Journal of Athletic Training 2015;50(7):742–747
doi: 10.4085/1062-6050-50.3.05

www.natajournals.org

original research

Physical Activity Levels in College Students With Chronic Ankle Instability

Tricia Hubbard-Turner, PhD, ATC; Michael J. Turner, PhD

Department of Kinesiology, University of North Carolina at Charlotte

Context: Ankle sprains are the most common orthopaedic pathologic condition, and more concerning is the high percentage of persons who develop chronic ankle instability (CAI). Researchers have reported that patients with CAI are restricted occupationally, have more functional limitations, and have a poorer health-related quality of life. We do not know if these limitations decrease physical activity levels.

Objective: To assess total weekly steps taken between persons with CAI and persons with healthy ankles.

Design: Case-control study.

Setting: University research laboratory.

Patients or Other Participants: A total of 20 participants with unilateral CAI (9 men, 11 women; age = 21.2 ± 1.9 years, height = 174.3 ± 6.9 cm, mass = 71.9 ± 11.7 kg) and 20 healthy participants (9 men, 11 women; age = 20.4 ± 2.1 years, height = 172.1 ± 5.5 cm, mass = 73.1 ± 13.4 kg) volunteered.

Main Outcome Measure(s): We provided all participants with a pedometer and instructed them to wear it every day for 7 days and to complete a daily step log. They also completed the Foot and Ankle Ability Measure (FAAM), the FAAM Sport version, and the International Physical Activity Questionnaire. A 2-way analysis of variance (group × sex) was used to determine if differences existed in the total number of weekly steps, ankle laxity, and answers on the International Physical Activity Questionnaire between groups and between sexes.

Results: We found no group × sex interaction for step count (F range = 0.439–2.108, P = .08). A main effect for group was observed ($F_{1,38}$ = 10.45, P = .04). The CAI group took fewer steps than the healthy group (P = .04). The average daily step count was 6694.47 ± 1603.35 for the CAI group and 8831.01 ± 1290.01 for the healthy group. The CAI group also scored lower on the FAAM (P = .01) and the FAAM Sport version (P = .01).

Conclusions: The decreased step count that the participants with CAI demonstrated is concerning. This decreased physical activity may be secondary to the functional limitations reported. If this decrease in physical activity level continues for an extended period, CAI may potentially be a substantial health risk if not treated appropriately.

Key Words: ankle sprain, laxity, exercise

Key Points

- The chronic ankle instability (CAI) group was less physically active than the healthy group.
- Increased laxity in the CAI group may have contributed to differences in physical activity levels.
- The decreased step count in the CAI group may have been caused by increased joint laxity or by the corresponding changes in neuromuscular control that occur with joint instability.
- The long-term consequences of decreased physical activity with any musculoskeletal injury could lead to the development of chronic diseases and warrant further study.

Ankle sprains are the most common injury associated with physical activity.[1] Researchers[2] have reported recurrence rates after an initial ankle sprain as high as 70% and rates of developing chronic residual symptoms as high as 74%. The development of these residual symptoms, termed *chronic ankle instability* (CAI), has been linked directly to posttraumatic ankle osteoarthritis.[3] Researchers have observed that participants with CAI have greater subjective disability,[4,5] neuromuscular changes,[6,7] and mechanical instability.[8–10] We do not know if these negative changes lead to decreased physical activity levels.

Physical inactivity is classified as one of the 3 highest-risk behaviors in the development of cardiovascular disease; cancer; and other chronic diseases, such as diabetes and obesity.[11] Physical activity has been shown to protect against the development of osteoarthritis.[12] Thus, whereas often viewed as mild injuries, ankle sprains may represent a substantial public health problem and a major health care burden.[13] The potential reduction in physical activity levels secondary to ankle pathologic conditions and the negative relationship that physical inactivity levels have on several chronic diseases is concerning.

Investigators have consistently observed that participants with CAI score lower on subjective self-report scales, including the Foot and Ankle Ability Measure (FAAM), the Foot and Ankle Disability Index, and the Foot and Ankle Disability Index–Sport.[4,5,8–10] These questionnaires assess the participant's ability to perform common activities of daily living (eg, walking, going up and down stairs). Investigators have reported that participants with ankle instability scored lower on health-related quality of life (HR-QOL) and had more functional limitations.[14] In addition, a positive correlation was reported between HR-QOL scores and functional limitations. The HR-QOL addresses functioning in everyday life and personal evaluation of well-being.[14] These decreases in subjective self-report and HR-QOL may negatively affect physical

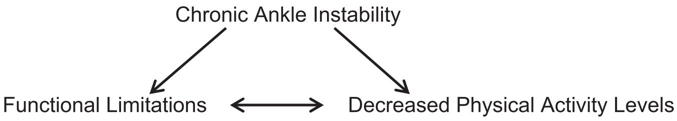

Figure. Theoretical model showing how chronic ankle instability affects physical and functional impairments.

activity levels. If physical activity levels are decreased in patients with CAI, they could possibly have a negative effect on subjective function. However, we do not know the physical activity levels of persons with CAI and healthy persons or how physical inactivity, if present, is linked to changes in subjective function (Figure).

Ankle laxity is an objective variable that influences subjective function. Increased laxity in persons with CAI has also been reported to relate to subjective function.[5] If the ankle ligaments are not allowed to heal after an ankle sprain, subjective function may be negatively affected, which may affect physical activity levels. In a recent study from our laboratory,[15] researchers demonstrated decreased physical activity levels in mice after an acute lateral ankle sprain. If this decreased physical activity continues across the life span, it could have numerous negative effects on overall health and well-being and, therefore, needs to be measured in patients with CAI. In addition, the differences in physical activity levels between males and females need to be examined. Researchers[16] have observed a strong sex-related difference in physical activity levels. In the animal literature, investigators have reported that females are regularly more physically active than males, whereas authors of the human literature have suggested that males are more active than females.[16] Further study is needed to examine if this difference exists with an injury model. Therefore, the purpose of our study was to assess total weekly steps taken between persons with CAI and persons with healthy ankles and between men and women in a university population. We also wanted to examine the relationship between ankle laxity and physical activity levels.

METHODS

Participants

A total of 20 participants with unilateral CAI (9 men, 11 women; age = 21.2 ± 1.9 years, height = 174.3 ± 6.9 cm, mass = 71.9 ± 11.7 kg) and 20 healthy participants (9 men, 11 women; age = 20.4 ± 2.1 years, height = 172.1 ± 5.5 cm, mass = 73.1 ± 13.4 kg) volunteered. We recruited them from a single, large, urban, public research university. All participants completed an ankle-instability questionnaire that established the criteria for classifying persons with CAI.[9] Inclusion criteria were a history of unilateral ankle sprain, frequent sensation of the ankle "giving way," pain, feelings of instability, and decreased function. Volunteers were excluded from participation if they had an acute ankle sprain in the 6 weeks before the study, a history of surgery or fracture to either lower extremity, or a previous sprain to the ankle contralateral to the chronically unstable ankle. The participants serving as controls had no previous musculoskeletal injury or surgery to either lower extremity. In addition, to be included, all participants had to report that they were healthy and had no illnesses or chronic diseases that would impair their normal physical activity levels. All participants provided written informed consent, and the study was approved by the Institutional Review Board of the University of North Carolina at Charlotte.

Procedures

Upon enrolling in the study, all participants first completed the FAAM and the FAAM Sport version. The FAAM consists of a 21-item activities-of-daily-living scale; the FAAM Sport version is an 8-item sport subscale.[17] The FAAM has been reported to be a reliable, responsive, and valid measure of physical function for persons with pathologic musculoskeletal conditions of the lower leg, foot, and ankle.[17] After completing the FAAM, all participants completed the International Physical Activity Questionnaire (IPAQ) short form. The IPAQ, which is used to obtain internationally comparable data on health-related physical activity,[18] includes 7 questions to determine the kinds of physical activities participants pursue and the intensity and volume of those activities (Table 1).

After completing the FAAM, FAAM Sport version, and IPAQ, all participants were provided with a pedometer (Digi-Walker SW-200; New Lifestyles Inc, Lees Summit, MO), and we explained both how to use it and our expectations of each participant. Participants were instructed to wear the pedometer on the waistband or belt close to the hip joint and to wear the device at all times except when bathing, showering, swimming, or sleeping at night. We instructed them to put on the pedometer first thing in the morning and to remove the pedometer, complete the provided daily step log, and zero the pedometer before going to bed. We sent e-mails to participants each day of the study week to remind them to wear the pedometer during the entire day and to record their daily step counts. Daily step totals were summed for each participant's total. We instructed participants not to make changes to their typical daily routines and leisure activities for the duration of the study. Daily pedometer measurements of 1 week (7 consecutive days) were recorded for each participant. Pedometers have been reported to be a valid option for assessing physical activity and have moderate to high reliability and validity.[19]

After providing the pedometer, we measured ankle laxity in participants with a portable instrumented ankle arthrometer (Blue Bay Research Inc, Milton, FL).[20,21] The ankle arthrometer has been reported to have high reliability and validity[20,21] and consists of an adjustable plate that is fixed to the foot, a load-measuring handle that is attached to the footplate through which the load is applied, and a tibial pad attached to the tibia. A 6 degrees-of-freedom spatial kinematic linkage connects the tibial pad to the footplate that measures all components of motion (3 rotations and 3 translations) of the footplate relative to the tibial pad.[20–22] Measurements quantify the anterior-posterior load displacement and inversion-eversion rotational laxity characteristics of the ankle-subtalar joint complex (talocrural and subtalar joints). The spatial kinematic linkage of the arthrometer measures the relative motion between the arthrometer footplate and the reference pad attached to the tibia.

Table 1. **Questions From the International Physical Activity Questionnaire[18]**

Number	Question
1a	During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, digging, aerobics, or fast bicycling?
1b	How much time in total did you usually spend on 1 of those days doing vigorous physical activities?
2a	During the last 7 days, on how many days did you do moderate physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.
2b	How much time in total did you usually spend on 1 of those days doing moderate physical activities?
3a	During the last 7 days, on how many days did you walk for at least 10 minutes at a time?
3b	How much time in total did you usually spend walking on 1 of those days?
4	During the last 7 days, how much time in total did you usually spend sitting on a week day?

Participants were positioned supine on a treatment table. The leg we were testing was positioned according to previous studies.[20–22] We tested anterior-posterior displacement and then inversion-eversion rotation. The mean of 3 trials for each motion was calculated and used for the dependent variable. A computer (MacBook Air; Apple Inc, Cupertino, CA) with an analog-to-digital converter (Blue Bay Research) was used to simultaneously calculate and record data. The resulting anterior-posterior displacement (in millimeters) and inversion-eversion rotation (degrees of range of motion) were recorded. A custom software program written in LabVIEW (version 2006; National Instruments, Austin, TX) was used for data collection.

Statistical Analysis

We analyzed the descriptive data of all participants using a 1-way analysis of variance between groups (CAI, healthy). A 2-way analysis of variance (group × sex) was used to determine differences in the total number of steps taken weekly, ankle laxity, and the questions on the IPAQ (Table 1) between groups and between sexes. Bivariate correlations using Pearson product moment correlations were calculated between ankle laxity and scores on the FAAM and FAAM Sport version and the weekly step counts. The α level was set at .05. We used IBM SPSS (version 21; IBM Corporation, Armonk, NY) to analyze the statistics.

RESULTS

Participants reported that they followed the guidelines of the study and accurately recorded daily step counts. We observed no differences in descriptive data (age, height, mass) between groups ($F_{1,38}$ range = 0.387–1.023, $P >$ .05). No group × sex interaction was noted for weekly step counts, ankle laxity, or questions on the IPAQ (F range 0.439–2.108, $P = .08$). The average daily step count was 7362.4 ± 1105.4 steps per day for men and 7012.1 ± 987.2 steps per day for women. We observed a main effect for group ($F_{1,38} = 10.45$, $P = .04$; Table 2). The CAI group took fewer steps than the healthy group ($P = .04$). The average daily step count was 6694.5 ± 1603.4 steps per day for the CAI group and 8831.0 ± 1290.0 steps per day for the healthy group. Participants with CAI also scored lower on the FAAM ($P = .01$) and FAAM Sport version ($P = .01$) and spent fewer minutes per day performing vigorous physical activity ($P = .01$) and moderate physical activity ($P = .03$) than the healthy participants (Table 2). The CAI group spent less time during an average day walking ($P = .001$) and spent fewer days per week pursuing vigorous activity ($P = .001$) or moderate activity ($P = .001$). We noted no difference in the time spent sitting each day between the groups ($P = .06$). On average, the CAI group spent less time per week (94.2 ± 28.6 min/wk) than the healthy group (212.5 ± 38.5 min/wk) performing moderate to vigorous physical activity. As part of the IPAQ scoring protocol, we calculated the metabolic-equivalent-of-task (MET) level because this physiologic measure expresses the energy costs of physical activity. The average MET levels were

Table 2. **Dependent Variables, Mean ± SD**

Variable	Group	
	Chronic Ankle Instability	Healthy
Step count, No./d	6694.5 ± 1603.4[a]	8831.0 ± 1290.0
Walking, min/d	41.6 ± 15.6[a]	59.2 ± 10.3
Sitting, h/d	6.7 ± 2.9	6.1 ± 2.3
Moderate activity, d/wk	2.3 ± 1.5[a]	4.6 ± 1.9
Moderate activity, min/d	32.1 ± 10.1[a]	46.3 ± 16.6
Vigorous activity, d/wk	1.1 ± 0.4[a]	2.8 ± 1.2
Vigorous activity, min/d	20.2 ± 5.2[a]	30.2 ± 8.3
Metabolic-equivalent-of-task level (metabolic-equivalent-of-task-minutes per week)	1020.3 ± 154.6[a]	2446.8 ± 123.1
Categorical score	Moderate	Moderate
Moderate to vigorous physical activity, min/wk	94.2 ± 28.6[a]	212.5 ± 38.5
Anterior displacement, mm	15.1 ± 2.5[a]	11.8 ± 0.65
Inversion rotation, °	36.1 ± 4.2[a]	30.2 ± 2.5
Foot and Ankle Ability Measure, %	88.5 ± 4.3[a]	100.0 ± 0.0
Foot and Ankle Ability Measure Sport version, %	76.3 ± 10.6[a]	98.7 ± 0.1

[a] Indicates a between-groups difference ($P < .05$).

1020.3 ± 154.6 MET-minutes per week for the CAI group and 2446.8 ± 123.1 MET-minutes per week for the healthy group. We observed a difference between groups for the average MET score, which is calculated by adding MET levels for time and days spent walking and performing moderate and vigorous physical activities. The IPAQ categorical scores for the CAI group and the healthy group were in the moderate range.

The CAI group had more anterior displacement and inversion rotation than the healthy group (both $P < .001$). In addition, we identified several bivariate correlations. The strongest relationship was between anterior laxity and average daily step count ($r = -0.84$, $P = .02$). As anterior displacement increased, average daily step count decreased. We observed a relationship between inversion rotation and average daily step count ($r = -0.78$, $P = .047$). Our r^2 for anterior displacement/inversion rotation and daily step count suggested that between 60% and 70% of the reduction in physical activity could be explained by laxity differences. As inversion rotation increased, average daily step count decreased.

DISCUSSION

To our knowledge, we are the first to study physical activity levels in persons with CAI. We observed that participants with CAI took fewer steps over a 1-week period and subjectively reported less time spent walking and pursuing vigorous or moderate physical activity. In addition, the average MET levels were lower in the CAI group than the healthy group. Both groups were categorized as having moderate levels of physical activity based on the IPAQ. For this classification, participants must perform 5 or more days of any combination of walking, moderate-intensity activities, or vigorous-intensity activities, achieving a minimum of at least 600 MET-minutes per week. The substantial amount of walking between classes required for this collegiate population helped both groups achieve the moderate level of activity. If these decreased physical activity levels continue, one would expect an effect on the development of numerous chronic diseases. Given the nature of the study, we do not know what the participants' physical activity levels were before they developed CAI. We were surprised that no activity differences were present between men and women. Authors of human studies have reported that males are more physically active than females. Again, we may not have observed a difference between men and women because the college-aged population had participated in athletic or recreational physical activities. As noted, we sent daily e-mails to participants, reminding them to wear the pedometer all day and to record their daily step counts. They reported following the study guidelines and accurately recording daily step counts.

The observed decrease in physical activity could have been secondary to the decreased subjective function that participants reported. Whereas we do not know the relationship between subjective function and physical inactivity, the decreased physical activity could have been present first, which then would have altered subjective function. We know that the CAI group had more laxity in anterior and posterior displacement and that a relationship existed between laxity and decreased physical activity. The increases in laxity likely changed joint function and neuromuscular control, which altered subjective function and physical activity levels.

Given that we are the first to measure physical activity levels in persons with CAI, direct comparison of our data with the literature on an injured population is not possible. Normative data have indicated that healthy adults typically take between 4000 and 18 000 steps per day and that 10 000 steps per day is reasonable for this population.[23] Both groups in our study were taking less than the recommended 10 000 steps per day. The mean number of steps taken by both groups was in line with a previous report in which researchers examined step counts in adults. Bassett et al[24] reported that adults took, on average, 5117 steps per day. This is fewer steps per day than we reported; however, the average age of participants was 45.7 years in the Bassett et al[24] study and 20.8 years in our study. Researchers[25] have observed that physical activity decreases with age. Therefore, whereas our participants were currently taking more steps on average than the participants in the Bassett et al[24] study, their physical activity will decrease further with aging. Knowing that our population comprised young college students, we would hope that they are taking more than 10 000 steps per day on average. Students naturally should be more physically active (age, campus setting, more time for exercise or recreational activity). Over time, with the constraints that come with aging, physical activity patterns may decline well below those recommended for optimal health.[25]

Similar to us, Mestek et al[26] evaluated the physical activity levels of college-aged students with the use of step pedometers over a 7-day period. College-aged men (mean age = 22 years) averaged 10 027 ± 3535 steps per day, whereas college-aged women (mean age = 21 years) averaged 8610 ± 2252 steps per day.[26] Their steps per day of relatively healthy college-aged persons were markedly greater than those of our students with CAI but similar to those of our healthy college-aged participants. Tudor-Locke et al[23] reported on the physical activity patterns of adults who participated in the 2005–2006 National Health and Nutrition Examination Survey. The adults averaged 6540 ± 106 steps per day, which was slightly less than the physical activity reported in our CAI participants. The participants in the National Health and Nutrition Examination Survey ranged in age from 20 to 80+ years. Given that the age range of participants in that study was different from the age range in our study, comparing physical activity levels is difficult.

Another variable that makes comparison of studies difficult is the type of pedometer used and the number of days it was worn. Tudor-Locke et al[23] had participants use accelerometers for 7 days, whereas Bassett et al[24] instructed participants to wear pedometers for 2 days. Investigators[27] have suggested that using pedometers or accelerometers for at least 5 consecutive days is necessary to achieve an intraclass correlation coefficient of 0.80 for reliability and validity. The differences in results between our study and previous studies[23,24] may be secondary to the different amount of time participants wore pedometers or accelerometers.

For optimal health, public health guidelines recommend that people should participate in moderate to vigorous physical activity (MVPA) for at least 150 minutes per week.[23] The healthy participants in our study were meeting this recommendation. Unfortunately, persons with CAI were not meeting this recommendation. The CAI group spent an average of 94.2 ± 28.6 minutes performing MVPA during the week tested, and the healthy group spent an average of 212.5 ± 38.5 minutes. Whereas the CAI group's overall step counts were not lower than previously reported step counts, they were not meeting physical activity guidelines for MVPA. The results of the IPAQ were based on subjective self-response, could have been influenced by many factors, were taken only at 1 time point, and should be reexamined at multiple time points. The CAI group's lack of involvement in MVPA may have been secondary to the increased joint laxity reported in our study or a fear of respraining the ankle. We did not specifically measure or ask participants about fear of respraining their ankles, and this is needed in future research because it will affect subjective function and physical activity levels. Over time and without an intervention, these subjective impairments may continue to lead to further declines in self-reported function and physical activity levels.

These decreases in step count, self-reported function, and self-reported physical activity levels are concerning. Given that this investigation was not prospective, we cannot conclude that CAI alone led to decreased physical activity levels; however, the decreased physical activity levels demonstrated do require further study. As stated, authors[15] of prospective animal research have reported that ankle sprains decreased physical activity levels. The strong relationship between laxity and physical activity levels also speaks to the potentially strong influence CAI may have on the decreased physical activity levels in our study. The development of CAI may affect long-term health and well-being if these physical activity levels remain low or continue to decrease with aging.

CONCLUSIONS

Based on the preliminary data we presented, participants with CAI were less physically active than participants with healthy ankles. Increased laxity in participants with CAI may also contribute to the differences in physical activity levels. We do not know if the decreased step count was due solely to increased joint laxity or potentially to the corresponding changes in neuromuscular control that occur with joint instability. Further research needs to be conducted in a larger sample and over a longer period. Researchers also need to determine if it is better to prescribe physical activity that patients with CAI can perform or to treat the CAI first by trying to improve the subjective functional limitations reported. Afterward, patients may be able to increase physical activity levels when their subjective function improves. Either way, the long-term consequences of decreased physical activity with any musculoskeletal injury could lead to the development of numerous chronic diseases and, therefore, warrant further study.

REFERENCES

1. Hootman JM, Dick R, Agel J. Epidemiology of collegiate injuries for 15 sports: summary and recommendations for injury prevention initiatives. *J Athl Train*. 2007;42(2):311–319.
2. McKay GD, Goldie PA, Payne WR, Oakes BW. Ankle injuries in basketball: injury rate and risk factors. *Br J Sports Med*. 2001;35(2):103–108.
3. Hintermann B, Boss A, Schafer D. Arthroscopic findings in patients with chronic ankle instability. *Am J Sports Med*. 2002;30(3):402–409.
4. Wikstrom EA, Tillman MD, Chmielewski TL, Cauraugh JH, Naugle KE, Borsa PA. Self-assessed disability and functional performance in individuals with and without ankle instability: a case control study. *J Orthop Sports Phys Ther*. 2009;39(6):458–467.
5. Hubbard-Turner T. The relationship between mechanical ankle joint laxity and subjective function. *Foot Ankle Int*. 2012;33(10):852–856.
6. Wikstrom EA, Naik S, Lodha N, Cauraugh JH. Balance capabilities after lateral ankle trauma and intervention: a meta-analysis. *Med Sci Sports Exerc*. 2009;41(6):1287–1295.
7. Wikstrom EA, Naik S, Lodha N, Cauraugh JH. Bilateral balance impairments after lateral ankle trauma: a systematic review and meta-analysis. *Gait Posture*. 2010;31(4):407–414.
8. Hubbard TJ. Ligament laxity following inversion injury with and without chronic ankle instability. *Foot Ankle Int*. 2008;29(3):305–311.
9. Hubbard TJ, Kramer LC, Denegar CR, Hertel J. Contributing factors to chronic ankle instability. *Foot Ankle Int*. 2007;28(3):343–354.
10. Hubbard TJ, Hertel J. Mechanical contributions to chronic lateral ankle instability. *Sports Med*. 2006;36(3):263–277.
11. Inactivity related to chronic disease in adults with disabilities. Centers for Disease Control and Prevention Web site. http://www.cdc.gov/media/releases/2014/p0506-disability-activity.html. Published May 6, 2014. Accessed November 21, 2014.
12. Hubbard-Turner T, Guderian S, Turner MJ. Lifelong physical activity and knee osteoarthritis development in mice. *Int J Rheum Dis*. 2015;18(1):33–39.
13. Verhagen RA, de Keizer G, van Dijk CN. Long-term follow-up of inversion trauma of the ankle. *Arch Orthop Trauma Surg*. 1995;114(2):92–96.
14. Arnold BL, Wright CJ, Ross SE. Functional ankle instability and health-related quality of life. *J Athl Train*. 2011;46(6):634–641.
15. Hubbard-Turner T, Wikstrom EA, Guderian S, Turner MJ. Acute ankle sprain in a mouse model. *Med Sci Sports Exerc*. 2013;45(8):1623–1628.
16. Bowen RS, Turner MJ, Lightfoot JT. Sex hormone effects on physical activity levels: why doesn't Jane run as much as Dick? *Sports Med*. 2011;41(1):73–86.
17. Martin RL, Irrgang JJ, Burdett RG, Conti SF, Van Swearingen JM. Evidence of validity for the Foot and Ankle Ability Measure (FAAM). *Foot Ankle Int*. 2005;26(11):968–983.
18. Booth M. Assessment of physical activity: an international perspective. *Res Q Exerc Sport*. 2000;71(suppl 2):S114–S120.
19. Tudor-Locke C, Williams JE, Reis JP, Pluto D. Utility of pedometers for assessing physical activity: convergent validity. *Sports Med*. 2002;32(12):795–808.
20. Hubbard TJ, Kovaleski JE, Kaminski TW. Reliability of intratester and intertester measurements derived from an instrumented ankle arthrometer. *J Sport Rehabil*. 2003;12(3):208–220.
21. Kovaleski JE, Gurchiek LR, Heitman RJ, Hollis JM, Pearsall AW. Instrumented measurement of anteroposterior and inversion-eversion laxity of the normal ankle joint complex. *Foot Ankle Int*. 1999;20(12):808–814.
22. Kovaleski JE, Hollis J, Heitman RJ, Gurchiek LR, Pearsall AW. Assessment of ankle-subtalar-joint-complex laxity using an instrumented ankle arthrometer: an experimental cadaveric investigation. *J Athl Train*. 2002;37(4):467–474.
23. Tudor-Locke C, Craig CL, Brown WJ, et al. How many steps/day are enough? For adults. *Int J Behav Nutr Phys Act*. 2011;8:79.

24. Bassett DR, Wyatt HR, Thompson H, Peters JC, Hill JO. Pedometer-measured physical activity and health behavior in U.S. adults. *Med Sci Sports Exerc*. 2010;42(10):1819–1825.
25. Caspersen CJ, Pereira MA, Curran KM. Changes in physical activity patterns in the United States, by sex and cross-sectional age. *Med Sci Sports Exerc*. 2000;32(9):1601–1609.
26. Mestek ML, Plaisance E, Grandjean P. The relationship between pedometer-determined and self-reported physical activity and body composition variables in college-aged men and women. *J Am Coll Health*. 2008;57(1):39–44.
27. Kang M, Bassett DR, Barreira TV, et al. How many days are enough? A study of 365 days of pedometer monitoring. *Res Q Exerc Sport*. 2009;80(3):445–453.

Address correspondence to Tricia Hubbard-Turner, PhD, ATC, Department of Kinesiology, University of North Carolina at Charlotte, 9201 University City Boulevard, Charlotte, NC 28223. Address e-mail to thubbar1@uncc.edu.