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A Large-Scale Study on Epidemiology and Risk Factors for Chronic Ankle Instability in Young Adults

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ABSTRACT

Up to 40% of ankle sprains can result in chronic ankle instability (CAI). The prevalence of CAI and its association with body mass index (BMI) and height in the general young adult population has not been reported. The database records of young adults before recruitment into mandatory military service were studied. Information on the disability codes associated with CAI was retrieved. Logistic regression models were used to assess the association between the BMI and body height with various grades of CAI severity. The study cohort included 829,791 subjects (470,125 males and 359,666 females). The prevalence was 0.7% for mild CAI and 0.4% for severe instability in males and 0.3% and 0.4%, respectively, for females ($p < .001$). An increased BMI was associated with ankle instability in males (overweight, odds ratio [OR] 1.249, $p < .001$; obese, OR 1.418, $p < .001$) and females (overweight, OR 1.989 $p < .001$; obese, OR 2.754, $p < .001$). The body height was associated with an increased risk of CAI when the highest height quintile was compared with the lowest height quintile in both males (OR 2.443, $p < .001$) and females (OR 1.436, $p < .001$) for all levels of instability severity. The present study has shown a greater prevalence of CAI among males than females in a general healthy young adult population. CAI was associated with an increased BMI and greater body height for all grades of instability severity.

Lateral ankle instability can be a single injury event or a part of an ongoing process that leads to functional ankle instability and a subjective feeling of the ankle joint “giving way” with recurrent sprains. This injury can be associated with long-term disability, adversely affecting injured individuals in their day-to-day and sports activities (1–3). This has been termed *chronic ankle instability* (CAI) if it has persisted for longer than 6 months. The progression of an ankle inversion injury to CAI is not well understood. It has been estimated that CAI will be the end result in up to 40% of ankle sprain cases (4–6). Although several studies on ankle injuries reported that a history of ankle injury is associated with a fivefold increased risk of additional ankle injury (7,8), other studies have shown that previous injury, ligament laxity, and the grade of sprain were not predictors of chronic dysfunction (9,10).

The risk factors for ankle sprain injury have been extensively investigated in published studies. They have traditionally been divided into intrinsic and extrinsic factors. Intrinsic factors include age, sex, height, weight, body mass index (BMI), previous injury, aerobic fitness, limb dominance, flexibility, limb girth, muscle strength, proprioception, reaction time, postural stability, anatomic alignment, foot morphologic characteristics, and inadequate rehabilitation. The extrinsic factors include the sport, competition level, shoe type, use of ankle tape and/or brace, and playing surface (11).

Previous published data have estimated the incidence rates of ankle sprain in the general population as 5 to 7 sprains per 1000 person-years (1,7). Worldwide, approximately 1 ankle sprain occurs per 10,000 person-days, and an estimated 2 million acute ankle sprains occur each year in the United States alone, where such a widespread injury pattern results in an annual aggregate healthcare cost of 2 billion dollars (7,11,12). Furthermore, these injuries have also been associated with significant time lost to work, a delayed

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Drs. Hershkovich and Tenenbaum contributed equally to the report and should be considered co-first authors.

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return to military duty, and long-term disability in up to 60% of the patients (9,10).

However, most of the available epidemiologic studies on the incidence rates of ankle sprain in the general population have actually focused on specific populations, such as active duty military service personnel (13), military cadets (11), or athletes (14). An attempt to extrapolate the results derived from a selected cohort for application to the incidence of ankle sprain injury in the general population would result in a major sampling bias. Moreover, the incidence and demographic risk factors for patients with ankle sprains presenting to hospital emergency departments could be quite different among patients treated in other ambulatory settings or those who do not seek medical care.

The incidence of recurrent ankle sprains resulting in CAI and the prevalence of CAI in a general nonselected population has not been evaluated by earlier epidemiologic studies (1,7,9–12). CAI is well recognized as a possible cause of degenerative changes in the ankle resulting from unbalanced loading across the ankle joint (4). A paucity of research is available on the effects of chronic instability risk factors on the pathogenesis of CAI. Furthermore, no stratification of risk factors to different levels of instability and functional impairment has been conducted. The present study was designed to evaluate the prevalence of CAI in a young and healthy adult general population. In addition, we explored the association of sex, BMI, and body height with CAI.

Patients and Methods

The Israeli Defense Forces review board approved the present cross-sectional epidemiologic study. As previously reported, we used the medical database to investigate the association between the anthropomorphic data and clinical disability codes (15,16).

The database contains the records of every 17-year-old Israeli citizen, who are obligated by law to report to specialized recruiting centers for comprehensive medical evaluation. The individuals of certain minority populations have been exempted, mainly according to nationality or religion issues. The medical evaluation includes a self-reported medical questionnaire and a medical questionnaire completed by the candidate's primary care physician. Measurements of height, weight, blood pressure, visual acuity, and so forth are routinely performed. The candidate undergoes a comprehensive medical history interview and a physical examination by physicians of the medical board. As deemed necessary, auxiliary tests and specialist consultations will be ordered. With completion of this medical evaluation, the examinee is assigned a medical profile and a disability classification by the medical board. These codes are set according to the Regulations of Medical Fitness Determination. The medical data, profile, disability classification, and demographic data are stored in the database and were our source for investigating CAI of various grades of severity.

Study Population

The study included 829,791 consecutive young adults who were evaluated in the regional recruitment centers from 1998 to 2010.

Variables

The BMI groups were classified according to the US Centers for Disease Control and Prevention matched percentile grading: underweight, less than the 5th percentile; healthy weight, 5th to 85th percentile; overweight, 85th to 95th percentile; and obese 95th percentile or greater. The height of the males and females were divided into quintiles.

The individuals with a Regulations of Medical Fitness Determination disability classification associated with CAI were grouped into 1 of 2 severity grades, mild and severe, according to subjective complaints of instability and objective findings from imaging studies or physical examination (Table 1).

Mild CAI was defined if the medical history was positive for recurrent ankle sprains but no instability on the imaging studies or physical examination was diagnosed. Severe CAI was defined if the medical history was positive for recurrent sprains combined with objective findings from the physical examination or imaging studies. Also, a history of surgical instability repair with present functional limitations was considered as severe CAI. The physical examination included a manual anterior drawer test and Romberg test. The anterior drawer test is performed with the ankle in 10° to 15° of plantar flexion. Holding the tibia, an anterior directed force using the deltoid ligaments center of rotation is executed on the foot. The amount and quality of anterior movement was compared between both ankles. The test result is considered positive if the talus translated anteriorly. A positive anterior drawer test has a sensitivity of 73% and specificity of 97% (17,18). The Romberg test is performed by having the subject stand motionless on 1 foot for 30 seconds with their eyes open and then with their eyes closed. The test result is considered positive if a lack of postural control is detected when the subject performs the test with the eyes closed. The association between CAI and postural control deficits was extensively studied and is well established (19–24). The findings from the imaging study were defined as positive if, on the inversion stress test, a difference in talar tilt of more than 7° was diagnosed (25,26). Radiographic measurements of talar tilt have shown 36% sensitivity but 100% specificity (27,28). The physical examination was performed by a group of selected experts in orthopedic surgery experienced with this diagnosis.

Table 1
Grading of chronic ankle instability

CAI Grade	Description
Mild	Recurrent ankle sprains with no functional impairment or restriction
	History of recurrent ankle sprains
	and
	No evidence of instability found on physical examination or imaging study
Severe	After ankle injury with functional impairment or restriction
	History of recurrent ankle sprains with positive drawer sign result and/or abnormal findings for inversion stress test (≤7° talar tilt compared with contralateral side)
	or
	History of recurrent ankle sprains with positive Romberg sign
	or
	Status 1 yr after ankle instability repair surgery with residual functional impairment or restriction

Abbreviation: CAI, chronic ankle instability.

Statistical Analysis

The associations between the BMI and height and CAI were evaluated using logistic regression analysis applying the following models: binary models when CAI was considered as a dichotomous variable and multinomial models, with no ankle instability as the base category. BMI and body height were considered as ordinal variables according to these subgroups and as continuous variables in separate models. The results from logistic regression analyses are presented as odds ratios (ORs), 95% confidence intervals (CIs), and significance. A p value of $\leq .05$ was considered statistically significant. All statistical analyses were executed using IBM SPSS®, version 19 (IBM Corp, Armonk, NY).

Results

CAI Prevalence

The study population included 829,791 adolescents (470,125 males and 359,666 females). The characteristics of the study population are listed in Table 2. The mean BMI and mean height was 22.04 ± 3.8 kg/m^2 and 174.1 ± 6.8 cm for the males and 21.8 ± 3.7 kg/m^2 and 162.1 ± 6.25 cm, respectively for the females. A total of 5441 males (1.1%) and 2531 females (0.7%) had a CAI code. The prevalence was 0.7% and 0.4% for mild and severe CAI among the males and 0.3% and 0.4% among the females, respectively (Table 2). The males had a 2.33-fold greater incidence of mild CAI than the females; however, no sex difference was found in the prevalence of severe CAI (0.4%).

Association Between BMI and CAI

The BMI was associated with CAI (Table 3). Obese and overweight males and females had a positive association with the likelihood of CAI and those underweight had a negative association compared with those of healthy weight. Similar results were found in an analysis of the study population according to CAI severity. Obese females had a greater OR (3.292; 95% CI 2.796 to 3.877; $p < .001$) for severe CAI compared with those of healthy weight. When the BMI was analyzed as a continuous variable, a statistically significant increase was found in the likelihood of CAI per unit of BMI (OR 1.057, 95% CI 1.050 to 1.063, and OR 1.097, 95% CI 1.880 to 1.060, for males and females, respectively). The effect of BMI was more pronounced for severe CAI in both