Prevalence and Impact of Chronic Ankle Instability in Adolescent Athletes

Luke Donovan,*† PhD, ATC, Scott Hetzel,‡ MS, Craig R. Laufenberg,§ MD, and Timothy A. McGuine,‖ PhD, ATC

Investigation performed at the University of Wisconsin–Madison, Madison, Wisconsin, USA

Background: The prevalence and impact of chronic ankle instability (CAI) in adolescent athletes are unknown. To better develop and justify prevention strategies of lateral ankle sprains and CAI, it is important to understand the origin and associated long-term impact of CAI within populations other than adults.

Purpose/Hypothesis: The purpose of this study was to determine the prevalence and impact of CAI on ankle function, health-related quality of life (HRQoL), and physical activity in adolescent athletes. The hypothesis was that the presence of CAI will be commonly reported among adolescent athletes and that participants with CAI will have lower self-reported ankle function, HRQoL, and physical activity when compared with participants without CAI.

Study Design: Cross-sectional study; Level of evidence, 3.

Methods: A cohort of 1002 healthy (able to fully participate) adolescent athletes (50.4% female; mean age, 15.6 ± 1.6 years) across 8 club sport facilities and high schools completed paper-and-pencil surveys to establish the presence of CAI (Identification of Functional Ankle Instability [IdFAI]) and estimate perceived ankle function (Foot and Ankle Ability Measure [FAAM]–Activities of Daily Living and FAAM-Sport), HRQoL (Pediatric Quality of Life Inventory 4.0 [PedsQL]), and physical activity (Hospital for Special Surgery Pediatric Functional Activity Brief Scale [HSS Pedi-FABS]).

Results: The overall prevalence of CAI was 20.0%. Participants with unilateral CAI reported significantly lower ($P < .001$) ankle function (FAAM-Sport: 87.0 ± 14.8) and HRQoL (total PedsQL: 89.8 ± 9.8) than participants who did not have CAI (FAAM-Sport: 97.7 ± 6.0; total PedsQL: 93.5 ± 9.1). Physical activity was not different between participants with and without CAI.

Conclusion: The prevalence of CAI was high among adolescent athletes. The presence of CAI negatively affected ankle function and HRQoL in adolescent athletes. Given the high prevalence and negative impact of CAI in an adolescent population, strategies to prevent ankle injuries and maintain physical activity are needed to alleviate future long-term consequences associated with developing CAI. These strategies should be implemented as soon as sport participation begins, as it appears that the origin of CAI may occur before adulthood.

Keywords: disablement; functional ankle instability; health-related quality of life; lateral ankle sprain

Lateral ankle sprains have consistently been reported as the most common musculoskeletal injuries to occur in physically active patients.[5,11,12,14,37,39] Despite the high occurrence, lateral ankle sprains are often considered innocuous injuries, as demonstrated by the low level of patients adhering to prevention strategies[40] and seeking interventions after an injury.[10] In reality, lateral ankle sprains greatly contribute to the financial health care burden within the United States and can manifest into a continuum of disability.

Within the United States, the direct treatment cost of a lateral ankle sprain is estimated to be approximately $1000 over the course of 1 year.[10,28,41] A study by Knowles et al[28] developed a revised injury cost model to include both direct (medical costs) and indirect (future earning losses and value of good health loss) costs. Using this model, Knowles et al estimated the total costs affiliated with an ankle sprain to be approximately $12,000. The development of chronic ankle instability (CAI), a condition characterized by prolonged symptoms such as a sensation of the ankle "giving way," repetitive bouts of instability, and/or recurrent ankle sprains,[18,19] further contributes to the financial burden by creating recurring annual costs stemming from repetitive ankle sprains associated with the condition.[10] CAI exacerbates the financial burden, as the condition has been linked to other long-term consequences such as the cessation of physical activity,[26,27] posttraumatic ankle osteoarthritis,[46] and reduced health-related quality of life (HRQoL).[1,24] Thus, lateral ankle sprains are not benign but are rather injuries that can negatively influence the long-term health and well-being of patients through the development of CAI. Accordingly, targeted prevention strategies

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are needed to alleviate the consequences associated with lateral ankle sprains and CAI; however, before implementing such interventions, more insight into the origin and initial impact of CAI is warranted.

Presently, the majority of literature pertaining to CAI has been focused on adult populations (aged 18-40 years).[14] Furthermore, studies that have investigated the incidence and prevalence of CAI have used numerous operational criteria for defining CAI, ultimately resulting in nonuniform ranges of rates, as depicted in a recent meta-analysis by Doherty et al.[5] Specific to prevalence, >25% of adults who participate in sports report having CAI or repetitive sprains,[2,39,45,47] with prevalence in sports such as dance being as high as 75%.[43] Aside from sports, approximately 20% of adults from the general population with a history of lateral ankle sprains report chronic issues related to the involved ankle.[20] Currently, much less regarding the prevalence and impact of CAI within an adolescent population is known.

A systematic review by Mandarakas et al[30] aimed to define the prevalence of CAI in children. Although the authors were able to identify studies examining patients with CAI aged ≤18 years, all of the reviewed studies targeted patients with a previous ankle injury or specific sport populations. In addition, the authors highlighted that the majority of the studies did not use the operational definition of CAI recommended by the International Ankle Consortium (IAC)[15] or appropriate questionnaires endorsed by the IAC to detect the presence of CAI. Therefore, the primary conclusion of this systematic review was that CAI is highly prevalent in adolescents who had a history of ankle sprains; however, the overall prevalence of CAI and the impact of the condition on HRQoL in adolescents remain unknown. Recently, Gruskay et al[16] conducted a review with the purpose of discussing the epidemiology, pathoanatomy, diagnosis, and treatments of lateral ankle instability in populations aged ≤18 years. Similar to the systematic review by Mandarakas et al, Gruskay et al reported on studies[13,31] that found a high prevalence of CAI after an ankle sprain or in specific populations such as dancers. Once again, the individual articles discussed within these reviews[16,30] did not assess the general athletic population of adolescents, use defined CAI criteria established by the IAC, or quantify the impact on HRQoL; therefore, the overall prevalence and impact of CAI within an adolescent population remain unclear.

To our knowledge, only 2 studies[22,45] have explored the prevalence of CAI within a general adolescent athlete population (aged 14-18 years) using survey instruments and selection criteria as recommended by the IAC. Although these studies found similar rates (29%[22] and 31.1%[45]) and identification criteria, both studies had relatively small sample sizes of approximately 200 participants and did not evaluate the impact of CAI on HRQoL within the adolescent population.[22,45] To better develop and justify prevention strategies of lateral ankle sprains and CAI, it is important to understand the origin and associated long-term impact of this condition within populations other than adults or based on injury history.

The purpose of this study was therefore to determine the prevalence and impact of CAI on ankle function, physical activity, and HRQoL in adolescent athletes. The results of this study will define the problem of CAI by estimating the overall prevalence of CAI within the general adolescent athlete population and by quantifying the impact that the condition has on HRQoL. Once the scope of the problem is defined, if warranted, future studies can determine the predictors and risk factors of developing the condition and reporting poor HRQoL.

METHODS

Data were collected for this cross-sectional study at 8 club sport facilities and high schools in Wisconsin. A convenience sample of male and female adolescent athletes (aged 14-18 years) participating at the venues was provided with study materials (study information, consent/assent documents, and surveys). This study was advertised to potential participants as a "study that is examining ankle function and quality of life in adolescents who participate in sport." To diminish selection bias, it was made clear to potential participants that eligibility was dictated by participation in sports and not a history of injuries. The paper-based survey asked for demographic information regarding the (1) participant's age, (2) sex, (3) sport participation within the past year, (4) history of ankle sprains for both the right and left ankles, and (5) measures of disablement that included ankle function, prevalence of CAI, HRQoL, and level of physical activity. This study was approved by the University of Wisconsin–Madison institutional review board.

Because a history of ankle sprains was reliant on participant recall, participants were provided with the following language to describe an ankle sprain injury:

*Address correspondence to Luke Donovan, PhD, ATC, Department of Kinesiology, University of North Carolina at Charlotte, 9201 University City Boulevard, Charlotte, NC 28223, USA (email: ldonova2@uncc.edu) (Twitter: @LukeTDonovan).
†Department of Kinesiology, University of North Carolina at Charlotte, Charlotte, North Carolina, USA.
‡Department of Biostatistics and Medical Informatics, University of Wisconsin–Madison, Madison, Wisconsin, USA.
§Department of Emergency Medicine, The Ohio State University Wexner Medical Center, Columbus, Ohio, USA.
||Department of Orthopedics and Rehabilitation, University of Wisconsin–Madison, Madison, Wisconsin, USA.
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Ethical approval for this study was obtained from the University of Wisconsin–Madison (No. 2015-0073-CP007).

"Ankle sprains are the most common injury sustained by athletes and active individuals. These injuries often occur in sports or activities that involve running, stopping and starting quickly or cutting and changing directions. Ankle sprains often occur when the individual plants their weight on the edge of their foot or lands on uneven ground or another player's foot, causing an awkward moment and loss of balance. Athletes often feel a 'pop' when the ligaments surrounding the ankle stretch or tear. In some cases, the pain is minimal and quickly goes away while in other cases the sprain is more serious which results in swelling and pain while walking and/or running. Athletes who have a serious ankle sprain often require treatment from their athletic trainer or doctor. In some cases the athlete will need to have x-rays to rule out a fracture (broken ankle) and need to utilize crutches, walking boots or braces to support and protect the ankle while it heals."

Ankle function and the prevalence of CAI were measured for each ankle (left and right) separately. The Foot and Ankle Ability Measure (FAAM)–Activities of Daily Living (ADL) consists of 21 questions (score range, 0-84) and was used to assess ankle physical function for daily living. The FAAM-Sport consists of 7 items (score range, 0-32) and was used to measure the ability to perform sport-related activities such as running, cutting, and pivoting. Scores were calculated as a percentage of the total possible score, with 0% equaling low/no function and 100% indicating the highest function.[3,32] Both FAAM-ADL and -Sport have been shown to be valid instruments to measure perceived foot and ankle function in patients with and without CAI[3,32] and are currently the recommended survey instruments to assess foot and ankle function by the IAC.[15]

The prevalence of CAI was determined by having the participants complete the Identification of Functional Ankle Instability (IdFAI). This validated instrument asks respondents to complete 1 question regarding their total previous ankle sprains, scored numerically, and 9 Likert-scale questions that focus on symptoms such as the ankle "giving way" or "feeling unstable."[6,17,42] Participants who have a total ankle score of $\geq$11 are considered to have CAI in that limb. CAI prevalence was calculated by taking the number of participants who reported an IdFAI score of $\geq$11 for at least 1 ankle and dividing that number by the total number of participants. Prevalence was expressed as a percentage by multiplying the ratio by 100. The IdFAI is a questionnaire recommended by the IAC to determine the presence of CAI.[15]

HRQoL was measured with the Pediatric Quality of Life Inventory 4.0 (PedsQL). The 23-item PedsQL assesses HRQoL for the previous 7 days. Individual domain scores can be tabulated in addition to physical and psychosocial subscale scores. Scores range from 0 to 100, with a higher score indicating greater HRQoL. The PedsQL has been validated for use in children aged 2 to 17 years[48,49] and is utilized by researchers to measure the impact of sport-related concussions on HRQoL in adolescents.[36,38]

Physical activity was measured with the Hospital for Special Surgery Pediatric Functional Activity Brief Scale (HSS Pedi-FABS). This validated 8-item instrument was designed to measure the activity of active children aged 10 to 18 years for the past month.[8] Scores range from 0 to 30, with a higher score indicating greater physical activity. The HSS Pedi-FABS has been used to measure disability in adolescent athletes.[9]

Participants were encouraged to complete the survey with their parent (if present). Study team members were available to assist participants who had questions regarding specific questions or their responses.

Sample Size

We estimated that we needed to collect data on a minimum of 1000 participants for this study. The sample size was initially estimated by using the prevalence of previous ankle injuries (25%-27%),[20,33-35,45] and studies that have reported a difference of 4.5 points on the PedsQL constituted a significant change/difference,[49] resulting in a minimum of 900 participants. However, we increased our sample size by a minimum of 10% ($\geq$90 participants) to ensure that we had an adequate sample size to determine if a relationship exists between a previous ankle injury and decreased HRQoL.

Statistical Analysis

Participant-specific function scores were summarized by group for all participants and separately for male and female participants by means ± SDs. Also, 95% CIs for the means were calculated based on a *t* distribution. Because of ceiling effects of our measures, statistical differences between groups were assessed using the nonparametric Kruskal-Wallis test. Ankle-specific function scores were summarized by estimated means (95% CIs) from linear mixed-effects models with ankle-specific injury designation as a fixed effect and participant as a random effect. The post hoc Wilcoxon rank-sum test utilized the Holm adjustment for 3 tests. The overall distribution of each score was estimated by ranges, interquartile ranges (IQRs), and medians.

RESULTS

A total of 1341 athletes were recruited to participate, with 1036 (77.3%) agreeing to enroll in the study. Complete surveys were returned by 1002 participants (50.4% female; mean age, 15.6 ± 1.6 years; grades 9-12). The sports participated in most often within the previous 12 months included basketball (55.4%), football (38.5%), and volleyball (36.5%). Overall, when not stratifying by ankle sprain history, participants reported high ankle function on the FAAM-ADL (median, 100.0 [IQR, 98.8-100.0]) and FAAM-Sport (median, 100.0 [IQR, 96.9-100.0]). Regarding HRQoL, the median PedsQL physical subscale score for the participants was 100.0 (IQR, 90.6-100.0), while the median PedsQL psychosocial subscale score was 96.7 (IQR, 88.3-100.0), and the median total PedsQL score was 95.6

TABLE 1
Participant Demographics[a]

	Female (n = 505)	Male (n = 497)
Age, mean ± SD, y	15.7 ± 1.7	15.6 ± 1.9
Distribution of age, n (%)		
14 y	101 (20.0)	108 (21.7)
15 y	126 (25.0)	138 (27.8)
16 y	137 (27.1)	104 (20.9)
17 y	124 (24.6)	130 (26.2)
18 y	17 (3.4)	17 (3.4)
Sport participation, n (%)		
Basketball	302 (59.8)	253 (50.9)
Football	1 (0.2)	385 (77.5)
Volleyball	345 (68.3)	21 (4.2)
Baseball/softball	103 (20.4)	133 (26.8)
Track	89 (17.6)	99 (19.9)
Soccer	100 (19.8)	49 (9.9)
Cross-country	29 (5.7)	7 (1.4)
Tennis	16 (3.2)	12 (2.4)
Golf	9 (1.8)	12 (2.4)
Wrestling	0 (0.0)	19 (3.8)
Lacrosse	0 (0.0)	17 (3.4)
Ice hockey	3 (0.6)	13 (2.6)
Other	8 (1.6)	12 (2.4)
Ankle function scores		
FAAM-ADL	100.0 (98.8-100.0)	100.0 (98.8-100.0)
FAAM-Sport	100.0 (96.9-100.0)	100.0 (96.9-100.0)
HRQoL scores		
PedsQL emotional	100.0 (85.0-100.0)	100.0 (90.0-100.0)
PedsQL social	100.0 (95.0-100.0)	100.0 (95.0-100.0)
PedsQL school	95.0 (80.0-100.0)	100.0 (80.0-100.0)
PedsQL physical	100.0 (90.6-100.0)	100.0 (93.8-100.0)
PedsQL psychosocial	96.7 (86.7-100.0)	96.7 (88.3-100.0)
Total PedsQL	95.6 (88.0-100.0)	95.7 (88.0-100.0)
Physical activity scores		
HSS Pedi-FABS	24.0 (19.0-27.0)	26.0 (22.0-28.0)

[a]Data are reported as median (interquartile range) unless otherwise indicated. ADL, Activities of Daily Living; FAAM, Foot and Ankle Ability Measure; HRQoL, health-related quality of life; HSS Pedi-FABS, Hospital for Special Surgery Pediatric Functional Activity Brief Scale; PedsQL, Pediatric Quality of Life Inventory 4.0.

(IQR, 88.0-100.0). Finally, physical activity measured using the HSS Pedi-FABS was a median of 25.0 (IQR, 20.0-28.0). The demographics for both male and female participants are found in Table 1.

A total of 262 participants (26.1%) reported sustaining at least 1 ankle sprain injury, with the median number of ankle sprains per participant being 0.0 (IQR, 0.0-1.0). The median IdFAI score for the participants was 0.0 (IQR, 0.0-0.0), although 163 (16.3%) reported having CAI in 1 ankle and 37 (3.7%) reported having CAI in both ankles. The median number of ankle sprains in participants who were classified as having CAI was 2.0 (IQR, 1.0-3.0), with the median time since the most recent ankle sprain being 12.1 months (IQR, 7.6-22.5 months). Descriptions of ankle injury history and prevalence of CAI for both male and female participants are found in Table 2.

Participants who reported no CAI in either ankle had higher ($P < .001$) ankle function (FAAM-ADL: 98.5 ± 4.4; FAAM-Sport: 97.7 ± 6.0) than participants with unilateral CAI (FAAM-ADL: 91.8 ± 11.5; FAAM-Sport: 87.0 ± 14.8) and bilateral CAI (FAAM-ADL: 85.5 ± 15.9; FAAM-Sport: 77.5 ± 21.4). Regarding HRQoL, participants who reported no CAI in either ankle had higher ($P < .001$) total PedsQL scores (93.5 ± 9.1) than participants with unilateral CAI (89.8 ± 9.8) and bilateral CAI (86.4 ± 10.3). Furthermore, participants who did not classify as having CAI had higher scores ($P < .05$) on the PedsQL emotional, PedsQL school, PedsQL physical, and PedsQL psychosocial subscales when compared with participants who reported CAI. Finally, there were no differences in physical activity as measured by the HSS Pedi-FABS between participants with and without CAI. Table 3 provides the mean ± SD, 95% CI, and distribution of ankle function, HRQoL, and physical activity stratified by sex in participants with unilateral, bilateral, and no CAI.

TABLE 2
History of Ankle Sprains and Prevalence of CAI[a]

	Female (n = 505)	Male (n = 497)
Ankle sprain history		
Previous ankle sprain, n (%)	147 (29.1)	115 (23.1)
No. of ankle sprains per participant[b]	0.0 (0.0-1.0)	0.0 (0.0-0.0)
IdFAI score[b]	0.0 (0.0-0.0)	0.0 (0.0-0.0)
CAI prevalence, n (%)		
No CAI	386 (76.4)	416 (83.7)
Unilateral CAI	98 (19.4)	65 (13.1)
Bilateral CAI	21 (4.1)	16 (3.2)

[a]CAI, chronic ankle instability; IdFAI, Identification of Functional Ankle Instability.
[b]Data are reported as median (interquartile range) and include participants both with and without a previous ankle sprain within the analysis.

DISCUSSION

The primary purpose of this cross-sectional survey study was to provide an estimate of the prevalence of CAI and the impact of the condition on ankle function, HRQoL, and physical activity in adolescents who participate in organized sports. The aim of the study was not to identify risk factors or establish the prevalence of injuries across sports but rather determine whether CAI is problematic within an adolescent population, given that the majority of CAI literature pertains to patients older than 18 years. Based on 1002 adolescent athletes across 8 club sport facilities and high schools in Wisconsin, we found the overall prevalence of CAI to be 20.0%. Therefore, at any given time, we would expect about 20% of adolescents who participate in sports to have CAI. When stratified by sex, the prevalence of CAI in female athletes was 23.6%, with male athletes being lower at 16.3%. Participants who were classified as having CAI reported significantly lower ankle function (FAAM-ADL and FAAM-Sport) and HRQoL (PedsQL) than participants

TABLE 3
Distribution of Ankle Function, HRQoL, and Physical Activity for Participants With and Without Chronic Ankle Instability[a]

	n	Mean ± SD	95% CI	*P* Value[b]	Range	IQR	Median
Ankle function							
FAAM-ADL							
All athletes				<.001[c,d,e]			
None	802	98.5 ± 4.4	98.2-98.8		51.8-100.0	99.4-100.0	100.0
Unilateral	163	91.8 ± 11.5	90.0-93.5		29.8-100.0	88.1-100.0	96.4
Bilateral	37	85.5 ± 15.9	80.2-90.8		42.9-100.0	81.5-97.6	91.1
Male				<.001[c,d]			
None	416	98.5 ± 4.3	98.1-98.9		57.1-100.0	99.4-100.0	100.0
Unilateral	65	89.0 ± 14.7	85.3-92.6		29.8-100.0	81.5-100.0	93.5
Bilateral	16	86.8 ± 14.4	79.1-94.5		54.8-100.0	81.7-97.2	91.4
Female				<.001[c,d,e]			
None	386	98.5 ± 4.6	98.1-99.0		51.8-100.0	99.4-100.0	100.0
Unilateral	98	93.6 ± 8.4	91.9-95.3		64.9-100.0	91.8-99.9	97.0
Bilateral	21	84.5 ± 17.2	76.7-92.3		42.9-99.4	81.5-97.6	89.3
FAAM-Sport							
All athletes				<.001[c,d,e]			
None	802	97.7 ± 6.0	97.2-98.1		31.2-100.0	98.4-100.0	100.0
Unilateral	163	87.0 ± 14.8	84.7-89.2		15.6-100.0	78.1-98.4	93.8
Bilateral	37	77.5 ± 21.4	70.4-84.6		20.3-100.0	75.0-89.1	84.4
Male				<.001[c,d]			
None	416	97.8 ± 5.6	97.2-98.3		54.7-100.0	98.4-100.0	100.0
Unilateral	65	83.5 ± 17.7	79.1-87.8		15.6-100.0	75.0-98.4	89.1
Bilateral	16	80.4 ± 19.4	70.0-90.7		39.1-100.0	80.9-92.6	85.9
Female				<.001[c,d,e]			
None	386	97.6 ± 6.5	96.9-98.2		31.2-100.0	98.4-100.0	100.0
Unilateral	98	89.3 ± 12.1	86.8-91.7		45.3-100.0	82.4-98.4	95.3
Bilateral	21	75.3 ± 23.0	64.8-85.8		20.3-96.9	75.0-89.1	82.8
HRQoL							
Total PedsQL							
All athletes				<.001[c,d,e]			
None	802	93.5 ± 9.1	92.8-94.1		44.6-100.0	90.2-100.0	97.5
Unilateral	163	89.8 ± 9.8	88.3-91.4		41.9-100.0	85.3-97.5	91.9
Bilateral	37	86.4 ± 10.3	83.0-89.9		64.5-100.0	79.5-94.2	89.7
Male				<.001[c,d]			
None	416	94.0 ± 8.4	93.2-94.8		57.8-100.0	92.1-100.0	97.8
Unilateral	65	89.7 ± 9.6	87.3-92.1		56.9-100.0	84.7-96.1	91.3
Bilateral	16	89.1 ± 10.9	83.3-94.9		64.5-100.0	85.0-96.2	93.5
Female				<.001[c,d,e]			
None	386	92.9 ± 9.8	91.9-93.9		44.6-100.0	89.1-100.0	96.7
Unilateral	98	89.9 ± 10.1	87.9-92.0		41.9-100.0	85.6-97.9	92.4
Bilateral	21	84.4 ± 9.5	80.1-88.7		64.7-98.9	77.2-90.5	85.9
PedsQL emotional							
All athletes				.001[c,d]			
None	802	92.7 ± 13.8	91.7-93.6		20.0-100.0	90.0-100.0	100.0
Unilateral	163	89.1 ± 16.4	86.6-91.7		20.0-100.0	82.5-100.0	95.0
Bilateral	37	86.5 ± 14.1	81.8-91.2		50.0-100.0	80.0-100.0	90.0
Male				.005[c]			
None	416	94.1 ± 11.6	93.0-95.2		30.0-100.0	95.0-100.0	100.0
Unilateral	65	90.2 ± 13.5	86.9-93.6		40.0-100.0	85.0-100.0	95.0
Bilateral	16	91.9 ± 11.8	85.6-98.2		60.0-100.0	85.0-100.0	97.5
Female				<.001[d,e]			
None	386	91.2 ± 15.7	89.6-92.8		20.0-100.0	90.0-100.0	100.0
Unilateral	98	88.4 ± 18.2	84.8-92.1		20.0-100.0	81.2-100.0	100.0
Bilateral	21	82.4 ± 14.6	75.7-89.0		50.0-100.0	75.0-95.0	80.0

(continued)

Table 3 (continued)

	n	Mean ± SD	95% CI	*P* Value[b]	Range	IQR	Median
HRQoL (continued)							
PedsQL social							
All athletes				.824			
None	802	95.2 ± 9.6	94.5-95.9		25.0-100.0	95.0-100.0	100.0
Unilateral	163	95.8 ± 8.5	94.5-97.1		55.0-100.0	95.0-100.0	100.0
Bilateral	37	95.9 ± 7.2	93.5-98.4		75.0-100.0	95.0-100.0	100.0
Male				.906			
None	416	95.0 ± 10.0	94.1-96.0		25.0-100.0	95.0-100.0	100.0
Unilateral	65	95.0 ± 9.4	92.7-97.3		55.0-100.0	95.0-100.0	100.0
Bilateral	16	95.6 ± 6.3	92.3-99.0		85.0-100.0	90.0-100.0	100.0
Female				.643			
None	386	95.4 ± 9.1	94.5-96.3		40.0-100.0	95.0-100.0	100.0
Unilateral	98	96.3 ± 7.9	94.7-97.9		60.0-100.0	96.2-100.0	100.0
Bilateral	21	96.2 ± 8.0	92.5-99.9		75.0-100.0	100.0-100.0	100.0
PedsQL school							
All athletes				<.001[c,d]			
None	802	89.8 ± 14.8	88.7-90.8		20.0-100.0	85.0-100.0	100.0
Unilateral	163	85.8 ± 17.3	83.1-88.5		15.0-100.0	80.0-100.0	90.0
Bilateral	37	84.5 ± 15.4	79.3-89.6		50.0-100.0	75.0-100.0	85.0
Male				.096			
None	416	89.7 ± 14.4	88.3-91.1		30.0-100.0	80.0-100.0	100.0
Unilateral	65	87.0 ± 15.0	83.3-90.7		40.0-100.0	80.0-100.0	90.0
Bilateral	16	85.0 ± 15.2	76.9-93.1		50.0-100.0	78.8-100.0	85.0
Female				.004[c]			
None	386	89.9 ± 15.2	88.3-91.4		20.0-100.0	85.0-100.0	100.0
Unilateral	98	85.0 ± 18.7	81.2-88.8		15.0-100.0	76.2-100.0	90.0
Bilateral	21	84.0 ± 16.0	76.8-91.3		50.0-100.0	75.0-100.0	85.0
PedsQL physical							
All athletes				<.001[c,d,e]			
None	802	95.5 ± 8.7	94.9-96.1		28.1-100.0	93.8-100.0	100.0
Unilateral	163	88.9 ± 12.1	87.0-90.8		46.9-100.0	84.4-100.0	93.8
Bilateral	37	81.3 ± 18.6	75.1-87.5		28.1-100.0	68.8-93.8	90.6
Male				<.001[c,d]			
None	416	96.2 ± 7.9	95.4-97.0		50.0-100.0	96.9-100.0	100.0
Unilateral	65	87.2 ± 12.9	84.0-90.4		53.1-100.0	81.2-100.0	87.5
Bilateral	16	84.6 ± 19.0	74.4-94.7		28.1-100.0	86.7-96.9	90.6
Female				<.001[c,d,e]			
None	386	94.7 ± 9.4	93.8-95.6		28.1-100.0	93.8-100.0	100.0
Unilateral	98	90.0 ± 11.5	87.7-92.3		46.9-100.0	87.5-100.0	93.8
Bilateral	21	78.9 ± 18.4	70.5-87.2		50.0-96.9	59.4-93.8	90.6
PedsQL psychosocial							
All athletes				<.001[c,d]			
None	802	92.5 ± 10.6	91.8-93.3		38.3-100.0	88.3-100.0	96.7
Unilateral	163	90.2 ± 11.2	88.5-92.0		35.0-100.0	85.0-100.0	93.3
Bilateral	37	89.0 ± 9.7	85.7-92.2		63.3-100.0	83.3-98.3	91.7
Male				.202			
None	416	92.9 ± 9.9	92.0-93.9		48.3-100.0	90.0-100.0	96.7
Unilateral	65	90.7 ± 10.3	88.2-93.3		46.7-100.0	86.7-100.0	93.3
Bilateral	16	90.8 ± 9.0	86.0-95.6		71.7-100.0	85.8-98.3	93.3
Female				.003[c,d]			
None	386	92.1 ± 11.3	91.0-93.3		38.3-100.0	88.3-100.0	96.7
Unilateral	98	89.9 ± 11.9	87.5-92.3		35.0-100.0	85.0-100.0	93.3
Bilateral	21	87.5 ± 10.2	82.9-92.2		63.3-100.0	83.3-93.3	90.0

(continued)

Table 3 (continued)

	n	Mean ± SD	95% CI	*P* Value[b]	Range	IQR	Median
Physical activity							
HSS Pedi-FABS							
All athletes				.664			
None	802	23.3 ± 5.1	23.0-23.7		4.0-30.0	20.0-28.0	25.0
Unilateral	163	22.8 ± 6.2	21.8-23.7		2.0-30.0	20.0-28.0	25.0
Bilateral	37	22.5 ± 6.0	20.5-24.5		6.0-30.0	22.0-26.0	25.0
Male				.344			
None	416	23.8 ± 5.3	23.2-24.3		6.0-30.0	21.0-28.0	25.0
Unilateral	65	24.2 ± 6.0	22.7-25.7		2.0-30.0	22.0-28.0	26.0
Bilateral	16	23.3 ± 4.9	20.7-25.9		10.0-30.0	22.8-26.0	24.5
Female				.55			
None	386	22.9 ± 4.9	22.4-23.4		4.0-30.0	19.0-27.0	24.0
Unilateral	98	21.8 ± 6.1	20.6-23.1		5.0-29.0	18.2-27.0	23.0
Bilateral	21	21.9 ± 6.7	18.9-25.0		6.0-30.0	17.0-27.0	25.0

[a]ADL, Activities of Daily Living; FAAM, Foot and Ankle Ability Measure; HRQoL, health-related quality of life; HSS Pedi-FABS, Hospital for Special Surgery Pediatric Functional Activity Brief Scale; IQR, interquartile range; PedsQL, Pediatric Quality of Life Inventory 4.0.

[b]*P* values are from the Kruskal-Wallis test.

Significant post hoc Wilcoxon rank-sum test results after the Holm adjustment: [c]none versus unilateral, [d]none versus bilateral, and [e]unilateral versus bilateral.

who did not meet the criteria of having CAI. Despite the negative consequence of CAI on perceived ankle function and HRQoL, physical activity was not compromised in participants with CAI. To our knowledge, this is the first study with a robust sample size (>1000) to establish the overall prevalence and impact of CAI in an adolescent population. The findings of this study support efforts to implement ankle sprain prevention strategies as soon as patients begin participation in sports.

The prevalence of CAI described in this study was lower than in 2 other studies that utilized similar CAI identification criteria within an adolescent population (20.0% vs 29%[22] and 31%[45]). The discrepancy may be driven by the sample being larger in our study by approximately 800 participants. In addition to sample size, the differences across the studies[22,45] may indicate that the prevalence of CAI may not be homogeneous across regions within the United States, given that the study location differed across 3 states. As expected, the prevalence reported in our study was lower than the epidemiological information provided by the Gruskay et al[16] and Mandarakas et al[30] reviews, which synthesized the results of studies that established the prevalence of CAI in patients with a history of ankle sprains. When comparing our results with those of the general adult population, the findings are similar: The prevalence of CAI ranged from approximately 20% to 30% within adults when not stratifying by specific sport, injury history, or activity.[2,20,39,45,47] The continuity in prevalence between adolescents and adults suggests that CAI does not simply resolve with age and that many adults who report CAI may have first developed the condition as an adolescent. However, without long-term prospective studies that track patients with CAI over numerous years, the previous statement is merely speculation.

To better contextualize the problem of CAI in adolescents, we also evaluated self-reported ankle function, HRQoL, and physical activity. Specific to ankle function, participants with CAI reported clinically meaningful deficits in ankle function during both ADLs (unilateral CAI: 8.2%; bilateral CAI: 14.5%) and sport-related tasks (unilateral CAI: 13.0%; bilateral CAI: 22.5%). The associated deficits far exceed established minimum detectable change scores for both the FAAM-ADL (3.96%) and FAAM-Sport (7.9%)[21] and were similar to the deficits reported in adults with CAI.[23,24] Across both adolescent and adult populations, patients without CAI generally do not report any dysfunction pertaining to their foot and ankle during ADLs or sports.[23,24]

The negative consequences associated with CAI do not appear to be restricted to solely the involved joint but also were associated with a systemic decline in overall HRQoL in adolescents. Participants who reported having CAI had lower scores on the total PedsQL as well as the PedsQL emotional, PedsQL school, PedsQL physical, and PedsQL pyschosocial subscales when compared with participants who did not report CAI. Previous studies[48,49] have established that the PedsQL is valid and reliable within the age population used in this study. These same studies[48,49] also established normative values across the general child and adolescent populations for the total score and each subscale score for the PedsQL. With the exception of participants with bilateral CAI on the PedsQL physical subscale, we found that the participants from our study, regardless of CAI, predominately reported higher scores across all components of the instrument when compared with the normative values established within a general population.[48] Despite the discrepancy between values from our study and the validity investigations of Varni et al,[48,49] the differences between participants with and without CAI from our study should not be dismissed.

One caveat to comparing our findings with the results of Varni et al[48,49] is that those authors did not include sport

and physical activity participation as a covariate when establishing the normative values. A systematic review[7] determined that children and adolescents who participate in sports have significantly greater HRQoL than those who do not. These findings were not restricted to only physical components of HRQoL but also included psychosocial improvements.[7] As part of our inclusion criteria, all participants within our study participated in some form of organized sports; therefore, they may have been subjected to the benefits of sport participation on HRQoL described by Eime et al.[7] Specific to the PedsQL, a study by Lam et al[29] found that adolescents who participated in sports generally reported higher scores on all components of the questionnaire when compared with the general population values established by Varni et al.[48] Because the Lam et al study reported values based on corresponding age and not overall means, we could not directly compare our results; however, generally, we found that participants who reported unilateral CAI had lower scores on the PedsQL physical subscale. Furthermore, participants who reported bilateral CAI had lower total, emotional, and physical scores when compared with the adolescent athletes described by Lam et al.

In summation, HRQoL was negatively affected in athletes with CAI when compared with athletes without CAI; however, the degree to which HRQoL was compromised is similar to normative values reported by the general nonsporting adolescent population. Considering that HRQoL is higher in adolescents who participate in sports,[7,29,44] the finding that having CAI decreased HRQoL, but not to the point at which it was substantially lower than in the general population, may be explained by the continued participation in sports. The presence of CAI may start to negate the benefits of sport participation on HRQoL, but not to the point at which HRQoL is lower than in adolescents who do not participate in sports. This theory is further supported by observing no significant differences in self-reported physical activity between participants with and without CAI. Perhaps the decline in HRQoL from the presence of CAI is being counteracted by the benefit of physical activity on HRQoL.

Presently, there is only 1 other study that has examined physical activity levels in adolescents with CAI. Holland et al,[22] using the International Physical Activity Questionnaire–Short Form, found that participants classified as having ankle instability reported higher levels of physical activity when compared with participants who did not have ankle instability. The results of the Holland et al study conflict with the findings of this investigation, which found no differences in self-reported physical activity between participants with and without CAI. The primary explanation of the conflicting results is that our population only included participants who were currently club or high school athletes, while the Holland et al study included any participant enrolled in high school. As a result, there was a high rate of participants with CAI who routinely participated in activities with a high risk of ankle injuries; conversely, participants without CAI reported less frequent participation in those same activities.[22]

The impact of CAI and acute ankle sprains has been studied in young adults from a university setting.[25,26] Both of these studies[25,26] found that patients with a previous ankle sprain are significantly less physically active than matched controls with no history of ankle sprains. The combination of the available literature[22,25,26] and our results suggests that physical activity may not immediately be compromised in adolescents, despite the reduced levels of perceived foot and ankle function and HRQoL, however it can become negatively affected by CAI and can decline in early adulthood. When synthesizing our results, it appears that to have a substantial impact on the long-term consequences and financial burden associated with ankle sprains and CAI, prevention programs must target youth sports. Especially when considering that 20.0% of the participants within this study reported CAI, it is likely that the origin of this condition for many participants occurred before adolescence (aged 14-18 years). Future research should aim to (1) identify intrinsic and extrinsic risk factors of ankle sprains and CAI, (2) refine treatment programs to tailor to adolescents, and (3) implement prevention programs to decrease injury occurrence rates.

Limitations

There are several limitations to this study that need to be noted. First, our data collection methods and study design may have influenced our results. Data were collected in a single state with participants from the Midwestern United States. As such, the results may not be generalizable to a broader population of all adolescent athletes. However, we did enroll participants from a variety of sports that have historically the highest rates of ankle injuries. Furthermore, with any cross-sectional study, there is the risk of recall bias for respondents' history of ankle sprains. To remedy this, we encouraged the participants to complete the injury history. In addition, the study team reviewed each completed questionnaire and confirmed the ankle injury history with the participants when it was returned to the study team. The recruitment strategy may have also created a selection bias. Because the study pertained to ankle function and HRQoL, participants who experienced a previous ankle sprain may have been more likely to participate, which in turn could have inflated the prevalence of CAI. To combat selection bias, this study was advertised as one designed to quantify ankle function and quality of life in those who participate in athletics and did not solely seek those with previous injuries. Considering that approximately 75% of athletes identified as eligible to participate in the study enrolled, we are fairly confident that selection bias did not sustainably influence our results.

The questionnaires included in this study also have limitations. First of which, we acknowledge that the presence of CAI was solely identified by using a survey instrument and included no physical examination or diagnostic testing. Because of the lack of physical examination and diagnostic testing, we cannot allude to what impairments may be responsible for causing the perceived feeling of ankle instability. With that being said, the IAC does acknowledge that the combination of patient-reported history and subjective questionnaires is a valid and reliable assessment to identify a patient with CAI.[15] Nonetheless, we cannot dismiss the

value that a thorough physical examination provides when making clinical decisions.

Furthermore, we recognize that when utilizing self-reported questionnaires, there is the possibility that an individual participant's reading comprehension is not sufficient to fully understand each question of the disablement scales. It should be noted that we utilized only scales that have been shown to be reliable and valid in athlete populations and utilized by researchers previously to report disablement in adolescents. Furthermore, we recognize that no study exists with the primary purpose of assessing the validity of the FAAM-ADL/-Sport and IdFAI within an adolescent population. However, the numerous investigations[4,22,30,45] that have used these questionnaires have found FAAM and IdFAI scores to be related to physical impairments and ankle sprain history in adolescent athletes with suspected CAI. Moreover, these instruments have been endorsed by the IAC for quantifying foot and ankle function and identifying the presence of CAI.[15] At this time, the IAC has not endorsed alternative questionnaires when studying adolescent athletes. To combat these limitations, the study team was available to assist and explain any words or phrases that a participant had difficulty comprehending. As such, we are confident that the study participants were able to comprehend the questions for each disablement scale. In addition to comprehension, a ceiling effect of the questionnaires should be noted. Despite some participants reporting reductions in ankle function and HRQoL, the majority of participants within this study were injury-free, and all participants were able to fully participate in sports. As a result, the overall means and medians of each questionnaire were near the maximum value, representing no dysfunction.

CONCLUSION

CAI is a common condition among adolescents that should not be considered an innocuous injury. Based on our results, the presence of CAI in adolescents affects their long-term health, given the deficits reported in ankle function and HRQoL. Despite observing deficits in HRQoL in adolescents with CAI, maintaining physical activity levels may contribute to preserving HRQoL. As such, strategies to prevent ankle injuries and maintain physical activity within an adolescent population are important to alleviate the financial burden and long-term consequences associated with developing CAI. These strategies should be implemented as soon as sport participation begins.

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