Clinician Patterns of Ankle Brace Recommendation and Perception of Factors Associated with Brace Use

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ABSTRACT

JASON DENTON: Clinician Patterns of Ankle Brace Recommendation and Perception of Factors Associated with Brace Use
(Under the direction of Michael T. Gross)

A group of athletic trainers and physical therapists were surveyed to determine which ankle braces they recommend most frequently to prevent ankle sprain injury, which factors associated with brace use influence decisions about ankle brace recommendation, and to determine if perceptions about factors associated with brace use are related to patterns of ankle brace recommendation. The ASO brace was the ankle brace recommended most frequently. Clinicians reported effectiveness in preventing ankle sprain injury was the most influential factor when recommending a specific ankle brace. Additionally, clinicians reported comfort of an ankle brace was the next most influential factor. Clinicians' concern about reduced ankle muscle strength after wearing an ankle brace for a period of time was related to the likelihood of whether they would recommend use of an ankle brace for patients after an ankle sprain injury.

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Introduction

Prevalence

Injury to the ankle joint is common among the athletic population (Garrick, 1988), military personnel (Milgrom, 1991), and the working population (Grimm, 1999). The vast majority (85%) of injuries to the foot and ankle are ankle sprains (Garrick, 1977).

Garrick (1988) reports that among injuries treated in a sports-medicine clinic over 6.5 years, twenty-five percent of the injuries occurred in the foot and ankle. Prevalence of ankle sprains in Canadian collegiate basketball players has been reported as 1.22 injuries/1,000 participations (Meeuwiss, 2003). Prevalence in recreational basketball players has been reported as high as 3.85 injuries/1,000 participations (McKay, 2001). Half of the recreational participants who incurred an ankle sprain injury missed a week or more of competition. Anderson et al. (2004) recently reported a prevalence of 4.5 injuries/1,000 match hours during competition between elite Norwegian and Icelandic soccer players. Ankle sprains also accounted for up to 41% of all volleyball injuries (Verhagen, 2004), and between 30 to 60% of all parachuting injuries in military personnel (Amoroso, 1998).

The general population also experiences an appreciable number of ankle sprains. Grimm and Fallat (1999) conducted a retrospective study of all foot and ankle injuries during a one year period at an occupational medicine clinic. They reported that 6.4% of all injuries treated at the clinic were injuries to the foot and ankle, 40.8% of which were ankle sprains. The average cost of medical treatment for all types of ankle injury for this occupational health study was $804 per case.

Mechanisms of Injury

Common mechanisms of injury for ankle sprains during sporting events include quick cutting motions, landing from a jump (McKay, 2001), landing on an uneven surface, and colliding with an opponent (Anderson, 2004). Additional mechanisms reported include missteps, stepping on objects, and inverting the ankle on uneven terrain while walking or jogging. The risk for additional ankle sprain injury increases following an initial injury (Surve, 1994; Yeung, 1994). McKay (2001) reported basketball players with a history of ankle sprain are up to five times more likely to suffer a recurrent sprain than individuals without previous injury.

Preventing Ankle Sprain using Ankle Braces

Recommended use of an ankle brace is a common clinical intervention intended to prevent ankle sprains. The results of multiple studies indicate that wearing an ankle brace can reduce the incidence of ankle sprains in sporting activities such as football (Rovere 1988), basketball (Sitler, 1994), and soccer (Tropp, 1985; Surve, 1994). Additionally, Amoroso et al. (1998) demonstrated a reduction in the incidence of ankle sprain injuries during Army paratrooper training when recruits wore an outside-the-boot brace.

At least two prospective studies have demonstrated reduction in the incidence of ankle sprains using the semi-rigid Aircast Sport-Stirrup (Aircast, Inc.) brace (Surve, 1994; Sitler, 1994). Additionally, the results of two studies offer strong evidence that a semi-rigid brace worn outside of paratroopers' boots can assist in preventing ankle injuries (Amoroso, 1998; Schumaker, 2000). Results of other studies indicate wearing a lace-up brace,

specifically the Swede-O Universal Ankle Support (North Branch, MN), may effectively reduce the incidence of ankle sprain injuries (Rovere, 1988; Sharpe, 1997).

Factors that may Discourage use of Ankle Braces

Even though ankle braces have been effective in reducing the incidence of ankle sprains, athletes may be less likely to use them if they believe a given brace will adversely influence performance. Clinicians' beliefs regarding the effect of ankle braces on functional performance may also influence decisions about brace recommendations. Considerable evidence exists, however, that ankle braces do not adversely affect functional performance (Bocchinfuso, 1994; Gross, 1994; McKean, 1995; MacPherson, 1995; Pienkowski, 1995; Verbrugge, 1996; Gross, 1997; Jerosch, 1997; Wiley, 1996; Hals, 2000). The results of only two studies contradict this general conclusion (Burks, 1991; MacKean, 1995).

Ankle brace comfort is another important issue to consider. Semi-rigid braces are made of stiffer material, are generally bulkier, and may cause more skin irritation. Gross and Liu (2003) reported no "consistent trends" across a series of studies comparing comfort between the Aircast Sport Stirrup and the Ankle Ligament Protector semi-rigid braces.

Little information is available regarding the effects of long-term ankle brace use on ankle muscle strength and function. The results of one investigation indicated no changes in postural control after using an ankle brace for four days (Palmieri, 2002). Cordova et al. (2000) investigated the effects of eight weeks use of a semi-rigid brace and a lace-up brace on peroneus longus muscle activation latency in healthy subjects. Post-testing EMG data for a sudden ankle inversion task indicated no effect of brace use on muscle onset latency. No investigators have examined the effect of long-term ankle brace use on the force producing capabilities of ankle musculature.

Some clinicians may have concerns about ankle brace use causing increased risk for injury at proximal joints. Forces must be absorbed throughout the lower extremity during landing and cutting tasks. Theoretically, greater forces may be transmitted to more proximal joints if ankle joint motion is restricted. While the effect of using an ankle brace on the risk of proximal joint injury has not been examined, Santos et al. (2004) did investigate the effect of ankle braces on knee motion. Santos et al. examined how the Active Ankle brace (semi-rigid with straps) affected motion at the hip and knee during a one-leg stance rotation task. Subjects exhibited an increase in knee internal rotation when they wore the ankle brace during the rotation task.

The Future of Ankle Brace Research

Several recently published reviews have called for additional research on the use of ankle bracing to prevent ankle sprains. Wilkerson (2002) has encouraged researchers to assess the effectiveness of braces and taping procedures in limiting foot abduction and adduction motion in the horizontal plane. Cordova et al. (2002) noted that while numerous studies have examined the efficacy of external ankle braces in limiting passive motion, the effects of ankle braces on ankle kinematics and kinetics during dynamic activities such as running, cutting, and lateral movements are poorly understood. Finally, Gross and Liu (2003) indicated in their review that a new generation of ankle braces is being recommended by clinicians and used by the general population. Gross and Liu recommend clinicians should be surveyed to determine which ankle braces are used most commonly. This initial effort could be followed by clinical trials to determine the effects of these braces on ankle sprain injury rates during selected activities as compared to control groups. Additional related

questions raised by Gross and Liu include: the influence ankle braces may have on injuries to more proximal lower extremity joints, the effects of long-term ankle brace use on muscle strength, and the length of time after an ankle sprain that a brace should be worn to reduce the risk of re-injury adequately.

No published data are available describing which ankle braces clinicians most commonly recommend or which braces individuals acquire on their own. Many new braces that are commonly recommended have not been included in previous research studies. Future studies will be more clinically relevant if investigators can study the effects of braces that are most commonly recommended by clinicians. Additionally, no data are available regarding the factors clinicians consider when they recommend a specific ankle brace. The purpose of this study is to address these deficiencies in the literature by answering the following research questions:

1) Which ankle braces do clinicians recommend and/or dispense most frequently to prevent ankle sprain injuries?

2) What factors related to brace use are most influential when clinicians decide to recommend specific ankle braces?

3) Is frequency of recommendation of ankle brace related to clinicians' beliefs about potential side effects resulting from using an ankle brace?

Methods

Data Collection

Survey methodology was used to collect data to address the research questions. Generation of survey items (Appendix) was guided by a review of the literature. The survey

instrument was formatted based on the Total Design Method by Dillman (1978). The specific braces listed in the survey were chosen based on clinical experience, informal surveys of vendors and other clinicians, and a review of relevant literature. In addition, space was provided for clinicians to report other braces not included in the survey list. The survey was conducted via the internet. An initial e-mail with a link to the survey website was sent inviting the subjects to participate in the survey. Informed consent was obtained on the first page of the survey. A follow-up e-mail was sent to all subjects after two weeks. The content of the follow-up e-mail thanked those who had already participated and notified the remaining subjects that the survey would be open for ten more days. The study was approved by the Office of Human Research Ethics- Biomedical Institutional Review Board at the University of North Carolina at Chapel Hill.

Survey Sample

The e-mail invitation to participate in the survey was sent to 2,000 potential respondents. The target population was clinicians who were either a licensed physical therapist (PTs) or a certified athletic trainer (ATCs). The principal investigator acquired e-mail addresses for 1,000 randomly selected members of the National Athletic Trainers Association (NATA). The survey was sent to these 1,000 members of the NATA. The principal investigator also acquired the e-mail list for members of the Orthopedic Section of the American Physical Therapy Association (APTA). The survey was sent to 1,000 randomly selected members from the Orthopedic Section of the APTA list. Of the 2,000 surveys sent to participants, 131 were returned secondary to invalid e-mail addresses. Of the 1,869 subjects

receiving the survey, 377 subjects responded to some portion of the survey for a response rate of 20.2 percent. See Table 1 for a full description of the subjects.

Survey Instrument

The survey contained questions about the clinicians' experience, practice setting, and patient volume. The survey contained Sections A-F. Section A contained questions about how many patients clinicians had treated for an ankle sprain injury and the number of patients for whom clinicians had recommended a brace. Clinicians who had not treated a patient for an ankle sprain injury were skipped by the survey program to Section F to complete their participation. Section F contained questions inquiring about clinicians' professional status, clinical experience, and current practice setting. Clinicians who had treated patients for an ankle sprain injury but had not recommended an ankle brace during the last 12 months were skipped by the survey program to Section D to complete Sections D-F. Clinicians who had recommended use of an ankle brace continued to answer questions in Section A regarding the percentage of patients with an initial ankle sprain injury for whom they had recommended use of an ankle brace. The question was repeated for patients with recurrent ankle sprain injury. Finally, clinicians answered whether they had the autonomy to decide if a patient needed an ankle brace and to decide which ankle brace a patient should wear.

In Section B of the questionnaire clinicians reported which braces they recommended most often and estimated how many times they had recommended each brace during the past 12 months. Clinicians selected braces from a list of nine braces and an "other brace" option. Clinicians also were asked to identify the braces they recommended most often, second most often, and third most often.

In Section C clinicians described the factors that are most influential for them when selecting an ankle brace. Clinicians were asked to identify the 1st, 2nd, and 3rd most influential factors.

Section D contained questions about potential brace side-effects to determine if clinicians' views about potential side effects were related to clinicians' frequency of recommendation of ankle brace. Each of the four questions asked clinicians how concerned they were about the following issues: 1) potential for reduced ankle muscle strength once a brace is no longer used, 2) potential for compromised ankle joint proprioception once the brace is no longer used, 3) potential for compromised dynamic balance once the brace is no longer used, and 4) increased risk of injury to knee joint structure. Clinicians responded to each of the four questions by choosing from the following responses: 1) not concerned at all, 2) minimally concerned, 3) moderately concerned, or 4) greatly concerned.

Section E contained two questions inquiring how long, on average, clinicians recommend a patient wear an ankle brace after an ankle sprain injury during physical activity that poses a risk of ankle sprain injury. One question inquired about patients with a first-time ankle sprain and the second question was related to patients following a recurrent ankle sprain. Clinicians selected among the following choices: 1) not at all, 2) 1-6 days, 3) 1-4 weeks, 4) 1-3 months, 5) greater than 3 months, or 6) forever when participating in the activity.

Data Analysis

The characteristics of the survey respondents and their current clinical practice were detailed using descriptive statistics. The specific research questions were analyzed using descriptive statistics, chi-square analysis, and regression analysis.

The data to address the first research question were analyzed using descriptive statistics. This includes a report of a) the number of clinicians who recommend use of each brace, and b) the frequency each brace was listed as being the most frequently recommended, second most frequently recommended, and third most frequently recommended brace. Additionally, clinicians estimated how many times they had recommended each brace in the past 12 months.

The second research question was addressed using descriptive statistics and a chi-square analysis of the data from survey Section C. Descriptive statistics were generated for the factors clinicians consider most influential when deciding which brace to recommend. Additionally, a chi-square analysis (.05 alpha) was used to determine if the observed frequencies were different from the expected frequencies to determine the significance of the most influential factor. A second chi-square test was conducted to determine if the remaining factors were selected equally or if differences exist.

Regression analyses are employed to answer the third research question. The dependent variables are the percentage of patients for whom a given clinician recommends use of an ankle brace for initial and recurrent sprains (survey Section A, questions 2b-c). The independent variables are the responses to the questions regarding potential side effects of using an ankle brace (survey Section D, questions 1-4). Data analysis indicated that professional status (ATC or PT) was highly correlated with the percentage of patients for whom clinicians recommended use of an ankle brace. Therefore, professional status was included as an independent variable in all regression models. Respondents who reported they did not have autonomy to decide if a patient needed an ankle brace or did not answer each of

the side effect questions (Section D, questions 1-4) were excluded from the regression analysis.

Results

Descriptive Statistics

Table 1 provides general descriptive statistics for the survey respondents. Of the 377 respondents, 324 respondents answered the professional status question. Of those 324 respondents, 198 (61.1%) reported ATC status, 99 (30.6%) reported PT status, and 27 (8.3%) reported ATC and PT status. The results of this survey pertain only to the respondents who confirmed professional status as an ATC or PT. The 53 subjects who did not confirm a professional status of ATC or PT were excluded from all analyses. Respondents with experience as an ATC reported a mean of 11.01 years of experience. Respondents with experience as a PT reported a mean of 12.80 years of experience. Overall respondents reported a mean of 11.45 years of experience in sports medicine and/or orthopedics. Of the respondents who reported their clinical setting(s), 49.7% (n=150) reported working in an outpatient orthopedic clinic, 33.6% (n=108) reported working with a sports team(s) (professional, college/university), 19.6% (n=63) reported working in a sports medicine clinic, 10.9% (n=35) reported working in a high school or middle school setting, 6.5% (n=21) reported working in an academic/university setting, and 7.2% (n= 23) reported other miscellaneous settings. The largest number of ATCs reported working for a sports team (99 ATCs, 4 PTs, and 5 ATC/PTs). The largest number of PTs reported working in an outpatient orthopedic setting (84 PTs, 45 ATCs, and 21 ATC/PTs). Of the clinicians who reported

working in a university setting or a high school/middle school setting all reported ATC status with the exception of one clinician who reported ATC and PT status (n=56).

Approximately 90% of respondents who had recommended an ankle brace reported having the autonomy to decide if a patient needed an ankle brace. Of those respondents with autonomy to recommend use of a brace, 90% also reported having autonomy to recommend a specific brace.

Overall, respondents who had recommended ankle brace use for patients in the past 12 months reported recommending a brace to 48.1% of the patients who had an initial ankle sprain. Subjects reported recommending an ankle brace to 64.1% of their patients who had a recurrent ankle sprain. ATCs recommended an ankle brace to 53.9% of patients with an initial ankle sprain and 70.1% of patients with a recurrent sprain. PTs recommended an ankle brace to 35.5% of patients with an initial ankle sprain and 49.7% of patients with a recurrent ankle sprain.

The majority of respondents reported recommending that patients with a first-time ankle sprain should wear an ankle brace for either 1-3 months (39.3%) or 1-4 weeks (32.9%) after injury when returning to physical activity that poses a risk for ankle sprain injury. When considering patients in the past 12 months with a recurrent ankle sprain returning to previous activity, most respondents reported recommending the patients wear an ankle brace "forever when participating in the activity" (34.3 %), 1-3 months (25.4%), or greater than 3 months (22.5%).

Research Question 1

The first research question examined which braces clinicians recommend most frequently to prevent ankle sprain injuries. To address this question, the data from survey section B "Most Frequently Recommended Braces" is reported using descriptive statistics. Tables 2 and 3 show the number of clinicians who recommend use of each brace. Of the clinicians who reported which braces they recommended or dispensed, 9% (n=26) reported they did not have the autonomy to decide which brace a patient should use. Therefore, for this small subset of respondents the brace or braces they dispensed may not have been the brace they most preferred. Table 4 shows clinicians' estimates of how many times they recommended each brace in the past 12 months.

The ASO brace was recommended by clinicians with considerably greater frequency than any other brace (Table 2). The ASO brace also was the brace recommended most often as the 1st, 2nd, or 3rd most recommended brace (Table 3), and was recommended to the greatest total number of patients (Table 4). The five braces reported by clinicians as the brace they recommended most frequently (Table 2) are as follows: ASO- 36% (n=102), McDavid- 13% (n=36), T2 Active Ankle Support- 10% (n=28), Swede-O Ankle LoK- 10% (n=27), and Aircast Air-Stirrup- 9% (n=26). For the braces recommended 1st, 2nd, or 3rd most by clinicians who recommended a brace in the past 12 months, the top five braces were as follows: ASO- 44% of clinicians (n=126), Aircast Air-Stirrup- 28% (n= 79), McDavid Sports lace-up- 28% (n=79), Swede-O Ankle Lok- 26% (n=75), and T2 Active Ankle Support- 22% (n=63). See Table 4 for a report of frequencies of total number of braces clinicians recommended to patients in the past 12 months. Ten clinicians reported recommending the ASO brace to greater than 51 patients. While the Aircast Air-stirrup brace

along with the McDavid lace-up brace was recommended by the second highest number of clinicians (n=79), fifty-four of those clinicians only recommended the Aircast Air-stirrup brace to between 1-5 patients in the past year.

Research Question 2

The second research question regarding the factors clinicians consider when deciding which brace to recommend was addressed using descriptive statistics and a chi-square analysis of the data from survey Section C. Clinicians who did not have autonomy to decide if a patient needed a brace and to decide which specific brace to recommend were excluded from the chi-square analysis. The frequency with which each factor is selected as the most influential, second most influential, and third most influential factor is shown in Table 5. Fifty-four percent (n=125) of the respondents reported "effectiveness in preventing ankle sprain" as the most influential factor when selecting an ankle brace. The factor selected with the next most frequency as most influential was "severity of ankle sprain" by fourteen percent (n=32) of respondents. "Effectiveness in preventing ankle sprain" was selected significantly more frequently than any other factor (Table 5). A chi-square analysis (.05 alpha) was used to determine if the observed frequencies were different from the expected frequencies to determine the significance of the most influential factor. The "other" category was not included in the analysis since a low frequency is expected for this type of category. The chi-square analysis indicated an abnormal distribution of the responses with significance at the .005 level ($\boldsymbol{X}$= 328.4, df=6) with "effectiveness" explaining most of the variability ($\boldsymbol{X}$=268.3). A second chi-square test was conducted to determine if the remaining factors were selected evenly or if differences exist. Excluding "effectiveness," a chi-square test was

performed to exam the distribution of total mentions as the 1st, 2nd, or 3rd most influential factor. After "effectiveness in preventing ankle sprain", "comfort of the brace" received the most mentions as the 1st, 2nd, or 3rd most influential factor when selecting an ankle brace (Table 6). The chi-square test proved significant at the .005 level ($\boldsymbol{X}$=36.0, df=5) with "comfort" explaining most of the variability ($\boldsymbol{X}$=28.2).

Research Question 3

Research question three pertained to whether clinicians' beliefs about potential side effects from using an ankle brace were related to decisions about prescribing a brace. A regression analysis was employed to answer research question three. The dependent variable is the percentage of patients for whom a given clinician recommends use of an ankle brace (survey Section A, question 2b). The independent variables are the responses to the questions regarding potential side effects of using an ankle brace (survey Section D, questions 1-4). The frequency and percentage of clinicians concerned about each of the potential side effects are reported in Table 9. In addition to the side effect variables, ATC status was included as a control variable in all the regression models. In this survey ATCs recommended an ankle brace to a higher percentage of patients. Therefore, the primary investigator decided to control for professional status in the regression models. A repeat analysis was performed with a different dependent variable (survey Section A, question 2c.) to determine whether the relationship changes if the patient involved has had a recurrent sprain. Respondents who reported they did not have autonomy to decide if a patient needed an ankle brace were excluded from the regression analysis. Additionally, only respondents

who answered each of the side-effect questions (Section D, questions 1-4) were included in the regression analysis.

Professional status was the characteristic most closely related to the likelihood a clinician would recommend an ankle brace ($p < .001$). Professional status was held constant for all regression analyses. Clinicians reported concern about each of the side effect variables, but only the "strength" variable was related to the percentage of patients for whom clinicians recommended an ankle brace. Clinicians' concern about potential for "reduced ankle musculature strength" once the brace is no longer used was significantly related to whether a respective clinician recommended use of an ankle brace to a patient after an initial ankle sprain (Table 7). Clinicians who were minimally concerned ($p=.03$), moderately concerned ($p=.013$), or greatly concerned ($p=.018$) about "reduced ankle musculature strength" were all less likely to recommend use of an ankle brace after an initial ankle sprain than clinicians who were not concerned at all. Clinicians' concerns about compromised ankle joint proprioception, compromised dynamic balance, and risk of injury to knee joint structures were not significantly related to whether clinicians recommended an ankle brace after an initial ankle sprain (Table 7). Results of regression analyses testing the relationship between beliefs about these side effects and recommending use of an ankle brace after a recurrent ankle sprain (Table 8) revealed that none of the factors were significantly related ($p>.05$ all tests).

Discussion

Our response rate of 20.2% was comparable with the reports in the literature for mass e-mailings without direct personal contact (Hamilton, 2003; Kaplowitz, Hardwick, and

Levine 2004; Cole 2005). The response to mass e-mails is generally very low. Response rates are usually increased by making direct contact with the participant and by offering incentives. Because of the low response rate, the findings of this study may not be generalizable to all ATCs and PTs or even those within the NATA and APTA Orthopedic section. Given the large sample of respondents, however, the results of the survey warrant serious consideration. A follow-up survey offered to a smaller, more focused group of clinicians with incentives included may result in a higher response rate and increase the confidence in the current findings. Another limitation of the current study is that the term "ankle sprain" was not defined within the survey. Respondents may have used their own definition, and this may have influenced individual answers to questions.

Athletic trainers responded to the present survey at twice the rate of physical therapists. Access to the e-mail list of the Sports Section of APTA was denied. Members of the Orthopedic Section of the APTA were sampled as an alternative. Athletic trainers may be more likely to treat patients with an ankle sprain in their respective practice settings. More athletic trainers than physical therapists may have replied to the survey because the survey was more relevant to the practice of athletic trainers. If access to the Sports section members had been granted, response rates of physical therapists may have been more similar to the response rate of the athletic trainers.

ATCs and PTs differ regarding the number of their patients to whom they recommend wear a brace after an ankle sprain injury. ATCs recommended an ankle brace to a higher percentage of their patients than physical therapists for both initial ankle sprains (53.9% versus 35.5%) and for recurrent sprains (70.1% versus 49.7%). Regression analyses were conducted to determine whether professional status or practice setting explained more of the

variability of the percentage of patients for whom clinicians recommend an ankle brace. Clinicians who reported working in an outpatient orthopedic clinic were included in a regression analysis to examine differences in brace recommendations between PTs and ATCs working in an outpatient orthopedic setting. Of clinicians working in an outpatient orthopedic clinic, ATCs were significantly more likely to recommend an ankle brace than PTs ($p<.001$, $R^2=.13$). An additional regression analysis, including only ATCs, was conducted to examine differences in brace recommendations between ATCs in different work settings. For ATCs who work in outpatient orthopedic and sports team settings, practice setting explained almost none of the variability of how often they recommended an ankle brace after an initial ankle sprain ($p=.761$, $R^2=.0008$). Both regression analyses were also repeated for data on recurrent sprains, and the results were almost identical. When controlling for professional status, the frequency of brace recommendation was not influenced by practice setting in this study. The strongest predictor of the likelihood of brace recommendation in this study was professional status.

ATCs, on average, treat patients who are functioning at higher levels of activity or higher levels of competition than orthopedic PTs. Given that a patient visiting an ATC is returning to a higher activity level or higher level of competition than the typical patient visiting a PT in an orthopedic clinic, it is reasonable that ATCs recommend use of an ankle brace to a higher percentage of their patients upon returning to their previous level of function.

Overall, clinicians reported recommending an ankle brace to more patients who had a recurrent ankle sprain than patients who had incurred an initial ankle sprain. Clinicians recommended an ankle brace to patients with an initial ankle sprain 48.1% of the time and to

patients with a recurrent sprain 64.1% of the time. Clinicians also recommended patients wear the ankle brace for a longer period of time if they had a recurrent sprain. The greatest percentage of clinicians (39.3%) recommended patients with an initial ankle sprain wear an ankle brace for 1-3 months upon returning to physical activity posing a risk of ankle sprain injury. The greatest percentage of clinicians (34.3%) recommended patients with a recurrent ankle sprain, however, continue to wear a brace forever when participating in physical activity posing a risk of ankle sprain injury. The apparent assumption by the clinicians who participated in this study is that if the patient has had more than one ankle sprain injury he or she is at greater risk for re-injury than someone with an initial sprain injury. Additionally, clinicians may be more optimistic that rehabilitation alone will be sufficient for someone with an initial ankle sprain. Individuals who have had recurrent sprains may have previously participated in rehabilitation which was unable to prevent a subsequent sprain. The difference in practice patterns between brace recommendation for an initial ankle sprain versus brace recommendation for a recurrent ankle sprain in this study, however, is not supported by the current literature. The bulk of the literature indicates that an individual with one or more ankle sprains is at higher risk for a subsequent ankle sprain (Surve et al., 1994; McKay et al., 2001; Verhagen et al., 2004). The established comparison is between subjects who have had no ankle sprains and subjects who have had one or more and are now at greater risk for future injury. No contrast currently exists in the literature comparing subjects with a history of one ankle sprain versus those with two or more. A subject with an initial ankle sprain, therefore, should be considered as a member of the higher risk category. Future research could investigate whether the injury risk of a participant with a history of one ankle sprain is different from participants with a history of two or more injuries. Currently, however, we

recommend use of an ankle brace for subjects who have had an initial ankle sprain and who then return to activities which pose a risk of ankle sprain injury.

The ASO brace was recommended by considerably more clinicians and to a higher number of patients per clinician than any of the other braces in this study. To date no published studies have examined the injury rates of subjects who wear the ASO ankle brace. If the ASO brace is the most commonly recommended brace among clinicians, prospective, controlled trials are needed to examine the ankle sprain injury rates for subjects who wear the ASO brace. While the experience of clinicians may suggest the efficacy of an ankle brace, scientific evidence is needed to confirm the effectiveness of commonly used braces. The second tier of braces most commonly recommended in this study consisted of the Aircast Air-Stirrup, McDavid Sports Medical Products Lace-up brace, Swede-O Ankle LoK, and T2 Active Ankle support. Similar to the ASO brace, no prospective, controlled studies have examined the injury rates of the McDavid lace-up brace or the T2 Active Ankle brace.

Clinicians sampled in this study reported that effectiveness in preventing ankle sprain injury and comfort of the brace were the two factors they considered most influential when selecting an ankle brace. Effectiveness in preventing ankle sprain was the dominant factor reported by this group of clinicians to influence their selection of an ankle brace. This is not surprising given the role of clinicians to promote and maintain the health of patients. Additionally, injury prevention capability of a brace may be of little consequence if a patient will not wear the brace or cannot acquire the brace. Therefore, clinicians must consider additional factors when recommending a brace. The factor clinicians considered as second most influential was comfort of the brace. Additional factors including availability of the brace, cost of the brace, likelihood of compliance, influence on performance, and severity

(grade) of the ankle sprain each received considerable mention as being important to clinicians in our survey but significantly less than both effectiveness in preventing ankle sprain and comfort. Although clinicians reported effectiveness in preventing ankle sprain as the most influential factor when selecting an ankle brace, it is important to note that the brace (ASO) clinicians recommend most frequently has no associated empirical evidence to date supporting that its use results in a reduction of ankle sprain injuries. Again, this disconnect demonstrates a need for a clinical trial to determine the effectiveness of the ASO brace in preventing ankle sprain injury.

Clinicians who were concerned about reduced ankle musculature strength after discontinuing use of an ankle brace were less likely to recommend use of an ankle brace to patients after an initial ankle sprain. However, this issue has not been addressed in the literature. We do not have sufficient evidence to support or dismiss the clinicians' concerns. Our data suggest, however, that some clinicians are withholding an efficacious, protective intervention secondary to concern about an unproven side effect. We recommend a controlled trial be performed for a minimum 6-8 weeks to determine if use of some of the most commonly used ankle braces influence the strength of ankle joint musculature. Healthy subjects and subjects who have had a recent sprain might be appropriate for such a study. Examining the effect of extended use of ankle brace on ankle musculature strength could prove useful in guiding clinicians' decision making about recommending an ankle brace.

Conclusion

The results of this study detail the current practice of a sample of clinicians in recommending ankle braces highlighting where clinical practice diverges from the literature.

Clinicians in this study considered effectiveness in preventing an ankle sprain the most important factor when recommending an ankle brace. The next most influential factor was brace comfort. Clinicians in this study who were concerned about reduction in ankle muscle strength upon discontinuing using an ankle brace were less likely to recommend use of an ankle brace to a patient after an initial ankle sprain.

The findings from this study demonstrate the need for clinical trials to guide future clinical practice. The issue of potential reduction in strength requires study. Future studies examining the influence of ankle braces on ankle joint motion during dynamic motion or examining injury rates when using an ankle brace should include the ASO brace since this was the most frequently recommended brace. Additionally, investigators should consider including the Aircast Air-Stirrup, McDavid Sports Medical Products Lace-up, Swede-O Ankle LoK, and T2 Active Ankle Support braces in future studies.

Table 1: Descriptive Statistics

	N	Percent
Clinicians' Professional Status:		
ATC	198	61.1
PT	99	30.6
Both ATC and PT	27	8.3
Total	324	100
Clinicians' Clinical Setting*:		
Sports Team	108	33.3
Sports Medicine	63	19.4
Outpatient Orthopedic	150	46.3
University	21	6.5
High School / Middle School	35	10.8
Other	23	7.1

* note: since respondents were allowed to select more than one setting percents add to > 100

Duration of brace use reccommended by clinicians after an Initial Sprain :		
Not at all	21	7.5
1 - 6 days	26	9.3
1 - 4 weeks	92	32.9
1 - 3 months	110	39.3
> 3 months	21	7.5
Forever when participating in the activity	10	3.6
Total	280	100
Duration of brace use reccommended by clinicians after a Recurrent Sprain:		
Not at all	6	2.1
1 - 6 days	8	2.9
1 - 4 weeks	36	12.9
1 - 3 months	71	25.4
> 3 months	63	22.5
Forever when participating in the activity	96	34.3
Total	280	100

Table 1: Descriptive Statistics (continued)

	Mean	Std. Dev.	Min	Max
Clinicians' Years of Experience:				
ATC	11.0	8.1	0	40
PT	12.8	9.7	1	40
Orthopedics and/or Sports Medicine	11.4	8.0	0	40
Percentage of patients for whom clinicians recommended use of an ankle brace:				
Initial Sprain - all clinicians	48.1	32.0	0	100
Recurrent Sprain - all clinicians	64.1	35.5	0	100
Initial Sprain - ATC only	53.9	32.6	0	100
Initial Sprain - PT only	35.5	28.0	0	100
Initial Sprain - both ATC & PT	38.3	25.1	2	100
Recurrent Sprain - ATC only	70.1	35.1	0	100
Recurrent Sprain - PT only	49.7	33.6	0	100
Recurrent Sprain - both ATC & PT	57.5	31.4	1	100

Table 2: Number of Clinicians Who Identified Brace as the Most Frequently Recommended

Brace	N	Percent
ASO	102	36
McDavid Sports Medical Products lace-up	36	13
T2 Active Ankle Support	28	10
Swede-O Ankle LoK	27	10
Aircast Air-Stirrup (Aircast)	26	9
RocketSoc	14	5
Universal Ankle Stirrup	7	2
Ankle Brace Lock	5	2

Note: All other braces selected by less than 2 percent of the respondents

Table 3: Number of Clinicians Who Identified Brace as First, Second or Third Most Recommended Brace

Brace	N	Percent
ASO (Medical Specialties Charlotte, NC)	126	44
Aircast Air-Stirrup (Aircast)	79	28
McDavid Sports Medical Products lace-up	79	28
Swede-O Ankle LoK (the original 'Swede-O')	75	26
T2 Active Ankle Support (Active Ankle)	63	22
RocketSoc (DonJoy)	27	10
Universal Ankle Stirrup (DonJoy)	22	8
Ankle Brace Lock (Breg, Vista, CA)	13	5
Ankle Ligament Protector (DonJoy)	11	4

Note: All other braces selected by less than 2 percent of the respondents

Table 4: Frequency of Recommendation for Five Most Frequently Recommended Braces*

	Number of Times Brace Recommended in Last 12 Months					
Brace	**51+**	**26-50**	**16-25**	**11-15**	**6-10**	**1-5**
ASO (Medical Specialties Charlotte, NC)	10	12	19	19	25	41
T2 Active Ankle Support (Active Ankle)	4	4	4	5	10	36
McDavid Sports Medical Products lace-up	3	2	5	4	17	48
Swede-O Ankle LoK (original 'Swede-O')	2	2	4	6	13	48
Aircast Air-Stirrup (Aircast)	2	0	2	6	15	54

*Entries in each column indicate the number of clinicians who have recommended the corresponding braces at the indicated frequency

Table 5: Number of Clinicians Who Identified Factor as Most Influential When Selecting a Brace

	N	**Percent**
Effectiveness	125	54
Severity of Ankle Sprain	32	14
Comfort	22	10
Availability	19	8
Compliance	14	6
Performance	9	4
Cost	4	2
Other	5	2
Total	*230*	*100*

Chi-square:	328.4 ***
Degrees of Freedom	6

***p<0.005

note: "Other" not included in calculation of Chi-Square

Table 6: Number of Clinicians Who Identified Factor as 1st, 2nd, or 3rd Most Influential*

	N	Percent
Comfort	126	55
Cost	79	34
Severity of Ankle Sprain	71	31
Compliance	70	30
Performance	65	28
Availability	62	27
Other	8	3

* The most common response, "effectiveness", was excluded from this analysis

Chi-square:	36.0 ***
Degrees of Freedom	5

***p<0.005

note: "Other" not included in calculation of Chi-Square

Table 7: Regression of recommendation of brace use after initial ankle sprain onto clinician beliefs about potential side effects

	Coefficient[a]		SE	P>t
Reduced Strength:				
Minimum Concern	-12.461	*	5.712	0.030
Moderate Concern	-15.978	*	6.378	0.013
Great Concern	-15.698	*	6.611	0.018
ATC	22.684	***	4.053	0.000
constant	37.486		5.981	0.000
df	4			
Adjusted R2	0.125			
Compromised Proprioception:				
Minimum Concern	0.596		6.117	0.922
Moderate Concern	-3.346		6.558	0.610
Great Concern	-11.871		7.092	0.095
ATC	23.987	***	4.152	0.000
constant	27.158		6.389	0.000
df	4			
Adjusted R2	0.119			
Compromised Dynamic Balance:				
Minimum Concern	6.156		5.362	0.252
Moderate Concern	-4.003		6.008	0.506
Great Concern	-8.883		7.020	0.207
ATC	23.169	***	4.105	0.000
constant	24.367		5.748	0.000
df	4			
Adjusted R2	0.129			
Risk of Injury to Knee Joint:				
Minimum Concern	-7.472		4.259	0.080
Moderate Concern	-7.414		5.993	0.217
Great Concern	0.924		10.540	0.930
ATC	23.325	***	4.108	0.000
constant	29.681		4.601	0.000
df	4			
Adjusted R2	0.113			
N	284			

[a]OLS unstandardized coefficients; Reference category is No Concern at All

*p<0.05 **p<0.01 ***p<0.001

Table 8: Regression of recommendation of brace use after recurrent ankle sprain onto clinician beliefs about potential side

	Coefficient[a]		SE	P>t
Reduced Strength:				
Minimum Concern	-8.799		6.769	0.195
Moderate Concern	-11.940		7.557	0.115
Great Concern	-4.706		7.834	0.549
ATC	27.184	***	4.803	0.000
constant	44.248		7.087	0.000
df	4			
Adjusted R2	0.108			
Compromised Proprioception:				
Minimum Concern	1.042		7.252	0.886
Moderate Concern	-3.883		7.775	0.618
Great Concern	-1.241		8.408	0.883
ATC	27.162	***	4.923	0.000
constant	37.631		7.574	0.000
df	4			
Adjusted R2	0.101			
Compromised Dynamic Balance:				
Minimum Concern	4.775		6.38705	0.455
Moderate Concern	-0.870		7.15654	0.903
Great Concern	1.986		8.36215	0.812
ATC	27.704	***	4.89034	0.000
constant	34.188		6.84758	0.000
df	4			
Adjusted R2	0.103			
Risk of Injury to Knee Joint:				
Minimum Concern	-2.599		5.03472	0.606
Moderate Concern	-1.150		7.08482	0.871
Great Concern	5.057		12.4595	0.685
ATC	28.074	***	4.85560	0.000
constant	37.399		5.43900	0.000
df	4			
Adjusted R2	0.101			
N	284			

[a]OLS unstandardized coefficients; Reference category is No Concern at All
*p<0.05 **p<0.01 ***p<0.001

Table 9. Frequency and percentage of clinicians reporting amount of concern about potential side effects from brace use

	N	Percent
Potential for reduced ankle musculature strength		
No Concern	40	14.08
Minimal Concern	126	44.37
Moderate Concern	65	22.89
Great Concern	53	18.66
Potential for compromised dynamic balance		
No Concern	47	16.55
Minimal Concern	129	45.42
Moderate Concern	73	25.7
Great Concern	35	12.32
Increased risk of injury to knee joint structures		
No Concern	92	32.39
Minimal Concern	140	49.3
Moderate Concern	42	14.79
Great Concern	10	3.52
Potential for compromised ankle joint proprioception		
No Concern	34	11.97
Minimal Concern	121	42.61
Moderate Concern	82	28.87
Great Concern	47	16.55
Total	*284*	

.

APPENDIX A: SURVEY

Clinician Patterns of Ankle Brace Recommendation and Perception of Factors Associated with Brace Use

A. Patient and Brace Volume:

1. In the last 12 months, please estimate the number of patients with ankle sprain injuries you have evaluated and/or treated: ☐ 0 ☐ 1-5 ☐ 6-10 ☐ 11-15 ☐ 16-25 ☐ 26-50 ☐ 51 or more

> **If you answered 0 to the above question, please skip forward to section F on page 5**

Ankle brace recommendations:

2a. In the last 12 months, please estimate the total number of ankle braces you have dispensed and/or recommended to your patients: ☐ 0 ☐ 1-5 ☐ 6-10 ☐ 11-15 ☐ 16-25 ☐ 26-50 ☐ 51 or more

> **If you answered 0 to the above question, please skip forward to section D on page 4**

2b. In the last 12 months, please estimate the percentage of patients you have treated for an **initial** ankle sprain injury for whom you recommend use of an ankle brace: _____ %

2c. In the last 12 months, please estimate the percentage of patients you have treated for a **recurrent** ankle sprain injury for whom you recommend use of an ankle brace: _____ %

3a. In your current position do you have the autonomy to decide if a patient needs to use an ankle brace?

☐ yes ☐ no

3b. If you answered yes to question 3a, do you also have the autonomy to decide which ankle brace a patient should wear?

☐ yes ☐ no

B. Most Frequently recommended braces

1. Please select the brace you have recommended and/or dispensed most frequently in the last 12 months:

_____

(drop down menu on web survey listing the following options:)
Active Ankle Support (Active Ankle)
Aircast Air-Stirrup (Aircast)
Ankle Brace Lock (Breg, Vista, CA)
Ankle Ligament Protector (DonJoy)
Ankle Lok (the original "Swede-O")
ASO (Medical Specialties Charlotte, NC)
Guardian Ankle (McDavid Sports)
McDavid Sports Medical Products lace-up brace
RocketSoc (DonJoy)Universal Ankle Stirrup (DonJoy)
Other (please specify)

In the last 12 months, please estimate how many times you have recommended and/or dispensed the above brace:
☐ 1-5 ☐ 6-10 ☐ 11-15 ☐ 16-25 ☐ 26-50 ☐ 51 or more

2. Please select the brace you have recommended and/or dispensed 2nd most frequently in the last 12 months:
(drop down menu of braces)
Active Ankle Support (Active Ankle)
Aircast Air-Stirrup (Aircast)
Ankle Brace Lock (Breg, Vista, CA)
Ankle Ligament Protector (DonJoy)
Ankle Lok (the original "Swede-O")
ASO (Medical Specialties Charlotte, NC)
Guardian Ankle (McDavid Sports)
McDavid Sports Medical Products lace-up brace
RocketSoc (DonJoy)Universal Ankle Stirrup (DonJoy)
Other (please specify) _____
N/A no more than one brace recommended

In the last 12 months, please estimate how many times you have recommended and/or dispensed the above brace:
☐ 1-5 ☐ 6-10 ☐ 11-15 ☐ 16-25 ☐ 26-50 ☐ 51 or more

3.Please select the brace you have recommended and/or dispensed 3rd most frequently in the last 12 months:
(drop down menu of braces)
Active Ankle Support (Active Ankle)
Aircast Air-Stirrup (Aircast)
Ankle Brace Lock (Breg, Vista, CA)
Ankle Ligament Protector (DonJoy)
Ankle Lok (the original "Swede-O")
ASO (Medical Specialties Charlotte, NC)
Guardian Ankle (McDavid Sports)
McDavid Sports Medical Products lace-up brace
RocketSoc (DonJoy)Universal Ankle Stirrup (DonJoy)
Other (please specify) _____
N/A no more than two braces recommended

In the last 12 months, please estimate how many times you have recommended and/or dispensed the above brace:
☐ 1-5 ☐ 6-10 ☐ 11-15 ☐ 16-25 ☐ 26-50 ☐ 51 or more

C. Most influential factors when selecting a brace

1. Please select the factor that is most influential when you select an ankle brace.

___ availability of the brace
___ comfort of the brace
___ cost of the brace
___ effectiveness in preventing ankle sprain
___ likelihood of compliance
___ influence on performance
___ severity (grade) of ankle sprain
___ other (please describe_____)

2. Please select the factor that is 2nd most influential when you select an ankle brace.

___ availability of the brace
___ comfort of the brace
___ cost of the brace
___ effectiveness in preventing ankle sprain
___ likelihood of compliance
___ influence on performance
___ severity (grade) of ankle sprain
___ other (please describe_____)
___ N/A only one factor influences my decision

3. Please select the factor that is 3rd most influential when you select an ankle brace.

___ availability of the brace
___ comfort of the brace
___ cost of the brace
___ effectiveness in preventing ankle sprain
___ likelihood of compliance
___ influence on performance
___ severity (grade) of ankle sprain
___ other (please describe_____)
___ N/A no more than two factors influence my decision

D. Potential Ankle Brace Side-Effects

Please check the box of the appropriate answer for each of the following questions:

1. When considering recommendation of an ankle brace, how concerned are you about the potential for **reduced ankle musculature strength** once the brace is no longer used?

☐ 1. not concerned at all
☐ 2. minimally concerned
☐ 3. moderately concerned
☐ 4. greatly concerned

2. When considering recommendation of an ankle brace, how concerned are you about the potential for **compromised ankle joint proprioception** once the brace is no longer used?

☐ 1. not concerned at all
☐ 2. minimally concerned
☐ 3. moderately concerned
☐ 4. greatly concerned

3. When considering recommendation of an ankle brace, how concerned are you about the potential for **compromised dynamic balance** once the brace is no longer used?

☐ 1. not concerned at all
☐ 2. minimally concerned
☐ 3. moderately concerned
☐ 4. greatly concerned

4. When considering recommendation of an ankle brace, how concerned are you about increased **risk of injury to knee joint structures**?

- ☐ 1. not concerned at all
- ☐ 2. minimally concerned
- ☐ 3. moderately concerned
- ☐ 4. greatly concerned

E. Current Practice

1. On average for how long after a **first-time ankle sprain** do you typically recommend a patient wear an ankle brace during physical activity that poses a risk of ankle sprain injury?

- ☐ Not at all
- ☐ 1-6 days
- ☐ 1-4 weeks
- ☐ 1-3 months
- ☐ greater than 3 months
- ☐ forever when participating in the activity

2. On average for how long after a **recurrent ankle sprain** do you typically recommend a patient wear an ankle brace during physical activity that poses a risk of ankle sprain injury?

- ☐ Not at all
- ☐ 1-6 days
- ☐ 1-4 weeks
- ☐ 1-3 months
- ☐ greater than 3 months
- ☐ forever when participating in the activity

F. Please provide the following information about your experience as a clinician:

1. Please indicate your professional status: ☐ ATC ☐ PT ☐ PT and ATC

2. Please record your total years of clinical experience as an ATC _____ PT_____

3. Please indicate your years of experience in orthopedics and/or sports medicine: _____

4. What is your current clinical Setting (please check all that apply):
   - ☐ Sports Team(s)
   - ☐ Sports Medicine clinic
   - ☐ Outpatient Orthopedic clinic
   - ☐ Other (please describe): _____

APPENDIX B: EXTENDED LITERATURE REVIEW

Introduction

Injury to the ankle joint is common among the athletic population (Garrick, 1988), military personnel (Milgrom, 1991), and the working population (Grimm, 1999). The vast majority (85%) of injuries to the foot and ankle are ankle sprains (Garrick, 1977). Garrick (1988) reports that among injuries treated in a sports-medicine clinic over 6.5 years, twenty-five percent of the injuries occurred at the foot and ankle. Ankle sprain rates for basketball participation have been reported as ranging from 1.22 injuries/1,000 participations in Canadian collegiate players (Meeuwisse, 2003) to 3.85 injuries/1,000 participations in predominantly recreational games (McKay, 2001). Half of the recreational participants who incurred an ankle sprain injury missed a week or more of competition. Anderson et al. (2004) recently reported a rate of 4.5 injuries/1,000 match hours during matches between elite Norwegian and Icelandic soccer players. Ankle sprains also account for up to 41% of all volleyball injuries (Verhagen, 2004). Ankle injuries also account for between 30 to 60% of all parachuting injuries in military personnel (Amoroso, 1998).

The general population also experiences an appreciable number of ankle sprains. Grimm and Fallat (1999) retrospectively studied all foot and ankle injuries during a one year period at an occupational medicine clinic. These investigators reported that 6.4% of all injuries treated at the clinic were injuries to the foot and ankle, 40.8% of which were ankle sprains. The average cost of medical treatment for all types of ankle injury for this occupational health study was $804 per case.

Mechanisms of Injury

Common mechanisms of injury for ankle sprains during sporting events include quick cutting motions, landing from a jump (McKay, 2001), landing on an uneven surface, and colliding with an opponent (Anderson, 2004). Additional mechanisms include misstepping, stepping on an object, and inverting the ankle on uneven terrain while walking or jogging. The risk for future ankle sprain injury increases following an initial injury (Surve, 1994; Yeung, 1994). McKay (2001) reported basketball players with a history of ankle sprain are up to five times more likely to suffer an ankle sprain than individuals without previous injury.

Recommended use of an ankle brace is a common clinical intervention to prevent ankle sprains. The results of multiple studies indicate that using an ankle brace can reduce the incidence of ankle sprains in sporting activities such as football (Rovere, 1988), basketball (Sitler, 1994), and soccer (Tropp, 1985; Surve, 1994). Additionally, Amoroso et al. (1998) demonstrated a reduction in the incidence of ankle sprain injuries during Army paratrooper training when recruits wore an outside-the-boot brace.

The Future of Ankle Brace Research

Several recently published reviews have called for additional research studying the use of ankle bracing to prevent ankle sprains. Wilkerson (2002) has encouraged researchers to assess the effectiveness of braces and taping procedures at limiting rotary motion in the transverse plane. Cordova et al. (2002) noted that while numerous studies have examined the efficacy of external ankle supports at limiting passive motion, the effects of ankle braces on

ankle kinematics and kinetics during dynamic activities such as running, cutting, and lateral movements are poorly understood. Finally, Gross and Liu (2003) indicated in their review that a new generation of ankle braces is being recommended by clinicians and used by the general population. Gross and Liu recommend that clinicians should be surveyed to determine which ankle braces are used most commonly. This initial effort could be followed by clinical trials to determine the effects of these braces on ankle sprain injury rates during selected activities as compared to control groups. Additional related questions raised by Gross and Liu include: the influence ankle braces may have on injuries to more proximal lower extremity joints, the effects of long-term ankle brace use on muscle strength, and the length of time after an ankle sprain that a brace should be worn to reduce the risk of re-injury adequately.

No published data are available describing which ankle braces clinicians most commonly recommend or which braces individuals acquire on their own. Additionally, no data are available regarding the factors clinicians consider when they recommend a specific ankle brace. The purpose of this study is to address these deficiencies in the literature.

Studies documenting decreased incidence of ankle sprain using ankle braces

Semi-rigid braces

At least two prospective studies have demonstrated reduction in the incidence of ankle sprains using the semi-rigid Aircast Sport-Stirrup (Aircast, Inc.) brace (Surve, 1994; Sitler, 1994). Surve et al. reported that soccer players with a history of previous ankle sprain who wore a semi-rigid ankle brace over the course of one season (Aircast Sport-Stirrup) experienced a significant reduction in the incidence of ankle sprains. The incidence of ankle

sprain for those with a history of ankle sprain was 0.14 injuries/1,000 playing hours in the braced group versus 0.86 injuries/1,000 playing hours for the unbraced group. Sitler et al. followed U.S. Military Academy cadets over two seasons of intramural basketball play. The authors reported that the subjects had no "preparticipation clinical, functional, or radiographic evidence of ankle instability." Of 789 subjects who wore the Sport-Stirrup ankle brace, 11 suffered ankle injuries. Among 812 subjects in the control group, 35 incurred ankle injuries.

Additionally, the results of two studies offer strong evidence that a semi-rigid brace worn outside of paratroopers' boots can prevent ankle injuries (Amoroso, 1998; Schumaker, 2000). Schumaker et al. reported 1.5 injuries/1,000 jumps in a braced group and 4.5 injuries/1,000 jumps in an unbraced group. Amoroso et al. reported data for paratrooper trainees who performed five jumps each. Seven inversion ankle sprain injuries were reported for a group of 376 trainees who did not wear this brace. Only one inversion ankle sprain was observed in a group of 369 trainees who wore the brace.

The previously reviewed studies indicate that semi-rigid ankle braces, and specifically the Aircast Sport-Stirrup, are effective at reducing the incidence of ankle sprains for individuals with or without a history of a previous ankle sprain injury. Activities included in these studies were basketball, soccer, and high impact landing during paratrooper training.

Lace-up and other braces

The results of several studies also indicate that wearing a lace-up brace may effectively reduce the incidence of ankle sprain injuries. The head football coach at Wake Forest University mandated in 1980 that all players have their ankles taped prior to practices

and games. He allowed players to begin choosing between tape and a lace-up brace in 1982. For six years the department maintained records detailing the type of support used and the injuries that occurred. The records were then retrospectively reviewed. Overall, taped players incurred 4.7 sprains/1,000 exposures and braced players incurred 2.9 sprains/1,000 exposures. Injury rates were greater for taped players across all positions. Readers should note that the players were encouraged to tighten the lace-up braces as they felt necessary. The authors did not specify the type of lace-up brace(s) used (Rovere, 1988).

Sharpe et al (1997) studied the effect of the Swede-O Universal Ankle Support (North Branch, MN) canvas lace-up brace on reducing recurrence of ankle sprain injury for female soccer players. Subjects were varsity female soccer players at a Division III college who had a previous history of ankle sprain injury. The players' medical records were retrospectively studied over a five-year period. The recurrence incidence for the group who wore the Swede-O brace was significantly less than the taped and control groups. The authors reported that the braced group incurred no ankle sprains in approximately 790 total game and practice exposures. Based on the previously reviewed studies, it appears that wearing a lace-up brace effectively reduces the incidence of initial and recurrent ankle sprains. Conducting a larger prospective study tracking specific braces and the observed rates of injury and re-injury during additional sporting activities would increase the degree of confidence in the previous claims.

Tropp et al (1985) studied the prevention of ankle sprains using the "Step 1" (Patrick Inc., Linkoping, Sweden) brace, which consists of a plastic sole with medial and lateral straps tightened to an anchor above the malleoli. The subjects were Swedish male soccer players in the national league Division VI. Seventeen percent of the participants in the control group

(n=171) suffered an ankle sprain and 3% of the participants in the braced group (n=60) incurred an ankle sprain.

Mechanism of Injury

Understanding the mechanisms of injury for ankle sprains is important to guide future studies that would evaluate the effects of ankle braces on ankle motion. Most ankle sprains involve the lateral joint structures and occur after the ankle joint is excessively inverted and plantar flexed. Garrick (1977) described the following three mechanisms for ankle sprain injury: 1) a poorly executed cutting motion, 2) landing on an irregular surface, and 3) landing on another player's foot.

Ankle injuries occur as a result of both contact and non-contact events. Video analysis has revealed that injuries during soccer matches were often due to player-to-player contact resulting in either the player landing in a vulnerable, inverted position or being forced into plantar flexion (Anderson, 2004). McKay et al (2001) observed 10,393 basketball participations, and reported that the most common mechanism of injury (MOI) for ankle sprains during basketball was landing from a jump. The authors reported that half of the landing injuries involved landing on another player's foot and half involved landing on the court surface. The next most common MOI was a sharp twist or turn (30%).

Wright et al. (2000) used "muscle driven computer simulations" to explore the mechanism for ankle sprains injuries. The movement studied was described as a simulation of the first half of the stance phase of a side-shuffle movement. A "sprain" was counted for a given stimulation when the torque or angular displacement at the subtalar joint exceeded an

established value. The authors reported that the joint angle of the subtalar joint at foot touchdown did not have a "considerable influence on sprain occurrence." The authors reported, however, that increased talocrural plantar flexion angle at touchdown resulted in an increase in "sprain" occurrence.

Effects of ankle braces on ankle joint kinematics and kinetics

Numerous investigators have assessed the efficacy of ankle braces for restricting passive joint motion. The majority of these efforts included at least an analysis of inversion and eversion (Hartsell, 1997; Greene, 1990; Eils, 2002; Gross, 91, 92, and 94; and Siegler, 1997). Braces have usually been evaluated for their ability to restrict inversion since excessive inversion, in addition to plantar flexion motion, is often considered the primary motion responsible of an ankle sprain injury. Most investigators have demonstrated that the test braces restrict inversion and eversion compared with unbraced testing. Several studies have also included measures of restriction of plantar flexion and dorsiflexion (Cordova, 2000). Very limited data are available, however, describing the influence ankle braces have on internal and external rotation range of motion (Eils, 2002; Siegler, 1997). Wilkerson (2002) details the importance of stability in the transverse plane and the role of the anterior talofibular ligament in restricting external rotation of the leg on the talus.

Cordova et al. (2000) performed a meta-analysis of nineteen studies to analyze the effect of ankle braces and taping on ankle joint range of motion before and after exercise. The analysis compared the effects of tape, semi-rigid braces, and lace-up braces on inversion, eversion, dorsiflexion, and plantar flexion motion both before and after exercise. Every condition significantly differed from the control condition (no tape or brace). Differences

existed, however, in the amount of motion allowed between the types of braces and tape. Inversion and eversion were significantly less for pre-exercise testing and when semi-rigid braces were worn, compared with taped conditions and other lace-up braces. After exercise the semi-rigid braces offered a level of support similar to pre-exercise, whereas the tape and lace-up braces loosened and allowed more inversion and eversion range of motion.

Cordova et al. indicated that the effect sizes were rather small for the data on restriction of plantarflexion and dorsiflexion motion. The tape and lace-up braces restricted plantar flexion and dorsiflextion more significantly than the semi-rigid braces. The tape condition provided greater restriction of dorsiflexion than the lace-up condition. Cordova et al reported no significant difference between the pre- and post-exercise effect on plantar flexion and dorsiflexion motions for the tape and lace-up conditions, indicating that there was not significant loosening in this plane. The general findings of this meta-analysis are consistent with the structure of the braces. Semi-rigid braces generally offer greater medial and lateral support to restrict frontal plane motion. Additionally, these braces are made of stiffer material, which should provide a more lasting level of support throughout an exercise bout. Tape and lace-up braces do not appear to restrict frontal plane motion as well as semi-rigid braces. Lace-up braces, however, appear to offer valuable additional support in the sagittal plane, which may contribute to a reduction of ankle sprain incidence.

Two investigations have studied the ability of braces to restrict internal and external rotation of the foot relative to the leg in response to a passively induced force (Siegler, 1997; Eils, 2002). Eils et al. compared 10 braces (one rigid, five semi-rigid, and four “soft” braces) and reported relatively consistent measures among the braces for internal and external rotation motion. Siegler et al. tested the three-dimensional support of two semi-rigid braces

(Aircast Sport-Stirrup, Aircast Inc. and Active Ankle, Active Ankle Systems) and two lace-up braces (Swede-O Universal, Swede-Inc. and Ascend, AOA Corporation). All braces provided significant support for internal rotation of the foot relative to the leg compared to the no brace condition. Both semi-rigid braces provided significantly greater restriction of motion than the lace-up braces. Additionally, the Active Ankle brace provided significantly greater restriction than the Aircast brace. All braces provided significant support for external rotation of the foot relative to the leg. The semi-rigid braces, however, provided significantly more support than the lace-up braces.

Several investigators have attempted to simulate dynamic inversion while subjects stand on a tilting platform and wear various ankle braces (Eils, 2002; Eils, 2003; Nishikawa, 2000; Vaes, 1998; Ubell, 2003). This dynamic inversion motion is similar to events that occur during a game situation when players land awkwardly on the sport surface or land on an opponent's foot. Eils et al. (2002) studied the effects of one rigid, five semi-rigid, and four soft braces for motion restriction with subjects who had a history of previous ankle sprain injury. The investigators measured passive inversion, as well as inversion that occurred when subjects stood on a platform that was suddenly tilted in the direction of inversion. All braces significantly reduced inversion for both types of testing compared with unbraced testing. The restriction of inversion for passive testing was less than the inversion restriction for platform testing, however, the measurements were significantly correlated for the two tests. These results suggest that the amount a brace restricts passive inversion is indicative of the relative amount of protection the brace might provide against rapidly induced inversion during functional weight-bearing activities.

Vaes et al. detailed that subjects with a history of ankle sprain injury demonstrated a decrease in inversion motion and inversion speed during a 50-degree ankle sprain simulation while wearing an Aircast Sport-Stirrup compared to a control group. Nishikawa et al. reported the Aircast Sport-Stirrup (semi-rigid plastic), Donjoy RocketSoc (lace-up cloth) braces, and ankle taping provided similar inversion and eversion support during a 10-degree tilt on a perturbation platform.

Two investigators have examined more dynamic inversion tilt tasks. Ubell et al. (2003) imposed a 24-degree inversion tilt on subjects who landed on one leg with an intensity intended to approximate two times the force of body weight. Each subject performed the task for five trials in each of three braces (Aircast Sport Stirrup semi-rigid, Bledsoe semi-rigid, and Swede-O Universal lace-up) and in a no brace condition. Subjects were instructed to resist the inversion motion upon landing. A landing was considered successful if the subject allowed less than 24 degrees of ankle inversion. The average success rate for all three braces was 44%. During the unbraced condition subjects demonstrated a 24% success rate. Only the semi-rigid braces, however, resulted in significantly better success rates than the unbraced condition.

Eils et al. (2003) imposed rapidly induced inversion on subjects who landed on the ground after jumping down from a platform. Eils et al. reported use of each of the ten braces (one rigid, five semi-rigid, and four “soft” braces) resulted in significantly reduced inversion compared to the no brace condition. An interesting finding was that the braces that restricted inversion most effectively during the free fall from the platform resulted in lower maximum inversion angle and maximum inversion velocity during the landing. The authors reported this relationship was relatively constant across all brace models. The results suggest that the

influence braces have on ankle position prior to landing may be a possible mechanism through which ankle braces reduce the number of ankle sprain injuries.

Relatively few investigators have examined the influence of ankle braces on ankle joint kinematics and kinetics during more dynamic activities such as running (Hamill, 1986) and lateral movements (Cordova, 1998; Simpson, 1999). Hamill et al. (1986) reported no differences in sagittal plane or frontal plane ground reaction forces among the no brace, taping, and "boot-type ankle stabilizer" conditions during a 5 m/sec running task. The investigators reported, however, that the variability of the forces was consistently greater for the no brace condition.

Another area of interest is the effects of ankle braces on joint kinematics and ground reaction forces during lateral movements and quick cutting motions. Cordova et al. (1998) tested subjects as they performed a lateral dynamic movement at 80-90% of their maximal speed during three conditions: no brace (control), Aircast Sport-Stirrup brace, and an Active Ankle brace. No significant differences in inversion peak impact force, maximum loading force, or peak propulsion force were observed among the brace and control conditions. Kinematic and moment values were not reported. Simpson et al. (1999) tested subjects with a history of two or more ankle sprains using a lateral shuffle movement task that involved a reversal of movement direction. The movements were performed at 85% of maximum velocity and required that subjects create the change of direction on the previously injured ankle. Subjects performed the activity using two semi-rigid braces (Aircast Sport Stirrup and Malleoloc) and a Swede-O Universal lace-up brace. None of the braces restricted inversion compared to the no brace condition. The amount of plantar flexion was significantly less (3 to 4 degrees) for each of the braced conditions compared to the control condition. The

Swede-O brace restricted maximum dorsiflexion significantly more than the two semi-rigid braces (differences from 2 to 4 degrees).

Effects of ankle braces on functional performance

Even though ankle braces have been effective in reducing the incidence of ankle sprains, athletes may be less likely to use them if they believe a given brace will adversely influence performance. Clinicians' beliefs about the effect of ankle braces on functional performance may influence decisions about recommending a brace. Considerable evidence exists that ankle braces do not adversely affect functional performance, however, a few studies contradict this general conclusion.

The results of several studies indicate that ankle braces do not negatively influence sprint times (Bocchinfuso, 1994; Gross, 1994; McKean, 1995; MacPherson, 1995; Verbrugge, 1996; and Gross, 1997), vertical jump height (Bocchinfuso, 1994; Gross, 1994; MacKean, 1995; MacPherson, 1995; Pienkowski, 1995; Verbrugge, 1996; Wiley, 1996; and Gross, 1997), or agility performance (Bocchinfuso, 1994; Gross, 1994; MacPherson, 1995; Pienkowski, 1995; Verbrugge, 1996; Wiley, 1996; Gross, 1997; and Jerosch, 1997). Subjects with a history of ankle sprain injury have been tested in some of these studies (Wiley, 1996; Gross, 1997; and Jerosch, 1997). Semi-rigid braces were tested in some of these studies (Boccinfuso, 1994; Gross, 1994; Jerosch, 1997; MacPherson, 1995; Pienkowski, 1995; Verbrugge, 1996; and Gross, 1997), as well as lace-up braces (MacPherson, 1995; Pienkowski, 1995; and MacKean, 1995).

MacKean et al. (1995) reported that some functional performance measures were adversely affected by wearing an ankle brace. The authors reported that when subjects used

an Aircast Sport-Stirrup or a Swede-O Universal brace, they exhibited decreased jump shot accuracy compared to when subjects wore tape. Additionally, MacKean et al. also reported that use of the Swede-O Universal brace resulted in decreased running efficiency on a treadmill compared to use of ankle tape. Burks et al. (1991) reported that use of the Swede-O Universal (lace-up) adversely affected sprint times. Burks et al. also reported that the Swede-O and Kallassy (lace-up) braces adversely affected vertical jump performance.

Hals et al. (2000), however, reported that use of the Aircast Sport-Stirrup resulted in improved performance on a shuttle-run task. Each of the 25 subjects had incurred a unilateral grade I to II ankle sprain within 3 to 4 weeks prior to testing. The improvement in the shuttle-run task did not require an acclimation period. The authors reported use of the brace did not result in an improvement in the vertical jump measure.

Results of performance testing using soft lace-up braces are less consistent. Lace-up braces have more material anteriorly and posteriorly to the ankle joint, possibly exerting greater influence on sagittal plane motion. Lace-up braces limit plantar flexion and dorsiflexion motion more than the semi-rigid braces (Cordova, 2000). Limitation of talocrural motion in the sagittal plane likely reduces the force and power producing potential of the triceps surae muscles during running and jumping tasks. Additional research on this topic is needed.

Ankle Brace Comfort

Ankle brace comfort is another important issue to consider. Semi-rigid braces are made of stiffer material, are generally bulkier, and may cause more skin irritation. Gross and Liu (2003) reported no “consistent trends” across a series of studies comparing comfort

between the Aircast Sport Stirrup and the Ankle Ligament Protector braces. Future survey questions which investigate clinicians' perceptions of brace comfort may clarify how this issue influences the recommendation of braces.

Effects of ankle braces on proximal joints

Some clinicians may have concerns about ankle brace use causing increased risk for injury at proximal joints. Forces must be absorbed throughout the lower extremity during landing and cutting tasks. Theoretically, greater forces may be transmitted to more proximal joints if ankle joint motion is restricted. An understanding of how ankle braces influence proximal joint function is important, especially considering the prevalence of non-contact anterior cruciate ligament (ACL) injuries in females. The effect of using an ankle brace on the risk of proximal joint injury has not been examined. Santos et al. (2004), however, did investigate the effect of ankle braces on knee motion. Santos et al. examined how the Active Ankle brace (semi-rigid with straps) affected motion at the hip and knee during a one-leg stance rotation task. Subjects exhibited an increase in knee internal rotation when they wore the ankle brace during the rotation task.

Restriction of plantar flexion and dorsiflexion motion may limit the absorption of forces at the ankle joint, which may result in greater transmission of forces to the knee or hip. Braces that restrict inversion and eversion of the ankle and internal and external rotation of the tibia may influence rotational motion and forces at the knee. Future investigators could assess how commonly used ankle braces affect frontal and transverse plane forces at the knee during jump landing and cutting maneuvers. The results of these studies would be

particularly useful for understanding if ankle braces place females at greater risk for proximal joint injury (e.g., ACL injury).

Effects of ankle braces on muscle strength

Little information is available regarding the effects of long-term ankle brace use on ankle muscle strength and function. A search of the literature revealed one investigation of postural control (Palmieri, 2002) and one investigation of peroneus longus muscle latency (Cordova, 2000). No investigators, however, have examined the effect of long-term ankle brace use on the force producing capabilities of ankle musculature. Palmieri et al. divided 28 subjects with no history of ankle sprains or use of ankle braces within the past 2 years into control (no-brace) and experimental (brace) groups. The participants in the experimental group wore a McDavid lace-up brace for 8 hours a day for 4 days. On the fifth day, both groups performed 5 trials of single-leg stance on a force platform for 20 seconds per trial. The authors reported no differences in postural control between the groups. The authors concluded that use of the lace-up brace for four days resulted in no change in postural control. Limitations to the application of this study include the short-term use of the brace, the static nature of the task, and the use of healthy, uninjured subjects for testing.

Cordova et al. (2000) investigated the effects of eight weeks use of a semi-rigid brace and a lace-up brace on peroneus longus muscle activation latency in healthy subjects. Post-testing EMG data for a sudden ankle inversion task indicated no effect of brace use on muscle onset latency. No investigators, however, have examined the effect of long-term ankle brace use on the force producing capabilities of ankle musculature.

Many factors must be considered when recommending an ankle brace. Some of these factors have received limited attention in the literature. Many new braces that are commonly recommended have not been included in previous research studies. Future studies will be more clinically relevant if we can determine which braces clinicians most commonly recommend.

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