elimination strategy was used for covariate selection, with percentage changes (15%) in the estimates of the BMI effect at month 1 used as the criteria for retention. This model controlled for the effects of baseline FAOS, sex, age, and access to a structured physical therapy program. Model 2 included all predictor variables associated with recovery from injury based on the literature, [12,30–33], which in addition to the variables in model 1 included number of days per week of physical activity, injury to the dominant leg, income group, and grade of injury. This analysis was repeated for FAOS subscale scores as the outcome (SS, PS, ADLS, SPS, and QOLS). Logistic regression analyses were used to examine the association between BMI and recovery, with full recovery defined as FAOS ≥ 450 versus less than full recovery, controlling for variables included in model 1 and model 2. Recovery was assessed at 1, 3, and 6 months post-injury. The analysis was repeated for all subscale scores (recovery defined as a subscale score ≥ 90) as the outcome. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated. All tests were two-sided without adjustment for multiplicity. *A priori*, the fully adjusted (model 2) 6-month difference in recovery between patients with non-overweight and obese BMI was considered the primary comparison. All analyses involved using SAS 9.4 (SAS Inst., Cary, NC, USA).

3. Results

3.1. Study participants

We recruited 504 participants aged 16 to 79 years old. One participant withdrew from the study and 3 did not have their height and weight measured, so 500 patients remained at baseline. Fig. 1 presents the flow of participants with available baseline height and weight data in the study. Overall, 95%, 88%, and 80% of the participants remained in the study at 1-, 3-, and 6-month follow-up, respectively.

3.2. BMI

At baseline, 38% of participants had BMI < 25 kg/m^2 (non-overweight; 3 participants had scores in the upper bounds of the underweight category and were included in the non-overweight category); 31% had BMI 25–30 kg/m^2 (overweight), and 31% had BMI ≥ 30 kg/m^2 (obese). Among a subset of 190 trial participants (baseline BMI non-overweight, 38%; overweight, 34%; obese, 28%) who consented to having BMI measured at all 3 follow-up times, BMI did not significantly change over the study period.

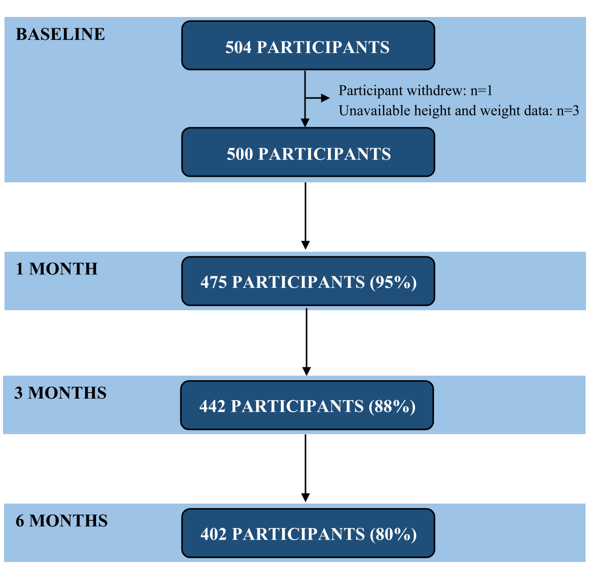

Fig. 1. Flow of participants with available baseline height and weight data in the study.

Table 1
Distribution of prognostic factors for ankle sprain recovery by body mass index (BMI) at baseline.

	BMI (kg/m^2)		
	< 25 *n* = 191 (38%)	25–29.9 *n* = 156 (31%)	≥ 30 *n* = 153 (31%)
Sex			
Male	86 (45%)	78 (50%)	57 (37%)
Female	105 (55%)	78 (50%)	96 (63%)
Age (years; mean, SD)	26 (12)	32 (14)	35 (13)
Ankle sprain grade			
Grade 1	55 (29%)	48 (31%)	45 (29%)
Grade 2	136 (71%)	108 (69%)	108 (71%)
Baseline FAOS scores (mean, SD)			
Symptoms subscale	52 (15)	52 (15)	51 (16)
Pain subscale	53 (15)	52 (15)	51 (16)
Function in Daily Living subscale	60 (17)	58 (16)	56 (18)
Function in Sport and Recreation subscale	29 (19)	27 (19)	28 (19)
Foot and Ankle-Related Quality of Life subscale	33 (18)	34 (19)	34 (21)
Overall score	226 (68)	223 (69)	220 (75)
Injured dominant foot			
Yes	106 (55%)	82 (53%)	83 (54%)
No	85 (45%)	74 (47%)	70 (46%)
History of past injury to ankle/foot			
Yes	108 (57%)	89 (57%)	100 (65%)
No	83 (43%)	67 (43%)	53 (35%)
Diagnosed with condition[a]			
Yes	8 (4%)	14 (9%)	25 (16%)
No	183 (96%)	142 (91%)	128 (84%)
Income category[b]			
Unemployed, student, retired	59 (31%)	35 (22%)	35 (23%)
< $19,999	69 (36%)	47 (30%)	36 (24%)
$20,000–39,999	30 (16%)	22 (14%)	36 (24%)
≥ $40,000	33 (17%)	52 (33%)	46 (30%)
Number days per week physically active for 60 min (mean, SD)	5.2 (1.7)	4.6 (2.2)	4.0 (2.4)

FAOS: Foot and Ankle Outcome Score.
[a] Previous diagnosis of an arthritic condition, diabetes, or loss of sensation in the extremities.
[b] Canadian dollars.

Table 1 describes the distribution of prognostic factors for ankle sprain recovery by BMI at baseline. Individuals with BMI ≥ 30 kg/m^2 tended to be female, older, and less physically active as compared with other BMI groups; they had a history of previous ankle or foot injuries and a previous diagnosis of an arthritic condition, diabetes, or loss of sensation in the extremities. Baseline FAOS and subscale scores were similar across the BMI groups.

3.3. Overall FAOS

When FAOS was classified by recovery status (excellent recovery score ≥ 450), the proportion of participants classified as recovered increased over time, despite no significant differences between the groups at any of the follow-up times (Fig. 2). However, at 6 months, a large proportion of individuals reported problems with ankle function, as demonstrated by an FAOS < 450 for 35% of

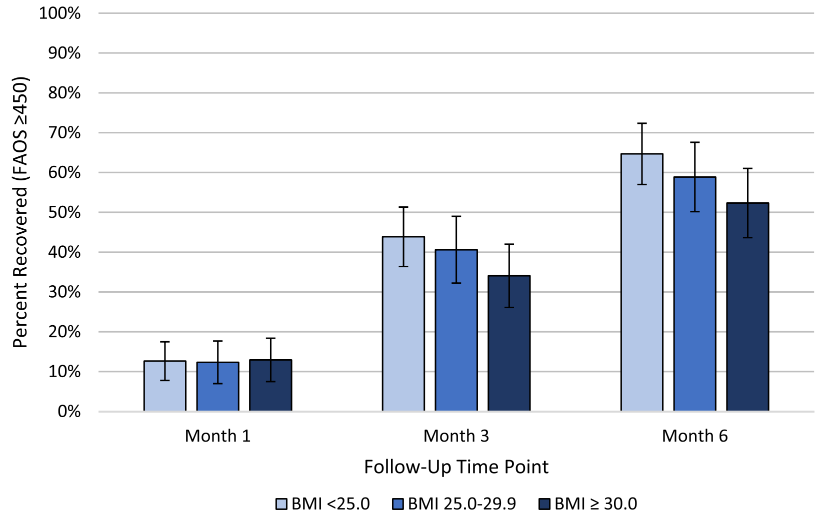

Fig. 2. Percentage of recovered participants (Foot and Ankle Outcome Score ≥ 450), with 95% confidence intervals, by body mass index at 1, 3 and 6 months post-injury.

Table 2
Linear repeated measures mixed-effects model of the effect of BMI on mean Foot and Ankle Outcome Score (FAOS) at each follow-up time.

		FAOS					
	BMI, kg/m^2	Unadjusted		Adjusted model 1[a]		Adjusted model 2[b]	
Month 1	< 25	356 (344–368)	ref.	351 (340–361)	ref.	352 (340–364)	ref.
	25–29.9	350 (336–363)	$p = 0.47$	350 (339–362)	$p = 0.95$	353 (340–366)	$p = 0.89$
	≥ 30	340 (326–353)	$p = 0.08$	346 (334–357)	$p = 0.52$	346 (334–359)	$p = 0.51$
Month 3	< 25	420 (409–431)	ref.	415 (404–425)	ref.	416 (404–428)	ref.
	25–29.9	417 (405–430)	$p = 0.76$	418 (407–430)	$p = 0.65$	421 (408–434)	$p = 0.51$
	≥ 30	408 (396–421)	$p = 0.18$	415 (403–426)	$p = 0.98$	415 (403–428)	$p = 0.97$
Month 6	< 25	450 (440–461)	ref.	445 (435–456)	ref.	447 (435–459)	ref.
	25–29.9	446 (434–458)	$p = 0.57$	447 (436–459)	$p = 0.84$	450 (437–462)	$p = 0.69$
	≥ 30	427 (416–439)	$p < 0.01$	434 (422–445)	$p = 0.14$	435 (423–447)	$p = 0.15$

Data are mean (95% confidence interval). ref.: reference subgroup.
[a] Controlled for baseline FAOS, sex, age, and access to a structured physical therapy program.
[b] Controlled for model 1 covariates and number of days of physical activity, injuring the dominant leg, income group, and ankle sprain grade.

individuals with BMI < 25 kg/m^2, 41% with BMI 25–30 kg/m^2, and 48% with BMI ≥ 30 kg/m^2. The mean FAOS improved over time for all BMI groups (Table 2). After controlling for covariates, individuals classified as overweight or obese versus non-overweight did not significantly differ in mean FAOS at any of the follow-up times. By 6 months, the fully adjusted (model 2) mean difference between participants classified as obese versus non-overweight was −11.95 (95% CI, −28.13 to 4.23, $P = 0.15$). The odds of recovery on the FAOS did not significantly differ among those with BMI classified as overweight and obese as compared with individuals classified as non-overweight after controlling for covariates (Table 3).

3.4. FAOS subscale scores

When the FAOS subscale scores were dichotomized by recovery status, the proportion of individuals who had recovered (score ≥ 90) increased over time for all subscales, with participants in the non-overweight category having the most recovery (data not shown). By 6 months, more than 50% of the participants in all BMI groups had recovered according to the SS, PS, ADLS, and SPS. Participants fared worse on the QOLS in that less than 50% of the patients had recovered by 6 months across BMI groups.

The PS score was significantly lower (worse) among individuals with BMI ≥ 30 versus < 25 kg/m^2 at 6 months (mean difference: −3.11, 95% CI, −6.08 to −0.13, $P = 0.04$, in model 2). On this subscale, the odds of recovery were reduced with BMI ≥ 30 versus < 25 kg/m^2 (OR: 0.48, 95% CI, 0.26 to 0.88 in model 2) at 6 months. The mean ADLS was significantly lower with BMI ≥ 30 than < 25 kg/m^2 at 6 months after adjustment for covariates (mean difference: −2.80, 95% CI, −5.28 to −0.32, $P = 0.03$, in model 2). Because the differences in the mean subscale scores between the non-overweight and obese categories did not exceed 8 to 10 points on any of the subscales (PS or ADLS) [2], the differences were not deemed clinically significant based upon our *a priori* criteria. We found no statistically significant differences with the SS, SPS, or QOLS.

4. Discussion

This study demonstrated that across all BMI groups, recovery from ankle sprains improved over time, as assessed by the FAOS and its subscale scores. However, at 6 months, a sizeable proportion of participants still had not fully recovered, with higher levels of incomplete recovery observed among individuals classified as obese. Some of the differences were accounted for by potential confounders including baseline FAOS, sex, age, access to a structured physical therapy program, injury to the dominant lower limb, days of physical activity per week, income category, and ankle sprain grade, which resulted in a loss of statistical significance of the estimates. As compared with the non-overweight referent group, individuals with a BMI ≥ 30 kg/m^2 had lower subscale scores on all domains, but after adjustment for

Table 3
Logistic regression analysis of the effect of BMI on recovery based on FAOS at each follow-up time.

	BMI, kg/m^2	Recovery based on FAOS					
		Unadjusted		Adjusted model 1[a]		Adjusted model 2[b]	
Month 1 ($n=475$)	< 25	1.00	ref.	1.00	ref.	1.00	ref.
	25–29.9	0.97 (0.50–1.88)	$p=0.93$	1.07 (0.53–2.16)	$p=0.86$	1.08 (0.53–2.21)	$p=0.84$
	≥ 30	1.03 (0.54–1.97)	$p=0.94$	1.27 (0.62–2.61)	$p=0.52$	1.40 (0.66–2.96)	$p=0.38$
Month 3 ($n=442$)	< 25	1.00	ref.	1.00	ref.	1.00	ref.
	25–29.9	0.88 (0.55–1.39)	$p=0.57$	0.97 (0.59–1.62)	$p=0.92$	1.00 (0.60–1.69)	$p=0.99$
	≥ 30	0.66 (0.42–1.05)	$p=0.08$	0.77 (0.46–1.29)	$p=0.31$	0.83 (0.48–1.42)	$p=0.49$
Month 6 ($n=402$)	< 25	1.00	ref.	1.00	ref.	1.00	ref.
	25–29.9	0.78 (0.48–1.28)	$p=0.33$	0.86 (0.51–1.45)	$p=0.57$	0.90 (0.53–1.53)	$p=0.69$
	≥ 30	0.60 (0.37–0.97)	$p=0.04$	0.70 (0.42–1.19)	$p=0.19$	0.74 (0.43–1.29)	$p=0.29$

Data are odds ratios and 95% confidence intervals. ref.: reference subgroup.
[a] Controlled for baseline FAOS, sex, age, and access to a structured physical therapy program.
[b] Controlled for model 1 covariates and number of days of physical activity, injuring the dominant leg, income group, and ankle sprain grade.

potential confounders, these differences reached statistical significance for only the PS and ADLS subscales and were not clinically meaningful.

The study findings are consistent with those reported by a previous prognostic study of adults from the United Kingdom: [12] at 4 and 16 weeks of follow-up, BMI was not a significant predictor of recovery. Furthermore, another study found that among adolescent Canadians surveyed and followed through the 2002 Canadian Health Behaviour in School-Aged Children survey, recovery time from sprains and strains did not differ by BMI category, although it did differ among participants with fractures combined with sprains or strains [36]. However, because we found that individuals classified as obese had significantly lower odds of recovery on the PS and lower mean scores on 2 of the FAOS subscales after adjustment for covariates at 6 months post-injury, individuals with obesity may have challenges regaining some aspects of full ankle function after injury. These findings would agree with those from Timm *et al.*, [11] who showed that children with overweight or obesity were almost twice as likely to experience persistent symptoms half a year following the ankle sprain injury than children with normal-weight BMI.

This study is among the largest prognostic studies of its kind, both internationally and in Canada. The objective measures of BMI measured at baseline were a further strength, used to avoid misclassification bias associated with self-reported height and weight data. The study also has limitations. Pre-injury days of physical activity per week, one of the potential confounders, was self-reported by participants at baseline and could have been recalled incorrectly. BMI is limited as a measure of adiposity in that it does not differentiate between fat and muscle composition [37]. However, in the case of recovery from ankle injuries, BMI served as a proxy indicator of load on the ankle, whereby mechanistically, it would not matter if this load was from excess fat or excess lean mass. A further limitation is the measurement of recovery, which is an individualized process and is affected by physical, psychological, and social factors [38]. In studies of injury, recovery is usually defined as a return to pre-injury functioning or being free of symptoms [39]. This definition often involves subjective process of assessment. The methods used to assess the properties of the ankle joint post-injury, which was accomplished by using the FAOS, are strengthened by the fact that this scale has been validated against more objective measures [24,25].

The findings point to the need for clinical monitoring of individuals with ankle sprains post-injury because of possible delayed or incomplete symptom recovery even at 6 months. From the evidence presented, healthcare professionals should advise patients that they may experience dysfunction and ongoing post-injury symptoms during the recovery period. Moreover, physicians may consider adapting the care of these patients because they are likely to be at risk of greater disability. This advice may be further targeted to individuals classified as obese, who more commonly report worse states of ankle function on certain domains of the FAOS after an ankle sprain. This advice is particularly relevant because the distribution of participants by BMI category in this study was similar to that seen in the adult population in the Canadian Health Measures Survey (2009/2011), in which 34% of the population was classified as overweight and 26% of the population as obese [40]. High BMI values are risk factors for injury and re-injury in such populations [7,8,10].

Future research could investigate the role of BMI on recovery from ankle sprains and other types of injuries, especially among individuals classified as obese, in terms of pain control and being able to perform activities of daily living. Furthermore, the impact of BMI on recovery post-injury could be studied to determine its effect on other weight-bearing joints, such as the hip or knee joints, with a longer time frame for follow-up used to explore the recovery process in the long-term. For data between the studies to be comparable, standard, internationally accepted definitions for BMI cut-offs among children, adolescents, and adults should be used, in addition to standard indicators of clinical function and recovery. It is important to better understand the role of regular physical activity in recovery from ankle sprains, particularly in the presence of obesity.

In conclusion, at 6 months after an ankle sprain injury, a large proportion of individuals report ankle dysfunction, as demonstrated by a FAOS < 450 among all BMI groups. In terms of mean scores on the overall FAOS, we found no statistically significant or clinically meaningful independent differences between non-overweight, overweight, or obese BMI groups when controlling for multiple potential confounders, most of which were not modifiable. However, overall and in each domain, we found a consistent trend suggesting lower functioning and recovery in the obese BMI group by 6 months, which may suggest an area for focusing treatment among individuals with obesity and ankle sprains. Accordingly, specialized programs for individuals with obesity that include closer monitoring of symptoms such as pain and tailored interventions focusing on daily function may positively improve recovery after these injuries. The study's findings are also valuable for physicians for estimating the degree of recovery among individuals with ankle sprains and show that patients across all BMI groups may not be fully recovered in all aspects of ankle function after 6 months, which may inform clinical management.

Disclosure of interest

The authors declare that they have no competing interest.

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